UiO : University of Oslo

Faculty of Dentistry

Department of Endodontics

Postgraduate program

Case Book

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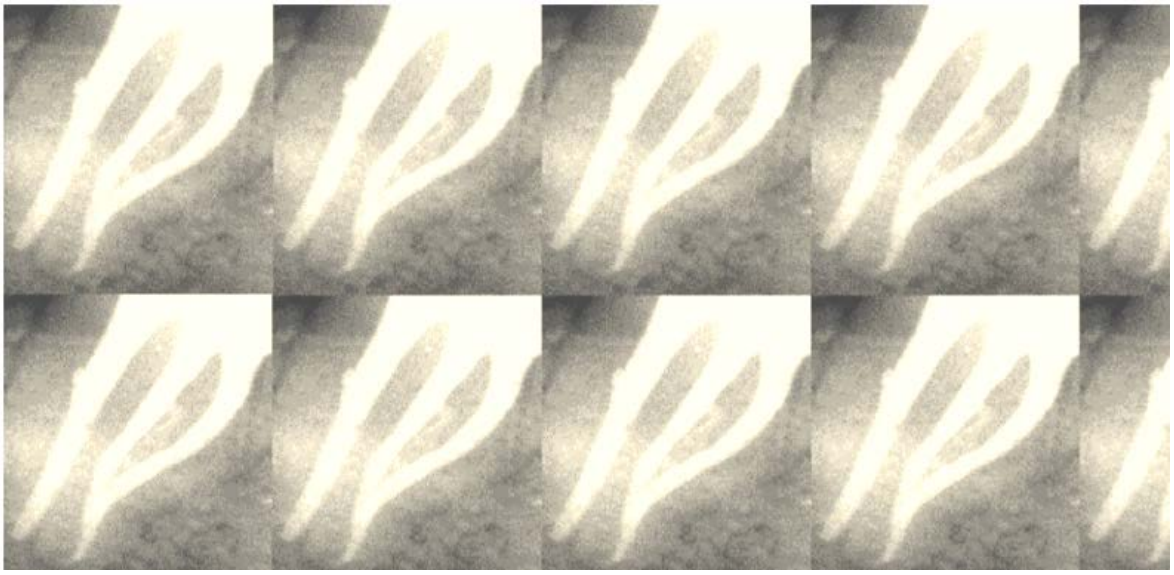

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Surgical cases

Prerequisites and general concepts concerning endodontic treatment of the following cases

Some general principles are not described in detail in each case presented, but a prerequisite for treatment and basis for all of the cases, are in brief outlined in this section.

The referral form is read and the issue considered for planning examination. The patient's own description of the chief complaint is noted and evaluated. Questionnaire including medical and dental history, allergies, earlier treatment experiences, use of medications, stimulantia and other aspects of relevance. The name of the patient's medical doctor (MD) recorded. Description of the diagnostic tests and procedures to the patient.

Clinical (intra- and extraoral) examination including pre-operative radiographs performed, evaluation if additional examinations, as extended or additional radiographical examinations including CT or MR, is indicated. Differential diagnosis assessed and evaluated. Diagnosis determined. Treatment plan, possibly including the necessity of multi-disciplinary approaches. Information of the treatment plan to the patient, including cost, prognostic aspects, plan for final restoration and follow-up.

After agreement and patient acceptance, the treatment is initiated. Prophylactic medicaments, antibacterial or sedative are provided, if indicated and in some cases, pre-agreed with the MD. If molar or premolar, cusp reduction is generally performed prior to treatment for fracture prophylaxis. An access cavity is made by appropriate burs, as diamond fissure bur and/or round burs with ordinary shanks. Localization of canal orifices.

Caries and leaky restorations are removed. In cases where the tooth substance is too weak or too heavily broken down for clamp to be retained, use of a metal ring or temporary crown with IRM® has been the procedure in the cases presented (fig.1-3).

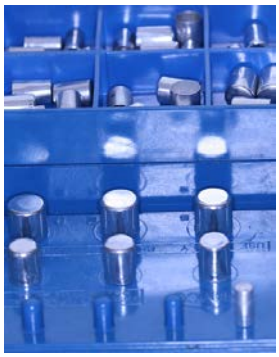


Fig.1. Alu- temp crown

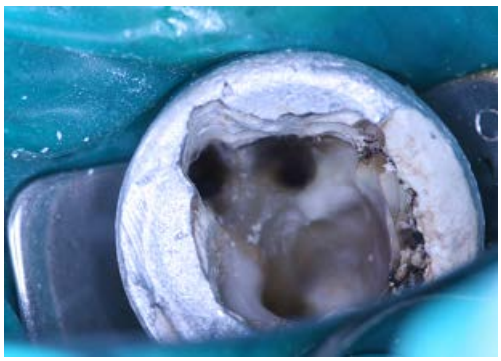


Fig. 2. Temp crown with IRM

Fig. 3. Introral, lateral view

Fig. 4, 5. The patient provided with safety glasses and a plastic sheet for protection of irrigation solutions.

Rubber dam is applied in all of the cases, for providing an aseptic operating field, facilitating the use of the strong medicaments necessary to clean the root canal system, for airway protection, tissue retraction, cross infection control, patient comfort and the ease of working. The correct clamp, dam, frame and correct hole size are chosen. As a part of the overall pre-treatment preparation, the patient is explained that the rubber dam is necessary to isolate the operating area in the same way as a surgical drape is essential for similar invasive medical procedures, where bacterial contamination may have an impact on the outcome. In research as well as regarding the patients in this case book, the rubber dam is well tolerated.

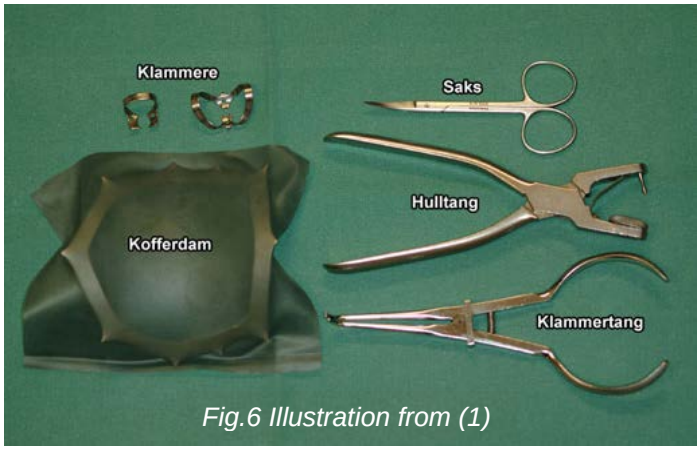


Fig.6 Illustration from (1)

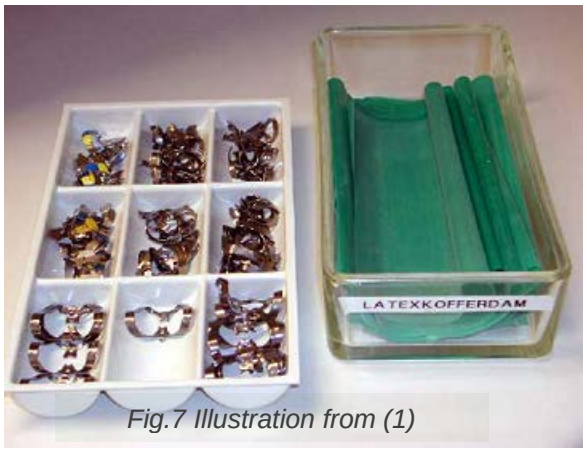


Fig.7 Illustration from (1)

After adequately adapted rubber dam an clamp, the operation field is disinfected with 0,5% chlorhexidine in 70% ethanol.

Fig. 8,9. Disinfection of the operation field

All of the instruments are placed with the handles, touched by unsterile glowes, at the side of the sterile cassette, and remains in this place during the whole treatment session. Everything in the cassette, later used in the root canal, as paper points, are not touched by hands (fig.11).


Fig. 10. The endodontic cassette used


Fig.11. Example of procedure during treatment

Dr. Eggen's filmholder for long-cone-paralleling-technique is used in pre-operative, post-operative and for follow-up radiographs. EndoRay® (DENTSPLY International) film holder is used for X-ray recordings during

treatment when clamp and rubber dam are present. A minimum of four radiographs exists in every digital journal for documentation and comparison on follow-up examinations.

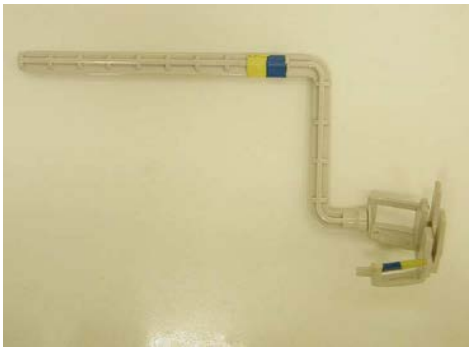


Fig.12. The EndoRay® film holder

Fig.13. Minimum set of radiographs during treatment

Measurement of working length (WL) by apex locator and radiograph. General goal is 0,5-1 mm short of the anatomical apex. (Length and diagnostic aspects are discussed later in the case book).

Fig.14. Electronical apex locator (EAL) is used as a routine in all cases. Most brands have in the literature shown to be reliable, but in these cases, the RootZX® from Morita or the ProPex® apexlocator from Dentsply International are the ones used.

The background for the chosen materials and the practical treatment procedures performed, always are based on theoretical, as updated and evidence-based, scientific information as possible, with focus of the level of evidence as well as critical reading and evaluation of the literature. As examples, from studies, fig. 15 and 16, give some of the background of the clinical procedures current used. See also later, under discussion sections.

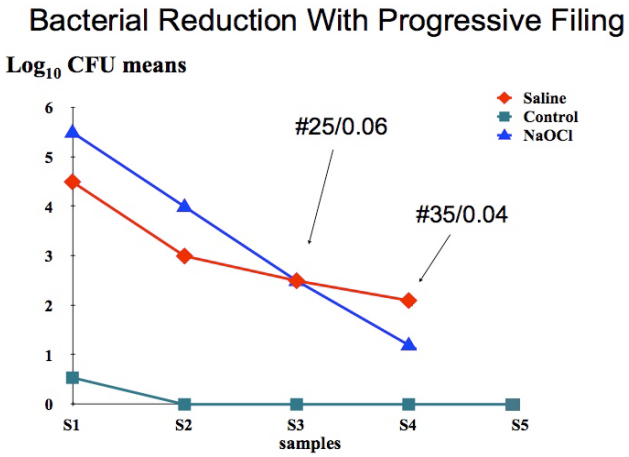
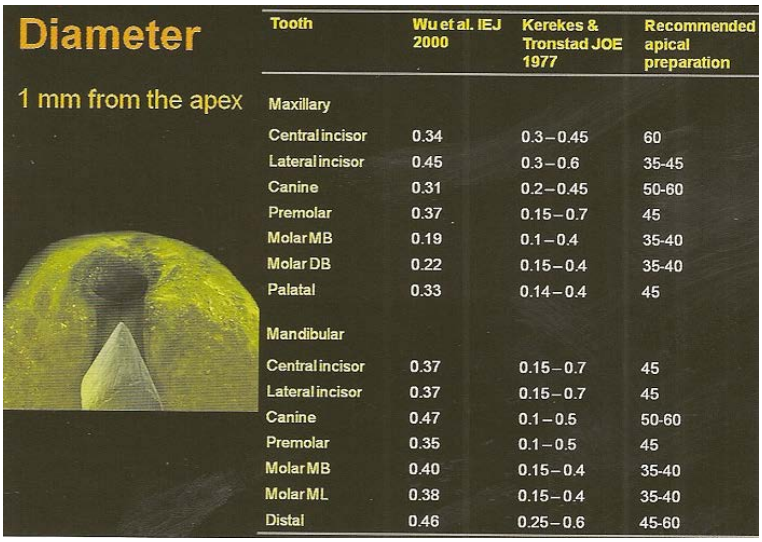


Fig. 15. Reduction of bacteria with increased instrumentation sizes using saline (red) or sodium hypochlorite (blue) irrigation. Only between size #25 to #35 does the use of sodium hypochlorite help decrease the number of bacteria. This indicates that until size #25 will not give enough space for the disinfectant to reach the apical third.(1)



Tooth	Wu et al. IEJ 2000	Kerekes & Tronstad JOE 1977	Recommended apical preparation
Maxillary			
Central incisor	0.34	0.3–0.45	60
Lateral incisor	0.45	0.3–0.6	35-45
Canine	0.31	0.2–0.45	50-60
Premolar	0.37	0.15–0.7	45
Molar MB	0.19	0.1–0.4	35-40
Molar DB	0.22	0.15–0.4	35-40
Palatal	0.33	0.14–0.4	45
Mandibular			
Central incisor	0.37	0.15–0.7	45
Lateral incisor	0.37	0.15–0.7	45
Canine	0.47	0.1–0.5	50-60
Premolar	0.35	0.1–0.5	45
Molar MB	0.40	0.15–0.4	35-40
Molar ML	0.38	0.15–0.4	35-40
Distal	0.46	0.25–0.6	45-60

Figure 16. Results from studies evaluating the anatomic diameter of the root canal 1 mm from the apex. Sizes for apical preparation are recommended based on these values(2).

Individual considerations must be applied but fig. 17 below is a general guideline of what is used as minimal sizes in the cases described in this case book. This is in order to have the best chance of cleaning the root canal and to achieve the optimal effect of irrigation solutions.

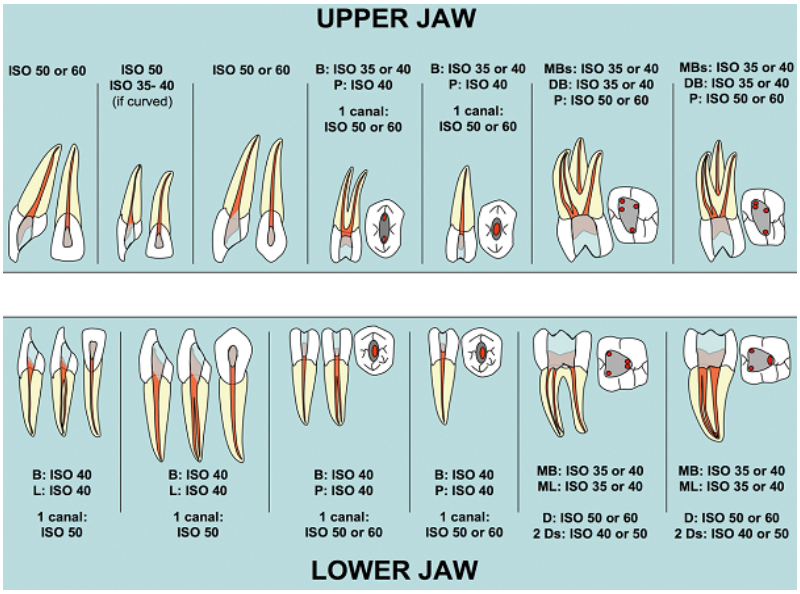


Fig. 17. Anatomical chart showing the recommended minimal sizes for each canal. Courtesy of Dr. G. Debelian.

Of the equipment and devices used in the following cases, most often NiTi hand and rotary files with endo motor ENDO-MATE TC2® (NSK) and rotary NiTi systems ProTaper® or BioRace® (FKG Dentaire, La-Chaux-de-Fonds, Switzerland) are used, as well as the PRE-RaCe system during re-treatment procedures.

Fig.18. Endo motor used

Fig. 19. ProTaper rotary files

Fig. 20. BioRaCe rotary files

Irrigation solutions used:

During the procedure, frequent irrigation is performed. Volumes of min. 10 ml/canal is used of sodium hypochlorite, molecular formula NaOCl. Final irrigation with 17% ethylenediamine tetra tetraacetic (EDTA), molecular formula $C_{10}H_{16}N_2O_8$. In necrotic cases and especially re-treatments; chlorhexidine digluconate, molecular formula $C_{22}H_{30}Cl_2N_{10}$ is used. The canal(s) are dried with paper points, and if a another appointment is indicated, an intra-canal dressing with calcium hydroxide, molecular formula $Ca(OH)_2$ is applied.

In cases with multiple appointments, the coronal seal between treatment sessions always is provided by a double layer; Cavit-G (3M, ESPE) with intermediate restorative material, IRM (Dentsply International, Caulk division, Milford, DE). The literature shows that a 4mm thickness of Cavit will hold a seal that is bacteria free for about three weeks. At the Dept of Endodontics, UiO, a combination (sandwich-type) are used, with the backround of use of Cavit as a base for the best seal and covered with IRM to give the best function. In cases where there are no immediate plan/scheduled appointment for permanent coronal seal, glass ionomer are used in some of the cases presendted. Although non-optimal as a permanent material, glass ionomer's properties exceed that of most all temporary materials with a bond to dentin without any treatment of the dentin.

Fig.21. Cavit G used as first layer (3)

Fig. 22. IRM used as second layer more coronally (3)

During the whole treatment procedure, the important concepts of aseptic regimen and preventing cross-contamination are in the focus of attention (fig.11, 23, 24).

Fig.23, 24.. Data and X-ray equipment, not included in the "patient zone", attention must be made for avoiding cross-contamination.

All the cases described have plugs of resin-enforced zinc oxide-eugenol cement in the orifices, as plugs of 3-4 mm (fig 25-27).

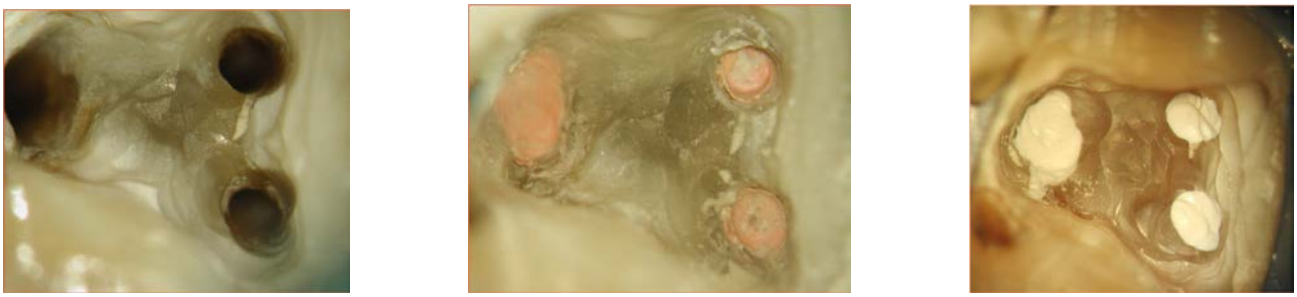


Fig. 25, 26, 27. Illustration of root canals after chemomechanical treatment, after obturation and with IRM® plugs. (Courtesy of Dr. H. Zandi)

After termination of the endodontic treatment, the permanent coronal restoration seldom is provided by the Department of Endodontics. However, the operator ensures that a plan for the permanent coronal seal is existing, and provide recommendations to the student clinic or referral dentist concerning these issues (4).

The Department of Endodontics, Dental Faculty, UiO, has a recall program for all patients received treatment at the student clinic or the post graduate clinic. The patients are recalled for follow-up examination, clinical and radiographical with PAI score and calibrated examinators.The pattern of healing is monitored until healthy conditions are verified or a second intervention is indicated.

The treatment is evaluated together with the patient, and the result presented on the radiographs on the screen. Prognostic aspects are repeated and the patient informed of the above mentioned recall-program, as well as the background and importance of he or she being scheduled for re-examination. Including in this; the dynamics of the healing process explained shortened and simplified.

Concerning surgical cases:

Common systemic medicaments of use:

If premedication of antibiotics, regimen used: Amoxicillin, perorally 2 g 1 hr before treatment (or clindamycin 600 mg or clarithromycin 500mg)

400-600 mg ibuprofen 3-4 /day or other non-steroidal anti-inflammatory medicaments/ antiflogistic, or combined with 500 mg paracetamol up to 3/ day. Doble start dosis of analgetics has been recommended. Alternative regimen if ; paracet/codein (500/30mg) up to 4/ day if stronger pain relief is indicated.

Antibiotic regimen prescribed in some cases of surgery or if flare-up;

Penicillin V phenoxymethylpenicillin 660mg / 1 +1+2 x7 or:

Clindamycin 300 mg, 2+2x5 Alternatives: Metronidazol 400mg, 1+1+1 x 7 or Erytromycin 250 mg, 2 + 2 x 7

Combination therapies if indicated.

Biopsy specimen are routinely submitted to analysis during operative procedures with excision of tissue.

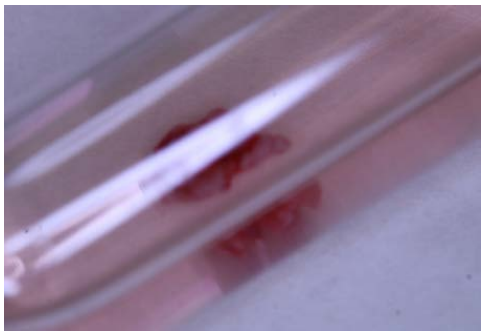


Fig. 25 All tissue removed by surgical procedures are sent to histological examination

All patients treated with surgical interventions are given pre-operative as well as post-operative information, verbal and written:

- Avoid exercise as this increases blood pressure in the head and can cause bleeding. Limit physical activity the first and second day.
- Avoid drinking/mouth rinsing first two hours
- Avoid pulling lip
- Analgetics recommendations (see below)
- Prevent swelling by ice pack in 20 min intervals repeatedly, alternating on and off for the first three hours after surgery.
- Rinse twice a day with chlorhexidine mouthrinse
- Suture removal 48hrs- 4 -7 days
- Bruising and discoloration may occur in the surgical area.
- The following day, brush other areas of the mouth except in the surgical area until the sutures are removed.
- Nutrition is an important part of post-operative healing. Patients should try to eat normally with a few exceptions:

  (a) Eat relatively soft foods for the first day or so. Pasta, eggs, sandwiches, lukewarm soup, stew, salads and other similar foods are acceptable.

  (b) Avoid hard or sharp foods such as chips, pretzels, crusty bread and crackers.

- As described before treatment, smokers are urged to cease smoking until the sutures are removed as smoking may delay wound healing.
- Consumption of alcohol should be avoided if analgetics containing codeine are used, since interaction between these substances occur.
- Should you have any questions, please call or send a message to telephone number xxxxxxxx. We will answer or return to you as soon as possible.

To decrease bacterial growth in the oral environment, all patients have rinsed with chlorhexidine 2 mg/ml for one minute before the surgical procedures during, as well as in the healing phase the first post-operative week.

Most of the patients have received pre-operative analgetics, as 1 g Paracetamol/ 400 mg Ibuprofen or diclofenac 50 mg prior to treatment because of the regimen of not eating or drinking two hours post treatment. The choice of analgetics are however individualized according to the other medicaments prescribed from the patient's medical doctor (MD). If long-acting LA injected combined with the analgetics, normally, a low level of post-treatment pain is to be expected. The patients are informed about the kind of symptoms to be expected, as well as swelling, which can to some degree be minimized by the use of ice pack during the first post op hours (as described above) . Information is also given about the more seldom

symptoms, giving rise to an unscheduled appointment, additional medications or a reassuring phone call. In this way the patient is able to be more prepared of the post-operative situation and better be able of judging if the symptoms within normal limits.

For references and further discussion of the different topics, refer to the 'discussion' section in each Case presentation.

1. Shuping GB, Orstavik D, Sigurdsson A, Trope M. Reduction of intracanal bacteria using nickel-titanium rotary instrumentation and various medications. J Endod. 2000 Dec;26(12):751-5.
2. Siqueira JF, Jr., editor. Treatment of endodontic infections: Quintessence publishing; 2011.
3. www.uio-endo.no. 2012.
4. https://fronter.uio.no [database on the Internet]2012.

Case 1 – K04.01 Acute irreversible pulpitis in patient with anxiety

Patient

23 year old Northern European female.

Fig.1. Frontal view

Chief complaint

Pain from her mandibular, right lower jaw, persisted for two weeks, worsening symptoms last few days.

Medical history

Non-contributory

Dental history

Low caries prevalence. Fear of seeking dental treatment has resulted in pulp-involvement of carious lesion. The patient was referred to the Department of Endodontics from her general dental practitioner (GDP) because of pain management problems, indication for procedural sedation and as short treatment session as possible. The patient demanded one-visit treatment because of anxiety concerning the treatment situation and insists on not coming back for another treatment session, with all the anxiety and fear this potential would have led to.

Clinical findings

Fig. 2 Occlusal view, maxilla

Fig.3 Occlusal view, mandibula

Fig.4. Lateral view

	47	46	45	44
EPT (0-80)	34	11	28	21
Thermal test	Yes	Yes	Yes	Yes
Percussion	No	Yes	No	No
Palpation	No	No	No	No
PPD	1 mm	1 mm	1 mm	1 mm
Soft tissue	Normal			
Restoration	-	IRM	-	-
Lymphadenopaty	No			
Mobility	No	No	No	No

Table 1. Summary of clinical findings 2011-01-26

After performing sensibiltiy tests; termal and electric, persisting pain was evident after terminus of stimuli.

According to the American Society of Anesthesiologists (ASA) physical status classification system (see below), the patient was classified in ASA group I, with no organic, physiologic, or psychiatric disturbance, suited for implementation of sedative medicament prior to treatment.

ASA Physical Status (PS) Classification System from the American Society of Anesthesiologists

ASA PS I, Normal healthy patient	No organic, physiologic, or psychiatric disturbance
ASA PS II - Patients with mild systemic disease	No functional limitations. Well-controlled disease of one body system.
ASA PS III - Patients with severe systemic disease	Some functional limitation; has a controlled disease of more than one body system or one major system; no immediate danger of death
ASA PS IV - Patients with severe systemic disease that is a constant threat to life	At least one severe disease that is poorly controlled or at end stage
ASA PS V - Moribund patients who are not expected to survive without operation	Not expected to survive > 24 hours without surgery

Table 2. ASA classification system

Radiographic findings

Fig. 5. 2011-01-26

X-ray findings	47	46	45	44
Dental	Intact	Temporary filling OD, composite M	No cavity, enamel decalcination	Intact
Periodontal	Normal	Normal	Normal	Normal
Apical	PAI 1	PAI 2	PAI 1	PAI 1

Table 3. Summary of radiographic findings

Diagnosis tooth 46

Pulpal: Acute irreversible pulpitis K04.01

Periapical: Normal

Periodontal: Normal

Problem list

- Patient with a distinct gag reflex
- Cleaning, shaping and filling in one treatment session in fearful patient (time issue)

Treatment plan

Sedation with benzodiazepine with the goals of the procedural sedation to provide analgesia, amnesia, and anxiolysis during a potentially painful and/ or frightening procedure. O_2 and HB monitoring. Orthograde endodontic treatment; pulpectomy and root filling

Treatment

Precautions, day of treatment

Verify time of fasting pre treatment:

- ✓ Clear liquids: 2 hrs
- ✓ Food/milk and unclear liquids: 6 hrs

Updated information concerning

- ✓ possible acute infection
- ✓ use of medication or stimulantia on treatment day

Equipment for monitoring SpO_2 and O_2 delivery device.

Fig. 6. Info from pulsoximeter during treatment

Detailed information concerning the endodontic treatment

1 mg Flunipam® 'Actavis' (flunitrazepam) oral administration 60 min before treatment. Injection of local anesthesia (LA) Carbocaine® (mepivacain) "Dentsply" 5,4 ml. The patient had a wish for avoiding conventional incjection technique. The Wand® (Milestone scientific Inc., Livingston, USA) device for administration of LA was used.

Fig. 7-9: LA used, with the Wand STA® for administration

IRM temporary restoration was removed with fissure bur on a high speed hand piece. An access cavity was prepared. Four root canal orifices were identified. Rubber dam was applied and disinfected with a solution of 0,5% chlorhexidine in 70% ethanol. LN- and Gates Glidden burs were used in order to open the root canal orifices and shaping and flaring the coronal part of the root canals. Use of apexlocator Root ZX® to determine working length (WL). WL radiograph was taken with NitiFlex K-files #15 in the buccal root canals, and Hedstrøm files #15 in the lingual root canals.

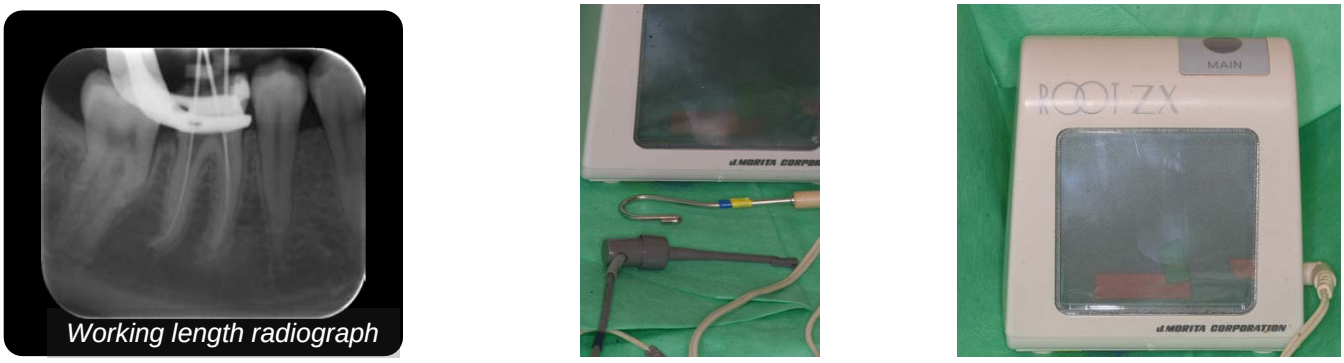


Fig 10-13. WL X-ray (left). Apex locator used, the ROOT ZX®

Mechanical instrumentation: BioRace® (FKG Dentaire from Swiss Dental Products) rotary instruments were used with ENDO-MATE TC2® (NSK) Reduction Endomotor. This device has a large LCD, 5-key operation and a lightweight, cordless handpiece, auto reverse & alarm function that alerts with an audible sound to let the operator know that the load is about to reach the preset torque level, allowing to unload the file before the auto reverse is setting in. TC2 has 5 programs for different file systems and supports most major brands of Ni-Ti files.

However, the patient felt uncomfortable and nervous by the sound and vibration of rotary instruments and requested minimal use of these. BR0-BR3 were used. NiTi hand instruments: MB #40/ 20,5 mm, ML #45/ 20,0 mm, DB 40/ 21,0 mm, DL 45/ 20,5 mm.

Chemical disinfection: Irrigation with 1 % NaOCl, 17 % EDTA

The root canals were dried with sterile paper points. A master cone radiograph was taken with gutta-percha cones size MB #40, ML#40, DB#40, DL#45.

Rotation Speed(min⁻¹)	Gear Ratio	Torque Level(Ncm)
200~900	10 : 1	0.2~2.2
140~550	16 : 1	0.3~3.0
100~450	20 : 1	0.4~4.0

Fig. 14, 15. Master cone radiograph (left), the NSK device settings (right)

The tooth was in the same treatment session obturated with gutta-percha and AH Plus® sealer (DENTSPLY International), using standardized lateral condensation technique. The coronal parts of the root canals were sealed with IRM plugs before an IRM temporary restoration was applied.

Information to patient after treatment:

- ✓ Do not return to work
- ✓ Do not sign documents
- ✓ Do not drink alcohol

Result and evaluation

Fig. 16. Final radiograph

Journal for documentation of specific findings concerning the sedation and implementation of this in the treatment, was used (table 7).

Positive:

- The obturation seems dense and good.
- Optimal procedure, including strict asepsis, was able to perform. The diagnosis of a vital tooth implies a good prognosis.

Negative:

- Tired and anxious patient.
- Long treatment session could possible give more fear and anxiety in the future.
- The dimensions of mechanical instrumentation of distal aspect of the tooth could be expected to be larger. The patient was exhausted and uncomfortable in the situation, despite the attempt to reduce the anxiety with premedication. On the background of the diagnosis vital pulp with no

microorganisms penetrating dentinal tubules, it seemed reasonable to finish the treatment in the dimensions described above.

Prognosis

- *Endodontic:* Good
- *Total:* Good
- *Concerning anxiety:* Expected to be worse. The use of Corah's dental anxiety scale to determine the degree of fear in the actual situation was indicated, as well as creating a plan for cognitive therapy and behaviour approach.

Follow-up examination 2011-10-25, clinical and radiographical

Fig.17. Buccal aspect at follow-up

Fig. 18. Lingual aspect at follow-up

The patient presented free of symptoms. A composite restoration, no cuspal coverage, was present. The coronal restoration was judged to be bacteria tight. In addition, solid IRM plugs are present, placed during the endodontic treatment.

The patient had not received any cognitive therapy or habituation treatment. This was recommended for her, to be able to go through examinations and procedures in the future, without the degree of fear and anxiety that the patient until now had experienced.

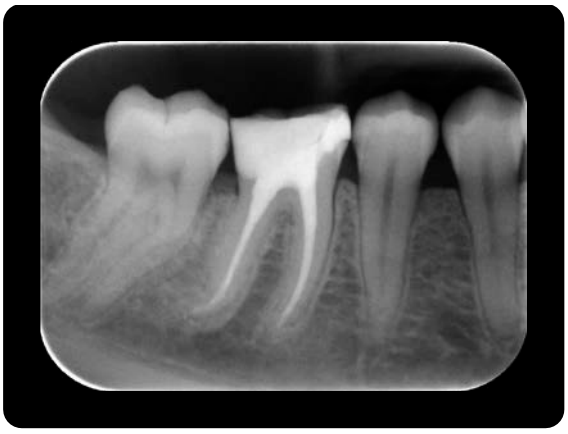


Fig. 19. Orthoradial angulation

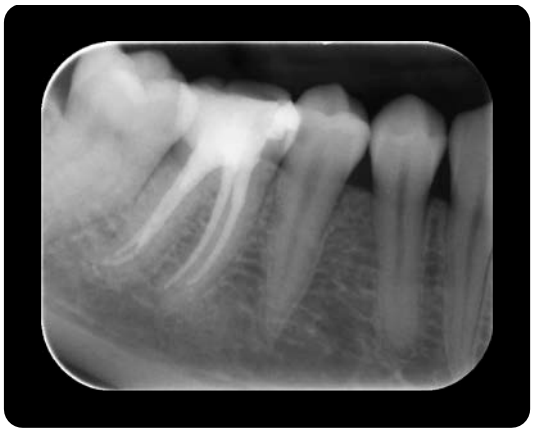


Fig. 20. Mesioeccentric angulation

Discussion

The mandibular, first molar is the earliest permanent tooth to erupt, is often extensively restored, subjected to heavy occlusal stress and the tooth most often root canal treated(1). It most often has two or three roots, with two or three canals in the mesial root and one, two or three canals in the distal root. The canals at the mesial aspect are the MB and ML. A middle mesial (MM) sometimes is present. The incidence of this MM is reported to be 1-15%(1). According to Vertucci; the mesial root has one canal in 40%, two canals in 59% and three canals in 1%. Caliskan *et al* reported 40%, 56% and 3% respectively. The distal root of the mandibular first molar has according to Vertucci; one canal in 85% and two canals in 15%. Caliskan *et al*: One canal: 81%, two canals: 16%. The Average time of eruption: 6 years. Average age of calcification: 9-10 years. Average length: 21mm.

When a dental pulp is inflamed, the inflammation may resolve completely or become chronic. The acute inflammatory response may succeed in eliminating the injurious agent, and the pulp may be restored to a physiologic condition(2). On the contrary, if the inflammation process proceeds with a story of spontaneous or long lasting provoked pain, indicating irreversible and extended inflammatory changes of the pulp tissue an increased pulpal pressure with inflammatory mediators such as prostaglandins. A radical treatment concerning the pulp then has to be performed.

To assess the pulp state correctly, it is important to remember that this will come from a synthesis ot the history, clinical examination, test procedures and radiological examination; not as the outcome of one specific test. The features of an ideal pulp tester should be assessing the pulp blood flow, give objective measurements, be free from error, effective for heavily restored teeth, effective when the pulp size is reduced, quick and easy to use and inexpensive. One of the most used sensibility tests are the thermal testing method; applying cold to a localized part of the tooth, which will stimulate Aδ nerve fibers within the dental pulp. (Heat is less reliable and not as useful as cold (3)). From stimulation of the A-fibers (90% myelinated axon type Aδ), sharp, well-defined pain in response to the hydrodynamic mechanisms occurs. With cold thermal testing, contraction of the dentinal fluid within the dentinal tubules rapid outward flow of fluid within the patent tubules. Test applied to a healthy pulp will be a sharp, localized pain or tingling sensation for the duration of the applied test and for a few seconds after removal of the stimulus. The rapid movement of dentinal fluid results in ‘hydrodynamic forces’ acting on the Aδ nerve mechanoreceptors within the pulp–dentine complex leading to this sharp sensation. The pain will reach a new level with dull, more deep and intense pain caused by stimulation of the C-fibers in the pulp proper. The non-myelinated axon type C are thinner and have a slower conducting velocity than the A-fibers.

The pain associated with an irreversible inflamed pulp may be hyperalgesic, demonstrating a lower threshold of pain by responding to stimuli that usually do not evoke pain, as well as persisting for a longer period of time than normal. A pulp response lasting more than half a minute after the stimulus has been removed is frequently interpreted as indicating an irreversibly inflamed pulp. Devices using electrical current has been commonly used for a long time in dentistry. The objective of electric pulp testing is to stimulate intact Aδ nerves in the pulp–dentine complex by applying an electric current on the tooth surface. Ohm law E=R x I applies to electrical pulp testing (EPT), even if the EPT can be more accurately said to be a combination of impedance and resistance. EPTs operate at a several hundred volts but al low current (mA)(1). Enamel and dentin constitute a high resistance in the electrical circuit through the tooth. A positive result from electric pulp testing is a result of an ionic shift in the dentinal fluid within the tubules with local depolarization and subsequent generation of an action potential from the intact nerve as a result. The Aδ fibres have lower electrical thresholds than the C-fibres and respond to a number of stimuli which do not activate C-fibres. Thinking of anatomical structures in the pulp, such as the pattern of dentinal tubules and the structure, number and branching of the nerve plexus, the probe should be placed on the incisal edge of incisors and on the occlusal two-thirds of the cusp tip or buccal surfaces of premolars and molars. If the goal is vitality testing (determing of presence of blood supply), pulse oximetry or laser-doppler has to be

used. No devices for use in common practice is available at this time, but the technique is used with good result in studies with a sensitivity of 100% and specificity of 95%.

There may however be false responses from sensibility testing used in ordinary clinical settings. Anxious patients, liquefaction necrosis, contact with metal restorations or vital tissue still present in partially necrotic root canal system, are some sources of errors. Possible reasons for false negatives could be incomplete root development, recently traumatized teeth, sclerotization of canals, recent orthodontic activation and patients with psychotic disorders (4). It is also known that the thermal test (ice test) is more reliable in immature teeth than the electric testing, because of the non-matured nerve system in the pulp. There have been several studies looking into the sensibility and specificity of the electric devices for pulp testing.

		Condition as determined by gold standard		
		Clinically normal pulp	Necrotic or pulpless tooth	
Test outcome	Positive	True positive(TP)	False positive (FP)	⇨ Positive predictive value [TP/(TP+FP)]
	Negative	False negative (FN)	True negative (TN)	⇨ Negative predictive value [TN/(TN+FN)]
		⇩ Sensitivity [TP/(TP+FN)]	⇩ Specificity	Accuracy [(TP+TN)/(TP+TN+FP+FN)]

Table 5 Definition of sensitivity, specificity, positive and negative predictive value, and accuracy of pulp tests(5) .

The concepts of sensitivity, specificity and positive and negative predictive values have been developed to characterize test accuracy and to compute the benefits of test usage. Of literature on this issue can be mentioned the findings Gopikrishna *et al* from 2007(3):

- ✓ *The sensitivity* was 0.81 for the cold test, 0.71 for the electrical test.
- ✓ *The specificity* was 0.92 for the cold test, 0.92 for the electrical test.

Peterson *et al* from 1999(6):

- ✓ *The sensitivity* was 0.83 for the cold test, 0.72 for the electrical test. (0.86 for the heat test)
- ✓ *The specificity* was 0.93 for the cold test, 0.93 for the electrical test. (0.41 for the heat test)

The positive predictive value was 0.89 for the cold test, 0.48 for the heat test and 0.88 for the electrical test.

In a study by Weisleder *et al* 2009, the combination of cold tests, Endo-Ice and EPT, improved the ability to correctly identify necrotic pulps (sensitivity= 96%) and vital pulps (specificity= 92%). The cases presented in this case book, this procedure has routinely been used during clinical examination.

The experience of acute pain may exacerbate the anxiety situation for patients with an already high degree of nervousness in the treatment situation, such as this patient. “Fear” is defined as an emotional reaction facing a real threatening situation. An adaptive response with increased muscular tension, HF and hyperventilation will be evident. Patients may have tremor and subjective problems with breathing, aggravating the already tensed situation. “Anxiety” is an emotional reaction in relation the expectation of a threatening situation. The anxiety reaction is characterized by a generalization and catasthropic think-pattern. 4% of the adult population are shown to have an extreme or “phobic” (a situation specific panic-disorder) anxiety of dental treatment. 6% had moderate to intense form and 30% some lesser degree of anxiety. Since the intencity of the anxiety reactions are of importance concerning treatment approach, a tool for measuring this is useful. Anxiety may be rated on visual analogue scale (VAS), and the patient

classified according to the Corah's Dental Anxiety Scale (DAS) (7) . This scale has been used since 1969 and shown to be practical to use, valid and reliable(8). With the help of the DAS, a judgement concerning the patients level of anxiety easily can be conducted. Every question is given a specific number from 1 (=a) to 5 (=e). The numbers are added and the result read: 4-7: No or slight anxiety. 8-11: Slight to some anxiety. 9 – 12: moderate anxiety but have specific stressors that should be discussed and managed. 13 – 14: high anxiety. 15 – 20: severe anxiety (or phobia). 17-20: Phobic reaction in almost all cases. The details of the characterization of different levels of anxiety, pattern of reactions, treatment approach including systematic desensibilization, cognitive therapy and self-efficacy is beyond the scope of this case book and will not be further discussed.

In this case, the patient received premedication with benzodiazepine (BZD) flunitrazepam Flunipam®. Flunitrazepam is a potent hypnotic, sedative anticonvulsant, anxiolytic, amnestic, and skeletal muscle relaxant drug, documented to help patients cope with situations as dental treatment(9). Adverse effects are minimal, but significant anterograde amnesia is to be expected. Problems with decrease in arterial oxygen saturation below critical level is not reported (9). Flunitrazepam has been shown to be an effective, safe, and recommendable alternative for premedication of anxious dental patients. In Norway, flunitrazepam is available as a prescription drug to treat insomnia under the brand name Flunipam®. BZDs enhance the effect of the neurotransmitter gamma-aminobutyric acid (GABA), the Cl^- channels opens up and the nerve hyper polarizes. This gives the result that the neurons need stronger stimuli to depolarize and the brain areas which modulates the moods and conditions as anxiety and wakefulness. The aforementioned effects are desirable for implementation of the dental treatment in the specific patient with these problems. In addition to the pharmacological aspects; the dentist should provide effective communication, explain what is going to happen, make the procedure with so little pain as possible, encourage the patient to ask questions and use relaxation techniques. It is also recommended to postpone complex dental procedures until patient is more comfortable in the dental environment (10). This was difficult to achieve in the referral situation concerning this patient, which was in need of immediate pain relief by adequate endodontic treatment and had a wish for define treatment in one visit.

In vital cases with pulpitis, the apical part of the pulp tissue normally is free of bacteria, but deviation from an aseptic procedure during endodontic treatment may introduce bacteria in the canal, which can jeopardize the treatment and cause periapical inflammatory reactions (11, 12). In vital cases, we should focus on asepsis while in cases with necrotic diagnosis, the treatment should focus on antisepsis. The clinical aim is removal of the entire pulpal tissue short of the anatomical apex, followed by a bacteria-tight, biocompatible and stable root filling (13).

Before starting the root canal treatment, is important to remove carious dentin and leaky fillings, as well as reduce weak cusps to prevent fractures. This first part is not done aseptically because it is not possible to achieve asepsis as long as carious dentin is present. If bacteria reach the pulp in a carious process, the defence apparatus is intact to combat the microorganisms. In the loose connective tissue of the pulp, there are cells and molecules which generate and support local inflammatory and immune reactions. Arterioles dilate and venules become more permeable so that fluid and plasma proteins can leave the blood stream and enter the tissue/ exudation. The immunocompetent cells resident in the tissue and are recruited from the bloodstream. If compared with the skin, there are Langerhans cells, DCs and T cells, but in the pulp; DCs macrophages and NK-cells are present. The first stage of pulpal inflammation involves innate immunity, especially the short-lived and numerous neutrophile granulocytes are in the first line of defence. They are involved in short-term responses, have a short life-span (hours). They are produced in bone marrow and have a high mobility, conducts active phagocytosis (by lysosomal enzymes), recognize exogenous antigens coated with antibodies and bacterial cell walls. CD14 on neutrofils are referred to as LPS-binding protein. Movement of ions -> vacuolar conditions -> microbial killing. These, as well as macrophages and dendritic cells (DCs) are recognizing exogenous antigens, including invading bacteria and their components or by-products, digesting them into small peptides by lysosomal enzymes.C5a and lipopolysaccaride (LPS) are strong chemoattractants for neutrophils(14). Macrophages are slower infiltration than neutrophils, last longer time and are capable of engulfing and digesting almost any foreign

agent. They develop from monocytes in blood and move to local tissues. Two subtypes: M1 and M2. Receptors on their cell surface is present: Mannose receptors/ CD206, rec for complement proteins, Toll like receptors (TLR), IgG-rec. Major source for chemical mediators such as IL-1, TNFα and interferon γ (INFγ). DCs are professional antigen presenting cells (APCs) -> essential for activation of T and B cells. They are derived from hematopoietic stem cells. Different types are: epidermal Langerhans cells, dermal DC, connective interdigitating cells in non-jymphoid tissue, CD8+ resident DC, plasmacytoid DC. The immature DC has more phagocytic activity. The mature DC has lower phagocytic activity but more antigen presenting capability.

There is a shift from acute to chronic inflammation with lymphocytes/ adaptive immunity with time. Continous infection will be beyond the capacity of the innate immune system and the adaptive immune system has much more specific towards exogenous antigens. T cells are classified in two categories according to their surface receptors (TCRs). α β type; CD4-positive helper cells (Th1, Th2) and CD8 positive effector cells (= cytotoxic T cells) and γ δ type. B cells are generated in bone marrow from pluripotent hematopoietic stem cells. Immature B cells exit bone marrow -> enter the spleen -> differentiation to mature follicular cells or marginal zone cells, which further can differentiate to become plasmacells (antibody producing).

In some cases it may be desirable to be able to carefully assess the morphology of the root contour, to correctly localize the canal orifices before the rubber dam is applied. The rubber dam should be applied only to one tooth at a time to reduce the chances for cross-contamination between teeth (15). The further treatment should be performed under stricktly aseptic conditions. The field of operation, including tooth and rubber dam, should be thoroughly disinfected. The instruments used in the first part of the treatment are replaced by a sterile cassette of root canal instruments (16). New, sterile burs remove the coronal part of the pulp to the root canal orifice. Sterility is defined as the absence of living microorganisms (15). The sedation with flunitrazepam was also indirectly a tool for adequate asepsis in this case, because otherwise the treatment procedures with rubber dam (which was unbearable for the patient under normal circumstances), were able to be performed.

Studies have shown that if a distance from radiographical apex to root filling exceeding 3 mm, the success rate will be reduced, compared to a termination of the filling 0–3 mm from the radiographical apex (17, 18). But, in the absence of infection, the wound level ought to be insignificant provided a biocompatible root filling material is used. A placement of the wound at the apical constriction is aimed at (19). When the pulp wound is left well inside the root canal, the cross-section of the wound surface will never exceed the cross-section size of the pulp tissue, even if the root canal preparation is made large. A smaller wound surface in the pulp normally heals better than a large (15). The residual pulp tissue will then be well vascularized, optimizing the healing process.

Since the bacteria in a carious lesion in vital tooth is not expected to reach too far into the root canal (20), a one-step treatment is the preferred treatment option. The patient time-and cost aspects as well as the possibility of contamination of the root canal between treatment sessions are aspects of relevance(21). If it for practical reasons should be necessary to postpone the obturation phase to a second visit, it is of great importance to protect the root canal from becoming infected between the appointments. An antiseptic medicament with long-lasting antibacterial effect should be applied to the root canal, and the access cavity sealed off with a bacteria-tight seal.

There are many variables affecting the outcome in different studies. Some of these factors are patient material, treatment procedures, method and criteria for evaluation of the result, including single- or multirooted teeth, variation in patients lost to follow-up, length of observation period and the diagnosis. Success rates reported in various clinical follow-up studies on pulpectomy, in which it is possible to distinguish vital from non-vital pulp therapies, tell us that a vital pulp has a significant higher success rate than teeth with pulp infection and periapical disease. Even in a high complexity root canal system, the success rate of treatment could be 90-97 % (13, 17, 22-24).

If the result of the treatment of a vital tooth is filling excess, it has been shown that this has no impact on the prognosis(22). In this case, slight excess of sealer could be seen in the post-treatment radiograph. On follow-up radiographs, there were no signs of sealer present and the lamina dura was intact.

DENTAL CONCERNS ASSESSMENT*

Please rank your concerns or anxiety over the dental procedures listed below by ranking them on the accompanying scale. Please fill in any additional concerns.

	Level of Concern or Anxiety			
	Low	Moderate	High	Don't know
1. Sound or vibration of the drill	1	2	3	4
2. Not being numb enough	1	2	3	4
3. Dislike the numb feeling	1	2	3	4
4. Injection ("novocaine")	1	2	3	4
5. Probing to assess gum disease	1	2	3	4
6. The sound or feel of scraping during teeth cleaning	1	2	3	4
7. Gagging, for example during impressions of the mouth	1	2	3	4
8. X-rays	1	2	3	4
9. Rubber dam	1	2	3	4
10. Jaw gets tired	1	2	3	4
11. Cold air hurts teeth	1	2	3	4
12. Not enough information about procedures	1	2	3	4
13. Root canal treatment	1	2	3	4
14. Extraction 1	2	3	4	
15. Fear of being injured	1	2	3	4
16. Panic attacks	1	2	3	4
17. Not being able to stop the dentist	1	2	3	4
18. Not feeling free to ask questions	1	2	3	4
19. Not being listened to or taken seriously	1	2	3	4
20. Being criticized, put down, or lectured to	1	2	3	4
21. Smells in the dental office	1	2	3	4
22. I am worried that I may need a lot of dental treatment	1	2	3	4
23. I am worried about the cost of the dental treatment I may need	1	2	3	4
24. I am worried about the number of appointments and the time that will be required for necessary appointments and treatment; time away from work, or the need for childcare or transportation	1	2	3	4
25. I am embarrassed about the condition of my mouth	1	2	3	4
26. I don't like feeling confined or not in control	1	2	3	4

Other (Use other side if needed):

*Developed by J.H. Clarke and S. Rustvold, Oregon Health Sciences University School of Dentistry, 1993 [revised 1998]

Table 6 Dental concerns assement form,to be used to better understand and prepare the patient for the treatment session

Vedlegg 1

DET ODONTOLOGISKE FAKULTET
Institutt for klinisk odontologi
Klinikk for allmenn odontologi - barn
Postboks 1109 Blindern
0317 Oslo

JOURNALVEDLEGG FOR SEDASJON

Behandlende tannlege	Navn Adresse Født Vekt (Kg)

		Ja		Ja
Generell anamnese	☐	Hjerte og sirkulasjonssykdom	☐	Kontraindikasjon for generell anestesi
	☐	Respirasjonssykdom	☐	Annet
	☐	Blødningssykdom	☐	Konsultert lege
	☐	Nerve-muskelsykdom	☐	Lystgass-sedasjon
	☐	Allergi		
	☐	Psykisk utviklingshemming		
	☐	Medikamenter Preparat		
Spesiell anamnese	☐	Tidligere behandling i narkose		
	☐	Tidligere premedisinering Preparat		

Preoperativ vurdering Risikogruppering (ASA):
- ☐ I. Helt frisk
- ☐ II. Mild systemisk sykdom uten funksjonsbegrensning
- ☐ III. Alvorlig systemisk sykdom med funksjonsbegrensning

Indikasjoner
- ☐ Behandlingsumoden (lav alder, sen utvikling, ingen utholdenhet)
- ☐ Generell redsel (angst, lav psykisk toleranse)
- ☐ Redsel basert på tidligere negativ erfaring av tannbehandling og eller medisinsk behandling
- ☐ Sprøyteskrekk
- ☐ Kontraindikasjon på lokalanestesi
- ☐ Behandling som krever generell analgesi (f.eks. for å gjennomføre behandling i flere kvadranter, visse oralkirurgiske inngrep eller depurasjon).
- ☐ Utsatt brekningstendens
- ☐ Muskelforstyrrelser (f.eks. spasme, tremor)
- ☐ Annet.....

Behandling

		Dato				
1. Planlagt behandling	2. Akutt Behandling					
Faste	JA/NEI					
1.Introduksjon 2.Undersøkelse 3.For å sette lokalanestesi 4.Oral kirurg 5.Sliping	6.Konserverende tannbehandling 7.Ekstraksjon 8.Perio. kirurgi 9.Avtrykk 10.Traumebehandl. 11.Annet.....					
Sedativ: type/mengde						
Sedativ: administrasjonsform						
Lokalanestesi: type/mengde						
Behandlingens varighet (min.)						
Pulsoksymeter: Preoperativt (før sedering): SaO_2 Under sedering (laveste verdi): SaO_2						

Resultat Behandlingen lot seg
1. **ikke** gjennomføre
2. gjennomføre **med** problemer
3. gjennomføre uten problemer

Komplikasjoner Under behandlingen (dvs. i klinikken)
Etter behandlingen (spørreskjema)

1.Kvalme 2.Brekninger 3.Hodepine 4.Pustebesvær 5.Uro 6. Annet.....

Eventuelle kommentarer :

KGIK nov.02

Table 7 Detailed journal concerning findings during procedural sedation

Corah's Dental Anxiety Scale, Revised (DAS-R)

Name _____ **Date** _____

Norman Corah's Dental Questionnaire

1. If you had to go to the dentist tomorrow for a check-up, how would you feel about it?

   a. I would look forward to it as a reasonably enjoyable experience.
   b. I wouldn't care one way or the other.
   c. I would be a little uneasy about it.
   d. I would be afraid that it would be unpleasant and painful.
   e. I would be very frightened of what the dentist would do.

2. When you are waiting in the dentist's office for your turn in the chair, how do you feel?

   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

3. When you are in the dentist's chair waiting while the dentist gets the drill ready to begin working on your teeth, how do you feel?

   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

4. Imagine you are in the dentist's chair to have your teeth cleaned. While you are waiting and the dentist or hygienist is getting out the instruments which will be used to scrape your teeth around the gums, how do you feel?

   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

Scoring the Dental Anxiety Scale, Revised (DAS-R)
(this information is not printed on the form that patients see)

a = 1, b = 2, c = 3, d = 4, e = 5 Total possible = 20

Anxiety rating:

- 9 - 12 = moderate anxiety but have specific stressors that should be discussed and managed
- 13 - 14 = high anxiety
- 15 - 20 = severe anxiety (or phobia). May be manageable with the Dental Concerns Assessment but might require the help of a mental health therapist.

Table 8 Corah's dental anxiety questionnaire

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Case 2 Treatment of dens invaginatus in young patient, sedation with nitrous oxide and later general anesthesia

Introduction

12 year old Norwegian girl was referred from Specialist in Pedodontics at Oslo County Special Clinic. She had a swelling buccally of tooth 21. Incision and drainage was performed and antibiotics prescribed. An unusual morphology was evident at radiographic examination and the patient was referred to the Department of Endodontics, University of Oslo.

Fig.1 Frontal view

Chief complaint

At the moment, the patient was free of symptoms. The experience with anesthesia in inflamed tissue and drainage of pus at the referral clinic had been painful, and the patient has a high level of fear and anxiety of dental treatment in general and local anesthetics (LA) in specific.

Medical history

Healthy patient, no known allergies, ASA group I.

Clinical findings

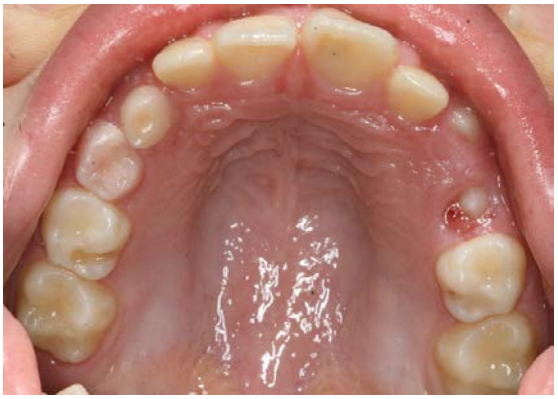


Fig.2 Occlusal view, maxilla

Fig.3 Occlusal view, mandibula

	12	11	21	22
Cold	Yes	Yes	Yes	Yes
EPT	11	08	12	20
Percussion	No	Yes, slightly vertically	No	No
Palpation	No	No	No	No
Mobility	No	No	No	No
PPD in mm	1	1	1	1
Restoration	No	No	No	No
Soft tissue	WNL			

Table 1. Summary of clinical examination

Fig.4. Close-up labial aspect

Fig.5. Close-up palatal aspect

Radiographic findings

Fig.6. 2010-01-12

Fig.7. 2010-01-12

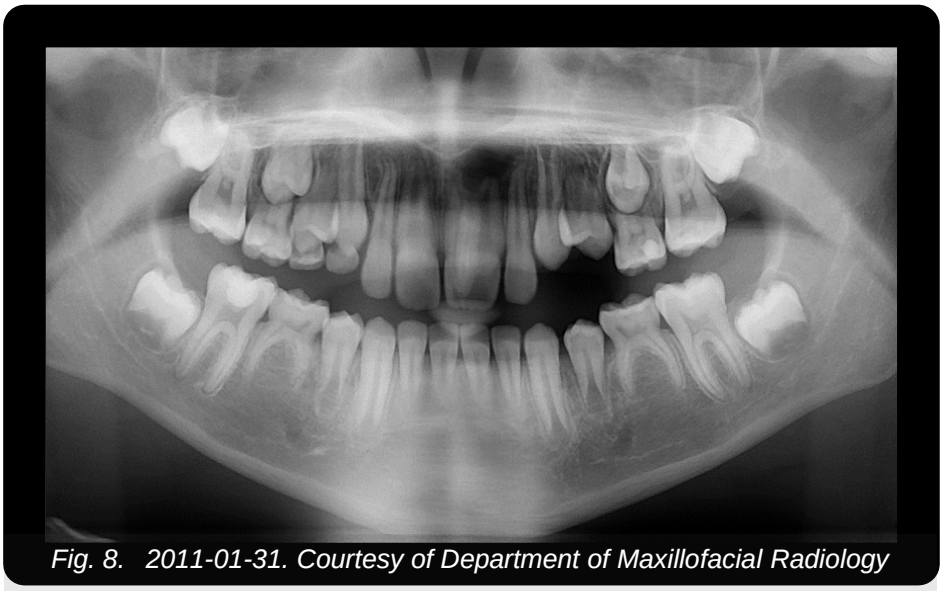
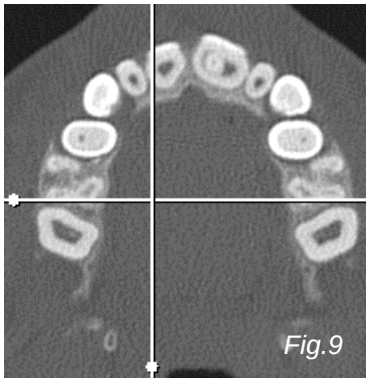
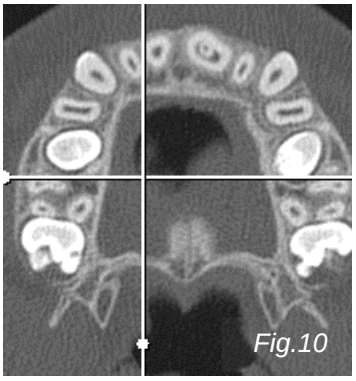


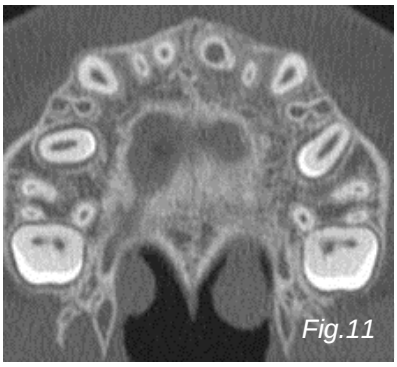
Fig. 8. 2011-01-31. Courtesy of Department of Maxillofacial Radiology

Fig. 6-8. Intact front teeth. Atypical morphology regio 21 with an internal radiolucent pocket surrounded by a radioopaque enamel border and circumscribed radiolucency of 8mm Ø periapically.

The use of CBCT in this case contributed to determine the extension of the chronic apical periodontitis and provided more details of the internal anatomy of the maxillary left central incisor.







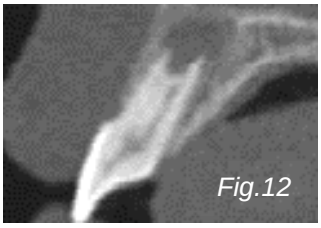
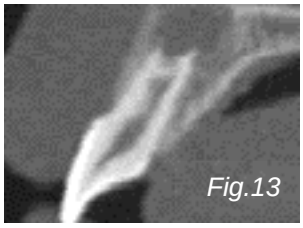


Fig 9-11: Axial view

Fig. 12-13: Sagittal view



CT-images;Courtesy of Department of Maxillofacial Radiology, dr. E. Redfors

OPG og CT maxilla fra 31.01.11:

Atypisk tannmorfologi tann 21. Stor, særlig i bredden, med en meget stor pulpa og med tannlignende struktur sentralt, som sanns. har en pulpa som munner ut i den "store" pulpaen. Periapikalt for tannen sees en radiolucens ca. 7 mm i diameter.

R: Dens-in-dente 21 med apikal periodontitt, konf. beskrivelse.

Maria Redfors
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Tore A. Larheim
Professor

Tore A. Larheim
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Diagnosis

Tooth 22: K0.02 Dens invaginatus type IIIB

Pulpal: Tentative: Infected tissue of invagination, vital pulp tissue.

Apical: Chronic apical periodontitis K04.5

Marginal: Within normal limits

Problem list

Complicated tooth morphology with infected root canal system.

Anxious patient unwilling to cooperate in treatment situation.

Treatment options

Orthograde treatment of the invagination, possible to locate clinically

Surgical treatment

Extraction and implant

Extraction and orthodontic treatment

Treatment plan

The mother of the child did not want extraction and a orthodontic treatment, which was the recommended treatment strategy. She wanted her daughter to keep the tooth because she considered the girl not to be able to cooperate during orthodontic treatment sessions. She had a wish for retaining the tooth as long as possible, and eventually replace the tooth with an implant in adult age, if necessary. Orthograde treatment with local anesteshetic was planned and because of earlier lack of cooperation and fear of anesthetics, sedation with Flunipam 1 mg was mentioned as possible to use. The treatment plan was made in understanding with the parents an appointment for orthograde treatment of the invagination part of the tooth was scheduled. The patient and parents was informed about the treatment and prognosis.

Treatment

Treatment attempt at second appointment was not possible to perform because the girl felt pain during position of the clamp. When local anestethics was going to be applied, she did not cooperate and it the treatment session had to be closed. A new appointment with Flunitrazepam 1 mg sedation was scheduled.

At the third appointment the benzodiazepine of choice was orally administred with precautions as mentioned in case 1. However, the medicament dit not have the desired effect; the patient was exitated and extremely worried, crying all of the time. A new strategy with nitrous oxide sedation was planned and scheduled. The parents and the patient was informed and agreed this approach. However, a short time before the fourth appointment, the patient had eaten a banana, which implies that treatment procedure is contraindicated. When patient returned for the fith time, she had fasted prior to surgery and the nitrous oxide procedure was given as planned.

Summary of technique of administrationof inhalation sedation with N_2O/ O_2:

A pre-oxygenation phase was performed with a flow of 5-6 lpm of O_2. Titration with nitrous oxide was done by increasing its flow to 1lpm and decreasing the oxgen flow by 1 lpm. This should generally be repeated several times while monitoring the patient to determine which level of sedation is desirable and optimal. Administration of LA was attempted by the specialist in Pedodontics, being beside the patient all of the time to contribute with their expertise concerning management of children. However, the patient received maximum dosage of N_2O without enough cooperation to perform the treatment or injection of LA. Her $Sp0_2$-level fell below the level of acceptance, she felt nauseous and dizzy. The treatment attempt was terminated, the patient well oxygenated and sent home.

The parents still refused to extract the tooth with subsequent orthodontic treatment. Appointment with general anesthesia (GA) was scheduled.

2012-04-25 The patient had fasted and was prepared for general anesthetic by the anesthesia nurse and the anesthesiologist. Remifentanil (GlaxoSmithKline) and Propofol (AstraZeneca) was given as intravenous infusion, as well as i.v. administration of analgetics Paracetamol (Actavis).

Fig. 15. Opening of invagination

Fig. 16. White MTA

Before the introduction of the anesthetics, the tooth was confirmed to still be positive on sensibility testing.1,8 ml of articain (Septocaine) infiltrational LA. Rubber dam with disinfection. Careful opening with magnification and illumination was performed, with aid and guidance of the CT-images. The goal was to chemomechanical clean the invagination, without interfering with the remaining pulp space; which was assumed vital. A narrow opening at the mesiopalatal aspect of 21 was prepared with diamond and later, round hard metal bur. Atypical and narrow opening was seen and confirmed with a #8 K-file used with electronical apex loxator (EAL) Root ZX®.

Fig. 17. Pre-op

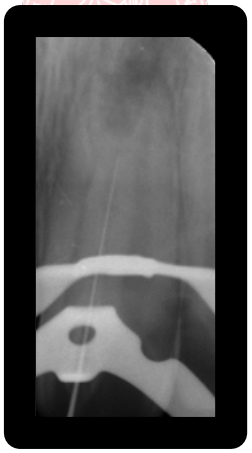


Fig. 18. WL radiograph

Fig. 19. Post-obturation MTA

The EAL responded apparently normal at 20 mm, which was the assumed pre-measured WL according to the radiographs. The WL was set to 19,5 mm. Hand and rotary NiTifiles were of little use because of the hard enamel surface in the “canal” and not the kind of hard tissue the NiTi files are made for removing. SS hand instruments and GG-burs, most coronally, were used. All the time, care and precision was taken not to interfere with the rest of the pulp space. The invagination was instrumented to #50/ 19,5. Copious irrigation with 1% NaOCl and 17% EDTA was undertaken. White MTA Angelus® was used with the MAP device for placement. No bleeding was recorded during the treatment. IRM coronal temporary restoration.

Result & evaluation

The treatment could be performed under aseptical conditions. The invagination was cleaned with proper irrigation solutions and obturated with a biocompatible material. Slight overfilling at the distal aspect can be

seen radiographically. Ideally, I had hoped to be able to get a better coronal flare with a better view of the canal and a larger file dimension during treatment. However, according to the CT-images and conventional radiography, I decided the level of instrumentation to be sufficient, and avoided by this to perforate in to the pulp tissue of the tooth. If the pulp of the tooth had been involved; a total removal of pulpal tissue, and most likely, all of the invaginated tissue; have had to be performed. This would imply severely weakened tooth prone to fracture. From the goal of retaining the tooth until age of 18-20, when implant therapy are planning to take place, the therapy was judged to be appropriate. If follow-up reveals a healing situation, the tooth could possibly retain for a longer period of time. The treatment resulted in very little weakening of tooth structure; most of the tooth was left intact. To note: The treatment was performed without an intracanal dressing, to avoid a second time of general anesthesia for the patient.

Uneventful GA procedure, detailed information concerning this is to be found in the anesthesia journal log.

Prognosis

Endodontic: Uncertain

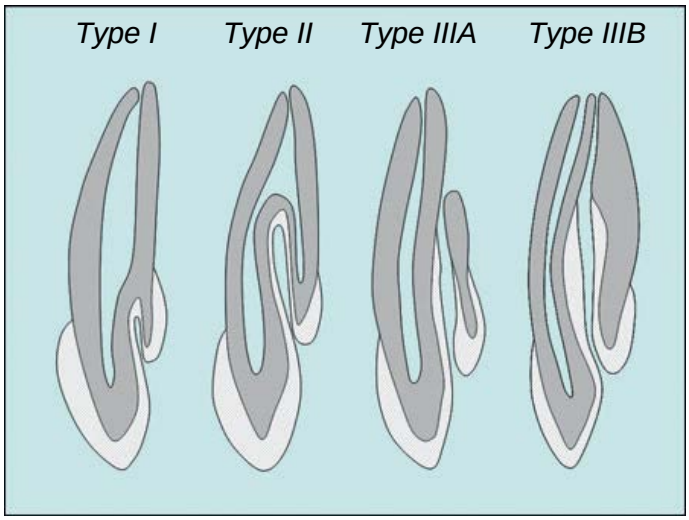
Total: Uncertain

Discussion

The root canal of the maxillary central incisor reflects the external surface outline. Multiple canals are rare but lateral canals are common(1). According to both Vertucci and Caliskan *et al*, one canal is present in 100%. The average time of eruption: 7-8 years. The average age of calcification: 10 years. Average length: 22,5 mm.

Dens invaginatus is an anomaly in the dental germ which occurs as a result of the invagination of the enamel organ. It most commonly occurs in permanent maxillary lateral incisors, followed by maxillary central incisors, premolars and canines. Other terms used of the condition are dens-in-dente, dilated composite odontome, invaginated odontome, dilated gestant odontome, dilated composite odontome, tooth inclusion and dens telescope (2). Some theories for explaining the aetiology includes: growth pressure of dental arch resulting in buckling of enamel organ, a focal failure of growth of internal enamel epithelium, the ‘twin-theory’ suggesting a fusion of two tooth germs, infection and trauma. Genetic factor cannot be excluded.

The morphology of the invagination may vary from barely noticeable with the only indication being a slightly exaggerated singulum pit to a deep infolding reaching the apical foramen. The most common classification system of dens invaginatus, is the one presented by Oehlers in 1957. This classification consists of three types, and is found to be useful during the treatment planning of dens invaginatus (3).



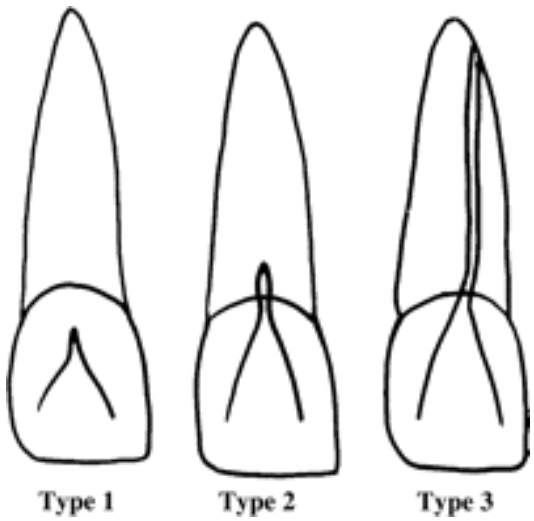


Fig. 20, 21. The Oehler classification, as illustrated in (4) to the right.

Type I is an enamel-lined infolding type, confined to the crown.

Type II is an enamel-lined form, invading the root, but remains confined as a blind sac. It may or may not communicate with the dental pulp.

Type IIIA is an infolding penetrating through the root, usually no communication with the pulp.

Type IIIB A form which also goes through the root and perforate at the apical area through a pseudoforamen. The invagination may be completely lined by enamel, but frequently cementum will be found lining the invagination.

Grahnen et al	1959	3020 right max inc	2,7%
Ulmansky& Herme	1964	500 Full-mouth surveys	2,0%
Poyton& Morgan	1966	5000 Full-mouth surveys	0,25%
Thomas	1974	1886 Full-mouth survey	7,74%
Ruprecht et al	1986	1581 Full-mouth surveys	1,7%
Backman& Wahlin	2001	739 full mouth X-rays	6,8%
Ezoddini et al.	2007	480 OPG	0,8%
Cakici et al	2010	1012 full mouth X-rays	1,3%

Table. 2. Prevalence of dens invaginatus in different studies

Histologically, the enamel organ is seen deepening or invaginating in the dental papilla during the dental organ development process. It begins in the crown and may penetrate throughout the whole root and occurs before the total dental tissue calcification.

Type I and II, is described to give the least treatment problems because the invagination can be removed, transforming the tooth into a one-canal root and conventional endodontics may be performed. In type III, however, the invagination presents communication with the oral cavity.

The patient was scheduled for sedation with nitrous oxide, because earlier treatment attempts with and without flunitrazepam premedication had been unsuccessful. N_2O sedation can be defined as a state of sedation, with different degree of analgesia, by which a conscious patient inhalates a mixture of N_2O and O_2 with adequate laryngeal reflexes (5). The sedation will give a reduction in the level of consciousness and a loss of protecting reflexes. In dentistry, sedation are supposed to be in the level “awake sedation”, that is a controlled and weak reduction in the consciousness level with intact protecting reflexes, as for instance coughering. The patient maintains normal breathing and responds to verbal and physical

stimulation. The patient is awake all the time, or has a light sleep where he or she easily can be awakened. This in contrast to deep sedation or general anesthesia. Prior to the sedation procedures, thorough anamnestic information was received. General questionnaire including information about systemic diseases, medications and allergies must be present. The name of the patient's medical doctor is written in the journal and earlier experiences with premedication or procedures noted. All information taken together give the classification of the patient in ASA-group I-V.

The treatment provider must have a licence to perform the treatment; "Helsepersonellslovens forskrift 2000-12-21 nr.1386 - krav om tillatelse til bruk av lystgassanalgesi ved tannbehandling". Tubes of sizes 0-3 must be present during the treatment, as well as oxygen delivery including flask and reduction valve, flowmetry and self expanding bag and mask sizes 2-5 with possibility of positive pressure ventilation. A monitoring device for SpO2 which also indicates heart frequency is present. The dentist has to know and be familiar with, theoretically and practically, emergency procedures with cardiopulmonary resuscitation. The patient had prior to the treatment received information of fasting and safety aspects, informed consent and the parents signed a statement concerning the daughters health state.

Fasting regulations, as recommended by the Norwegian Anesthesiological Association (6): Clear liquids: 2 hours, breast milk: 4 hours, solid food or milk: 6 hours. Definition of clear liquids is liquids without solid particles or fat, as water, soda, tea, coffea and juice without fruit particles. Smoking, use of chewing gum or pastilles are not to be taken within 2 hours before treatment.

Before the patient returns back home, the level of consciousness, circulation and respiration is evaluated. The patient should have a normal pattern of respiration, an adequate oxygen saturation and be fully recovered. Diffusion hypoxia is avoided by an optimal post-oxygenation procedure for at least 5 minutes. The situation where nitrous oxide diffuse to air-filled entities faster than nitrogen diffuses out, is then avoided.

This case turned out to be treated under GA. After termination of the treatment session, the patient and her parents describe the situation as comfortable. The patient is relieved over managing treatment of the tooth. Recommendations are given concerning maintaining appointments at the hygienist and general dentist for behavioral treatment, as systematic desensitization and other methods of increasing patient compliance.

Treatment techniques of dens invaginatus reported in the literature includes non-surgical treatments, surgery case reports, a combination of non-surgical and surgical treatment, intentional re-implantation and removal of the invaginated portion. There have been different opinions concerning if only treating the infected invagination is sufficient. Some authors argue that it is also necessary to treat the pulp even if it is apparently still healthy. This finding may reflect the close inter-relationship and possible communication between severe invaginations and the main root canal system even when radiographically they appear distinct. Others state that it is possible to treat an infected invagination in isolation of a healthy pulp, but close follow-up and monitoring is recommended (7).

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Case 3 – Treatment of vital mandibular right second molar with C-shaped root canal morphology

Introduction

A 26-year old South Asian female was referred to the post-graduate clinic, Department of Endodontics, Faculty of Dentistry, University of Oslo, by the dental student in January 2012 for treatment of the mandibular right second molar.

Fig.1. Frontal view

Medical history & chief complaint

The patient presented healthy, no use of medications, no known allergies. ASA group I, with no complaints.

Dental history

The patient moved to Norway 2 years ago. She had earlier a low prevalence of DMFT but her caries incidence has increased, with more need for dental treatment, after living in Norway for this time. She explained that her diet had changed into more carbohydrate-rich meals. She was now aware of the increased risk of developing caries and had improved her oral hygiene and more concerned about her diet. She had been educated in the student clinic about these issues and the causality between diet/oral hygiene and development of caries.The patient consulted her dental student in December 2011, complaining of pain from the mandibular region, right side. The student found the mandibular right second molar to be the cause of the pain and a pulpectomy was initiated. An access cavity was prepared and root canal treatment started. The student found the pulp chamber to have an “unusual” appearance. The canals were instrumented partially, filled up with calcium hydroxide and the access cavity sealed with an IRM temporary filling. The symptoms disappeared after a short time after this appointment. Because of the challenging morphology, the patient was then referred to the post graduate endodontic clinic for further treatment of this tooth, as well as tooth 36, which had iaterogenic damage during retreatment procedure at the student clinic.

Clinical findings

Fig.2 Occlusal view, maxilla

Fig.3 Occlusal view, mandibula

Fig.4 Lateral view

Fig. 5 Occlusal view

	47	46	45	44
Sensibility test, thermal (cold)	**-**	**-**	**Yes**	**Yes**
Sensibility test, EPT	**-**	**-**	**24**	**21**
Percussion	**No**	**No**	**No**	**No**
Palpation	**No**	**No**	**No**	**No**
Mobility	**No**	**No**	**No**	**No**
PPD	**2 mm**	**4 mm**	**1 mm**	**1 mm**
Restoration	**IRM**	**IRM**	**No**	**No**
Intraoral examination	**WNL**			
Extraoral examination	**WNL**			

Table 1. Summary of clinical findings

The patient was at this time free of pain, some degree of increased pocket depth was evident buccaly of tooth 46, which had undergone treatment of strip perforations two weeks ago.

Radiographic history

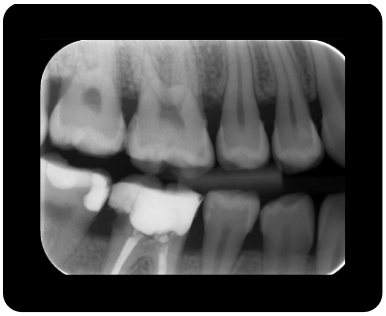

Fig 6. BW radiograph 2011-09-05

Radiographic findings

The radiograph (fig 7) shows region from mandibular right second molar to mandibular right second premolar.

Mandibular right second molar: Restored with an occlusal distal radiopaque filling material extending into the access cavity. Two tapering roots in close proximity, but apparently separate and with two root canals can be seen. Lamina dura is followed around the tooth with a small widening in the apical part. No periapical pathosis is evident.

Mandibular right first molar: Restored with a temporary filling material after retreatment attempt at the student clinic. The marginal bone is reduced interradicuarly due to earlier strip perforation, otherwise normal marginal bone level.

Mandibular right second premolar: Intact tooth structures. Lamina dura can be followed around the root without any disruption.

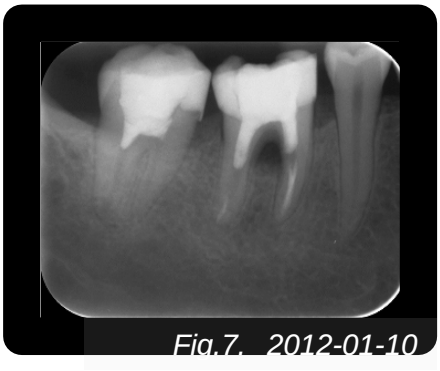

Fig.7. 2012-01-10

Fig. 8. 2012-01-19

Diagnosis tooth 37

Pulpal: K04.a Vital tooth

Apical: K04.b Normal apical periodontium

Marginal: Within normal limits

Treatment plan

Endodontic treatment of vital tooth.

Problem list

Instrumentation, shaping and debridement of the root canal system in C-shaped canals are assumed complicated.

Treatment

Fig.9, 10. 2011-02-12

Rubber dam with disinfection applied. The distal root canal had been instrumented to a Nitiflex #50 at the student clinic. The mesial aspect was not optimal mechanical debrided, as well as the root canal wall in the C-configuration. The coronal, access area was opened up with Gates Glidden burs and an ultrasonic device, piezoelectric Satelec (Dentsply Tulsa Dental, Tulsa, Okla.) with diamond coated tip. Taken into account that the dentin thickness between the external root surface and the internal root canal wall is less than in other teeth, a careful instrumentation was carried out with filing motions starting in the mesiobuccal canal all the way to the distal area under constant irrigation with disinfectant 0.5% sodium hypochlorite and chelating agent EDTA, ensuring removal of the tissue remnants and possible residual pulpal tissue.

Mesial aspect

Distal aspect

Fig. 11, 12 showing the C-shaped canal appearance

A distal aspect, bleeding was evident apically, as well as some symptoms in spite of use of anesthetic. The instrumentation seemed to have extended beyond the WL at the student clinic, up to # 55. The mesial aspect was chemomechanical instrumented unil Nitiflex #45. Satelec ultrasonic device was used advantaging the final debridement and irrigation of the C-shaped root canal system. The root canals were dried with sterile paper points.

Because of some degree of overextended instrumentation at distal aspect, I decided to use MTA as an apical plug.

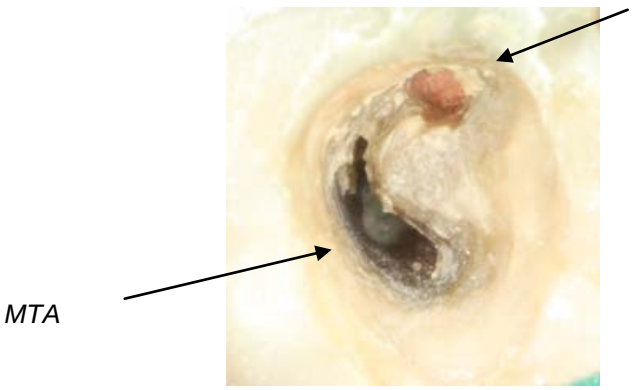

Fig. 13

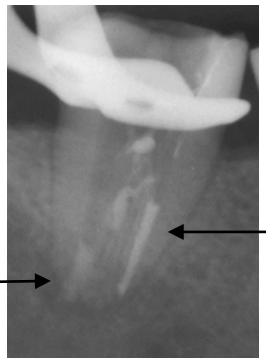

Fig. 14

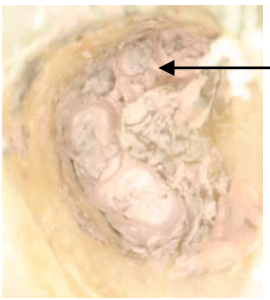

Fig. 15

Result

Fig. 16. Final radiograph after obturation

Evaluation

The obturation seems dense and good, optimal aseptical regimen was performed and the materials of choice are expected to give a favourable outcome.

Prognosis

Endodontic: Good

Total: Good

Discussion

To be familiar with common, but also the more uncommon, variations in root canal morphology, is of importance in endodontics. Most often, the mandibular, second molar has two- four canals. Often, the roots sweep in a curvature with the apices close together. According to Vertucci: Mesial root has one canal in 65%, two canals in 35%. The distal root has one canal in 95% and two canals in 4%. According to Caliskan *et al*: Mesial root has one canal in 41% and two canals in 57%. Distal root has one canal in 96% and two canals in 4%. The apices of this tooth often are very close to the mandibular canal, this should be held in mind during the procedure to prevent instruments or irrigation solutions to be able to cause paresthesia. Average time of eruption: 11-13 years. Average age of calcification: 14-15 years. Average length: 19,8 mm.

One of the most important anatomic variations is the “C” configuration. The C-shaped canal, which was first documented in literature by Cooke and Cox in 1979 (1), is so named for the cross-sectional appearance of the root and root canal. Instead of having several discrete orifices, the pulp chamber of the C-shaped canal is a single ribbon-shaped orifice with a 180° arc or more, which, in mandibular molars, starts at the mesiolingual line angle and sweeps around the buccal to the end at the distal aspect of the pulp chamber (2).

The C-shaped canal configuration is mostly seen in the mandibular second molar, as in this patient. Typically, this C-shape is found in the teeth with fusion of the roots either on its buccal or lingual aspect. In such teeth, the floor of the pulp chamber is usually situated deeply.

The prevalence of C-shaped canal systems in second mandibular molars has been reported to be 31,5 % in a Chinese population (3). Weine and his group looked retrospectively into 811 teeth treated by the Arizona Endodontic Association. These patients were from a wide ethnic background because many of the people living in Arizona are from families who had emigrated from eastern or central Europe. They identified 7,6% of these teeth to be of C-shape configuration (4). In a Lebanese population it has been shown to have a prevalence of 19,1%. C-shaped canals in Saudi Arabian population is reported to be 10,6% (5). The two latter may best represent the ethnic population most relevant comparable with this patients ethnic background.

Cooke and Cox reported that it was impossible to diagnose the condition on a pre-operative radiograph (1).

Category I: continuous C-shaped canal running from the pulp chamber to the apex defines a C-shaped outline without any separation (C1)

Category II: the semicolon-shaped (;) orifice in which dentine separates a main C-shaped canal from one mesial distinct canal (C2)

Category III: refers to those with two or more discrete and separate canals: subdivision I, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals that join apically; subdivision II, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals in the midroot to the apex; and subdivision III, C-shaped orifice that divides into two or more discrete and separate canals in the coronal third to the apex (C3).

C2 are reported to be the most common category.

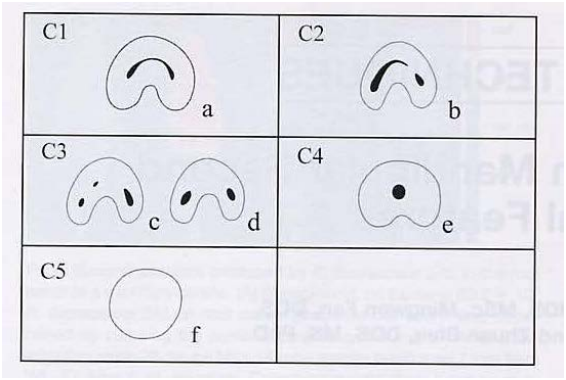

Fig. 17. Classification of C-shaped canal configuration (6)

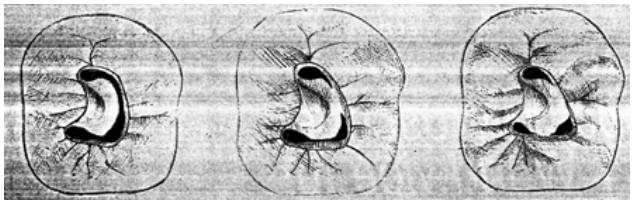

Fig. Category I, II, III (7)

Shape	No.	%
C1	48	88.89
C2	4	7.41
C3	2	3.70
Total	54	100.00

Table 2. Appearance of the orifices.

Because of the anatomic complexity in C-shaped canals, this tooth was chosen to be obturated using a thermoplastic technique that heat soften the gutta-percha and enhance its movement into the canal irregularities.

For teeth with vital pulps, leaving an apical pulp stump of up to 3 mm is recommended, the favorable point to terminate instrumentation and to form an apical stop seems to be 2 to 3 mm short of, rather than 0 to 2 mm from, the apex (8-10). Following this principle, a good success rate has been documented to be obtained. In this case; one of the root canals had an apical pulp stump remaining, preventing extrusion of potential irritating filling materials against the periradicular area, thereby favoring apical healing (11). In the other part of the tooth, where apical stump was not present, a minimal tissue-irritating material was chosen.

An intracanal dressing will not enhance the treatment outcome for vital pulp treatment (table 3) (12).

If the opposite situation had been the case; knowing the anatomical variation and the challenge of cleaning the canals in molars with C-shape morphology, it had been likely that some of the necrotic pulp tissue and bacteria remained in the root canal system. It is widely accepted that one of the most important factors influencing the outcome of endodontic treatment is the preoperative status of the pulp space, including the presence or absence of a radiographically detectable periapical bone lesion (9, 10, 13-15). Teeth, where the pulp was vital, had a higher rate of successful treatment than when the disease of the pulp tissue had progressed and resulted in an AP. However, this tooth had as mentioned a vital diagnosis, no

radiographically signs of periapical pathology and was treated under an aseptic regimen in the student clinic as well as at the specialist clinic.

Medicament	Total, n	Successful %
Ca(OH)2, multivisit	415	94,2
No dressing, single-visit	207	91,8

Table 3. Treatment of root canals with vital pulp, from (12)

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Case 4 - Endodontic treatment of mandibular right premolar in a medically compromised patient

Introduction

A 36 year old Scandinavian female was referred to the Post graduate clinic, Department of Endodontics, UiO, from the TAKO-center, the national resource center of rare, medical conditions, Lovisenberg hospital.

Figure 1. Frontal view

Chief complaint

Pain on hot and cold temperatures from her lower right side. The patient reported waking up at night because of spontaneous pain.

Medical history

Q81.02 Recessive dystrophic epidermolysis bullosa. Surgically amputated both arms and one leg as a result of the diagnosis.

Dental history

The patient presented partially edentulous, - the teeth in lateral segments had been extracted several years ago because of lack of treatment access. She had problems with being able to manage oral hygiene regimen. Mouth breathing and lip closure not possible; leading to xerostomia. Because of the patophysiology of her primary condition, the anatomical landmarks was been altered, as the tissue no longer was possible to move and the scar tissue extremely rigid, with minimal flexibility.

Clinical findings

Extra oral: The skin presents scarred, firm and with little elasticity. Previous bullous lesions throughout the body had healed with atrophic scars.

Intra oral: It was not possible to perform an ordinary routine intraoral examination. The patient had atrophy of the mucosa, ankyloglossia with minimal mobility, microstomia with limited ability to open the mouth. Tongue depapillation was evident. The vestibulum was obliterated and almost abscent. 44: Temporary

filling Intermediate restorative material (IRM), 43: Small composite restorations, 42: Composite restoration. (Summary of clinical examination in table 1).

	44	43	42
Electric pulp test	Positive	Positive	Positive
Thermal test (Endoice)	Positive	Positive	Positive
Percussion test	Positive,vertically	Negative	Negative
Palpation test	Negative	Negative	Negative
PPD Periodontal probing depth	Normal	Normal	Normal

Table 1. Summary of clinical findings

Figure 2, 3. The patient; sensitive to the bright light of the dental lamp and SOM light bulb (left). Maximal mouth opening (right)

Radiographic findings

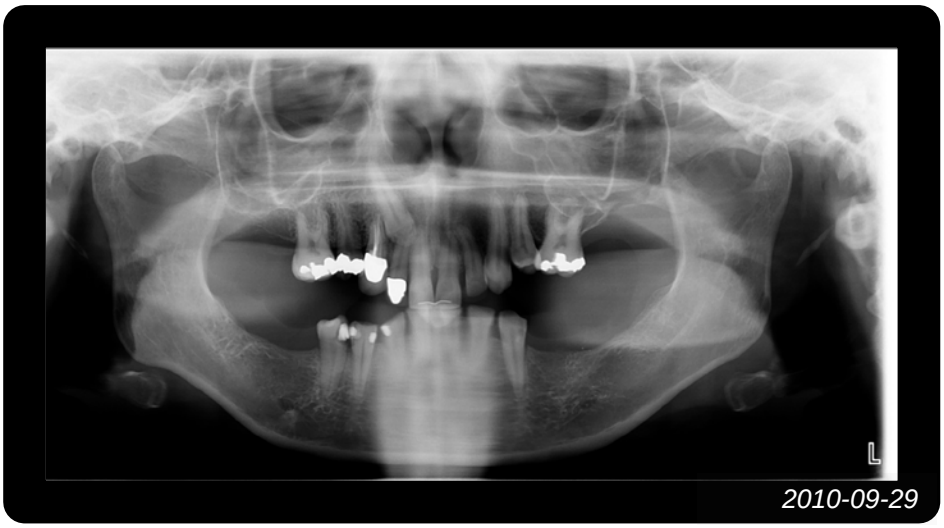

Figure 4. Radiopaque material consistent with intermediate restorative material (IRM) is seen partially in place in cavity, surrounded by a radiolucent area in the dentin which radiographically seems to extend into the pulp. It was not possible to conduct a periapical radiograph without a large degree of tissue damage. (Courtesy; Department of Maxillofacial radiology, UiO)

Diagnosis

Pulpal diagnosis: K04.01 Acute irreversible pulpitis

Periapical diagnosis: Normal

Marginal diagnosis: Normal

Problem list

The patient had severe problems in coping with dental treatment because the lack of elasticity in the skin, Soft tissue lesions, edema and hematoma formation in relation to the treatment situation. Difficulty of achieving aseptical conditions during treatment because of problems with applying rubber dam.

Treatment plan

Treatment of a vital tooth with pulpectomy and root filling of mandibular, right second premolar. No cotton rolls should be applied, according to the recommendations from the TAKO-center, because the cotton fibers stick to the mucosa and give severe irritation-mediated lesions.

Treatment

Vaseline applied to lubricate the skin and lip area. 2 carpules of xylocaine/adrenaline local anesthetics. Access cavity preparation with short-shaft dental burs because of the limited ability of mouth opening. Clamp and rubber dam applied after several attempts. Intraoral radiographs were not possible to achieve. Root ZX® apexlocator was used in this case. Preparation with ProTaper® rotary instruments and manually with NiTi files to dimension # 60/19 mm. Irrigation with 1% NaOCl and 17% EDTA.

Figure 5, 6. Left: The patient wanted to show how well the hand prosthesis was functioning, holding small objects with a firm grip. She wished to drain the painful bullous lesions occurring during treatment herself. However, during the treatment session, I explained that this had to be performed by the treatment provider. After emptying the vesicles which contained serous fluid/ blood exudate, the pain was relieved. Right: The EAL used in this case: The RootZX® from Morita.

The canal was dried and root filled with gutta-percha and AH-plus sealer. IRM was applied as a coronal plug and top filling. It was not possible to perform x-ray control of master point or final obturation during or after the treatment. An OPG was taken prior and post treatment.

Figure 7. After some time of treatment, outher epithelial layers were detatched from the underlaying tissue despite of attempt of gentle and careful treatment.

Result

Fig. 8 Before treatment

Fig. 9 After treatment

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Evaluation

Residual caries is observed at the mesial aspect. This should have been removed before root canal therapy for optimal aseptic regimen. The dentist at the TAKO-centre, which was going to perform the coronal filling therapy, was informed that complete caries excavation had to be performed.

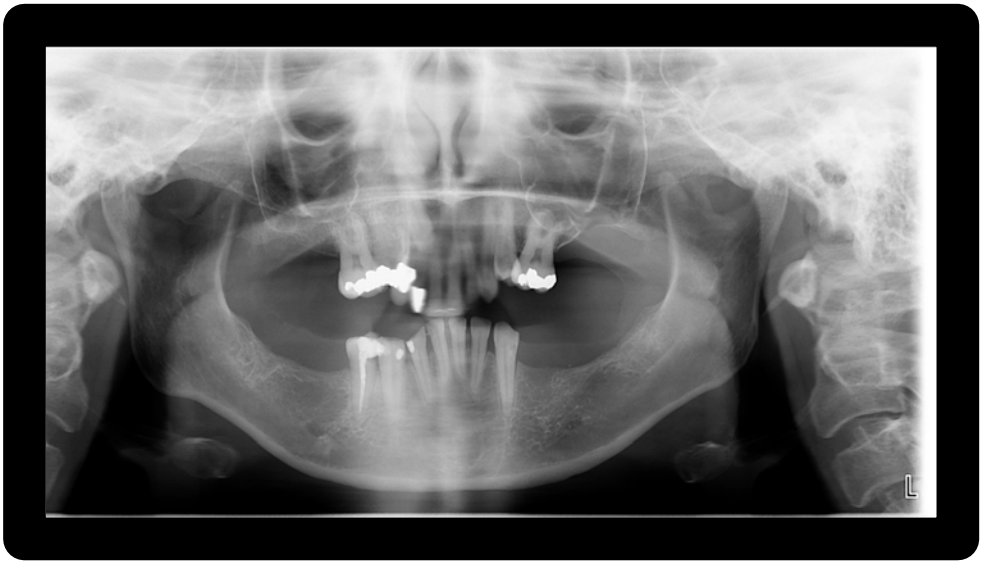

Fig. 10. After treatment 2010-09-29 (Courtesy; Department of Maxillofacial radiology, UiO)

Prognosis

Endodontic: Good.

Total: Good if continued ability to maintain intra-oral hygiene regimen

2 years follow-up examination

Fig. 11. 2012-01-24: The patient is free of symptoms in the actual area but has several carious lesions. Conservative treatment and prophylactic measures are taken care of at the Lovisenberg Hospital, TAKO-centre. An optimal follow-up X-ray is not possible to obtain without pain and tissue distruction, and therefore not attempted.

Discussion

The mandibular second premolar is a lot similar to that of the first premolar, but with the lingual pulp horn usually larger; the root and root canal are more often oval than round. Morphological variations are found less often than in the first premolar. According to Vertucci; one canal is present in 97,5%, two canals in 2,5%. Caliskan *et al*: One canal: 94%, two canals in 6%. Average time of eruption: 11-12 years. Average age of calcification: 13-14 years. Average length: 22,3 mm.

Epidermolysis bullosa (EB) is a rare, inherited group of genodermatoses, caused by genetic mutation which can be passed from parents to child. Whether the child will develop the genetic disorder depends on the pattern of inheritance. This condition is caused by a mutation in gene coding for the keratin or collagen. EB, all forms included, has an incidence of 1/50,000. Its severity ranges from mild to lethal. EB is divided into 4 main categories. At electron microscopic resolution, the blistering in EB simplex occurs within the basal keratinocyte layer, in junctional EB it is within the basement membrane and in dystrophic EB it is under the lamina densa. In autosomal dominant disorders, the mutated gene occurs on an autosome and the person only needs one copy of it to have the disorder. Males and females are equally likely to inherit the genetic mutation and be affected by it. Children of a person with an autosomal dominant disorder have a 50% chance of inheriting the disorder. In autosomal recessive disorders, the mutated gene occurs on an autosome but the person needs two copies of the gene, one from each parent, in order to have the disorder. A person with only one copy of the mutated gene is a carrier. Carriers are not affected by the mutated gene. However, the carrier can pass on the genetic mutation to his or her children. Each child the couple has will have the same chances of inheriting the mutated gene. Therefore, recessive diseases are single gene disorders that occur only when an individual carries two malfunctioning copies (or mutant alleles) of the relevant gene.

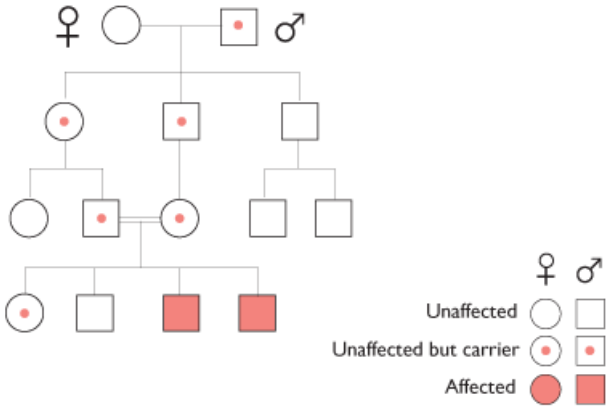

Fig. 12. Because carriers do not display disease symptoms, recessive diseases are difficult to trace through family pedigrees. These diseases tend to affect groups of brothers and sisters. The illustration applies to genes that are present on the autosomes - the chromosomes that are present in both sexes. Recessive diseases caused by genes on the X chromosome show a different type of inheritance pattern because males only have one copy of this chromosome, while females have two.

Illustration from (1)

In recessive dystrophic EB, as in this patient, the patients are prone to development of squamous cell carcinoma, which behaves aggressively and may metastasize widely. Patients often do not survive beyond early adulthood. Elevated collagenase activity in skin fibroblasts has been implicated in pathogenesis (2). EB is characterized by mucocutaneous fragility and blister formation, either spontaneously or as a result of minimal mechanical trauma. Blistering and scarring can be severe. The recessive dystrophic form of EB presents the greatest oral alterations with the formation of vesicles that rapidly tear(3). When these vesicles break,they leave erosive surfaces on the mucosa of cheeks, tongue, uvula, and lips. There are concerns about causing injury to the mucosa because of the risk of formation of bullous lesions with scar formation and loss of elasticity as a result, as clearly seen in this case. Because of this, she was not able to close her eyes or mouth, resulting in red, sore, dry and painful eyes as well as an increased risk of caries developement.

Most patients in dental practice have already been diagnosed with EB. If other and milder forms than in this patient, a possibility of non-diagnosed patient may be present. In these cases, differential diagnostic aspects of relevance could be: Bullous pemphigoid, dyshidrotic eczema, epidermolysis bullosa acquisita, friction blisters of thermal burns, insect bites, linear IgA dermatosis, Lupus erythematosus, bullous form or pemphigus vulgaris.

In this case, I was forced to rely solely on the apex locator during the RCT. The working length (WL) of a root canal is defined as the distance from a coronal reference point on the tooth to the point at which canal preparation and obturation should terminate (4). To short WL may lead to unsufficient debridement of the root canal, whereas overestimation may result in damage to periapical tissues, with possible delaying of healing or reduced outcome (5). The cement dentinal junction (CDJ), where pulp tissue changes into apical tissue, or the minor diameter/ apical constriction, is found to be the ideal physiologic apical limit of the working length (6).

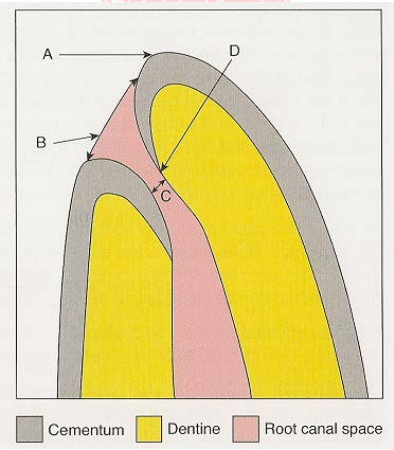

Fig. 13. A= anatomic apex. B= major apical foramen. C= The apical constriction. D= CDJ. From (7)

The apical constriction of the root does not coincide with the anatomic apex. It could deviate linguo-buccally or mesio-distally from the root and it is not always so easy to accurately locate the position of the apical foramen using only radiographs, even with multidirected angles. If the apical constricture is set as the apical limit of the WL, it is easier to clean, shape and obturate the canal. Morphological studies(8-10), pulp-PA pathological studies (11, 12) and outcome studies (5, 13-15) lies behind the rationale for instrumentation 0,5-1 mm short of the radiographic apex. On the basis of studies on extracted human teeth, the distance from the apical foramen to the apical constriction is on average 0,5-0,8 mm, with an increase in distance with increasing age (7).

In this case, intraoral radiographic imaging caused too much damage to soft tissue. Attempts to take X-ray for WL determination were done in the beginning of the treatment, before I realized that this involved too

much of a trauma to the patient (fig.7). Therefore, I chose to rely on the Root ZX® (J. Morita Corp., Tustin, California, USA) apex locator. Several studies have shown the electronic apex locator to provide accurate and reliable information about the location of the apical constriction of the root canal (16-18). In vitro as well as in vivo studies have also found that EAL can be safely used in patients with pacemakers(19).

With conventional radiographic techniques, we have a compressed two-dimensional image with limited clinical information about the three-dimensional anatomy of the root canal. Superimposition of anatomical structures may also happen. By the use of EAL, one may overcome many of the limitations of radiographs.

In 1918, Custer first found that the root canal length could be determined by using the electrical conductance. Little was done with this finding until 1942, when Suzuki reported to have developed a device that measured that the electrical resistance between the periodontal ligament and the oral mucosa was 6500 Ω in dogs. Sunada found then the same in humans. The resistance-type EALs often yielded inaccurate results when electrolytes/ excessive moisture, as hemorrhage, was present. The impedance type of EAL was developed in the late 1980s. This type of EAL uses the electronic mechanism to find the apical constriction - the narrowest part of the canal, by measuring the feedback variation in impedance of the two signals. In 1991, Kobayashi *et al* reported on the 'ratio method' for measuring the root canal length, which was the basic working mechanism of the Root ZX. This type EAL measures the impedances of 0.4 kHz and 8 kHz at the same time, calculates the quotient of the impedances, and expresses this quotient in terms of the position of the file inside the canal. As the instrument approaches the terminus of the root canal, the electrical impedance gradually reduces until the foramen is reached. At the point where the instrument makes contact with the PDL, '0' reading or equivalent symbol, is present. ALs are shown to be accurate, capable of measuring to within 0,5 mm of the apical foramen in over 90% of the cases (17, 20). Shabahang, at Loma Linda, did an *in vivo* evaluation of the Root ZX® (J. Morita Corp., Tustin, CA), a device commonly used for determination of WL. In the study, the Root ZX® was used to locate the apical foramen in 26 root canals of vital teeth. After extraction of the teeth, a stereomicroscope was used to confirm visually the relationship of the tip of the endodontic file to the apical foramen. The Root ZX® located exactly the apical foramen in 17 canals (65.4%) and was short in 1 canal (3.8%). It was overextended in 8 canals (30.8%). When a potential error of +/-0.5 mm from the foramen is accepted as a tolerable range for the clinical application of an electronic apex locator, the Root ZX® was able to locate the foramen within this range in 25 teeth for a clinical accuracy rate of 96.2%. If a tolerance of 1 mm is accepted; the accuracy approaches 100% (7, 16).

Modern apex locators, are shown to be able to work in the presence of fluid within the root canal, as the presence of sodium hypochlorite, blood, water, local anesthetic, and pulpal tissues. Neither the type of irrigation solution or the diagnosis of the tooth have shown to influence the readings.

It is also mentioned in the literature that pre-flaring allowed more consistent EAL readings (21), this is normal procedure at the Department of Endodontics, UiO.

If the apex locator does not work as supposed, possible errors are:

Excessive fluid in pulp chamber
Contact with a metallic restoration
Iaterogenic perforation of the pulp chamber floor or root canal
Purulent discharge within canal
Perforation due to internal or external root resorption
Teeth with significant apical resorption
Teeth with large apical foramina
Lateral canal

Table 2. Possible errors of apex locator readings

There are no cure for any form of EB but these precautions will minimize the risk of scarring and infections (3):

- a program of cutaneous hygiene
- open large blisters with a sterile needle in order to drain the fluid (as done during the treatment in this case (fig. 5)
- open erosions should be cleansed with saline soaks and covered with non- adherent dressings.
- use of topical antibiotics should decrease the risk of infections.
- oral antibiotics should be used whenever signs of cellulitis are present.
- Any indurated or hyperkeratotic growths of recent onset should be biopsied to rule out squamous cell carcinoma.
- Vitamin, protein and iron supplementation are indicated because of predisposition to anemia/malnutrition.
- Use of soft-bristle toothbrushes and water-jet systems for oral hygiene are recommended to prevent trauma.
- Individually made impression trays should be used.
- Small-sized instruments are recommended, such as pediatric instruments.
- Lubrication of skin and mucosa prior to treatment.

Useful advise concerning treatment and how to handle patients with EB can be found in the 'Guideline on management of dental patients with special health care needs, from the American Academy of Pediatric Dentistry Council on Clinical Affairs'(22).

Roots without apical radiolucency are showed to develop disease in about 6% of cases (23). About 76% of AP lesions developing post-treatment are seen within a year. As mentioned in other parts of this case book, one year and up to four years of recall is recommended (24), although one year follow-up will in most cases predict long-term success (23, 25). The patient is followed-up in the Department of Endodontics recall program.

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Case 5 - Treatment of traumatized front teeth

Patient

15 year old white, Northern European boy

Figure 1,2. Frontal view with (left) and without (right) partial denture

Chief complaint

Aesthetic appearance

Medical history

Non-contributory. ASA group I.

Dental history

Bicycle accident 2 years ago. Tooth 11 and 21 exarticulated. 12 and 13 lateral luxated. Of the avulsed teeth, only 21 was replanted, stored in saline for 30 min before replantation. Tooth 11 was not found after the accident. Orthodontic treatment with correction of open anterior bite was delayed because of the trauma. Referred by Specialist in Pedodontics, Public Dental Service.

Clinical findings

UiO : Det odontologiske fakultet

Clinical findings

	13	12	21	22	23
EPT (0-80)	-	-	80	24	33
Cold	-	-	No	Yes	Yes
Palpation	No	No	No	No	No
Percussion	No	No	No	No	No
Pocket depth	2	2 mm	2 mm	2 mm	2mm
Restoration	Previous endodontic treated	Previous endodontic treated & comp	Intracanal dressing & IRM	-	-
Extraoral exam	WNL	WNL	WNL	WNL	WNL

Table 1. Summary of clinical examination

Figure 3 . Occlusal view, maxilla

Figure 4. Occlusal view, mandibula

Fig. 5. Lateral view showing anterior open bite

Fig. 6. Close-up of earlier traumatized tooth 21.

Radiographic findings

Figure 7. 2011-01-20. At time of referral.

Figure 8. 2011-01-20

13: Partially, obturated tooth with radiopaque material in the root canal, lack of obturation material in apical 5 mm, PAI score 1. ***21:*** Tooth with radiographic appearance of an intracanal dressing. PAI score 2

Diagnosis, tooth 13:

Pulpal: K04.19 Previous endodontically treated tooth

Apical: K04.b Physiological apical conditions

Periodontal: Normal

Diagnosis tooth 21:

Pulpal: K04.19 Previous initiated endodontic therapy

Apical: K04.b Physiological apical conditions

Periodontal: Normal

Problem list

The tooth 21 was referred for treatment because of open apex. Trauma happened at approximately 13 years of age, which means that the root formation should have been completed. Apical area presented however larger than normal morphology, unknown etiology, possible during intital instrumentation.

Treatment plan

13: Retreatment of tooth**. *21:*** Endodontic treatment of non-vital tooth.

Treatment

Fig.9. 2011-01-20 WL radiograph. Open apex verified after removal of interappointment dressing

1st appointment 2011-01-20. *21: Root canal disinfection mechanical:* Gates-Glidden burs, rotary BioRaCe, K- and NiTi hand files.UL irrisafe irrigation. Instrument size one canal:R070/21 mm under aseptical condition with disinfected rubber dam and operation field. *13:* Removal of gutta percha, instr. SS files #50/26mm, applying of CH dressing, Cavit, IRM

Both teeth: Root canal disinfection chemical: 1% NaOCl, 17% EDTA*,* 2% CHX*,* $Ca(OH)_2$ intra-canal dressing*,* Cavit, IRM.

2nd appointment 2011-02-05. Aseptical procedure. Indication for apical MTA (Angelus, Brazil) plug for avoiding extrusion of gutta percha. Micro-Apical Placement (MAP)- system used for delivery. Warm vertical compaction. The Elements Obturation Unit was used

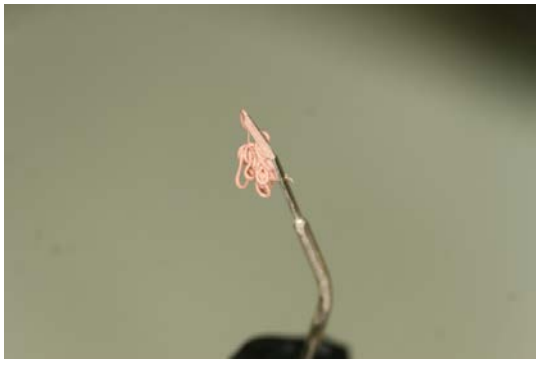

Figure 10. Thermoplasticized gutta percha

No complications during treatment, good cooperation with the patient during the procedure. Information to the patient concerning the treatment and prognosis.

3rd appointment 2011-02-05. *13:* Aseptical procedure, standard protocol. Master cone radiograph, obturation with gutta percha and AHplus sealer.

Result

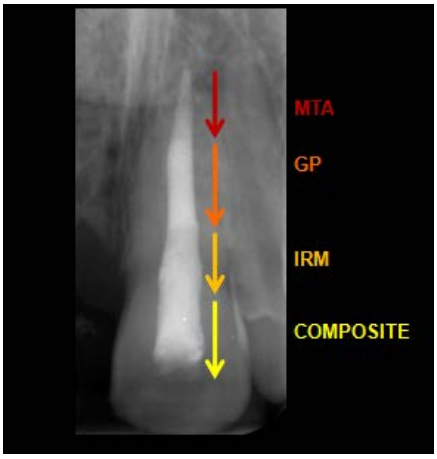

Fig. 11. Specification of the type of materials used

Evaluation

The obturation of both teeth 13 and 21 seem dense and homogeneous and the maxillary, right canine is now obturated to the optimal level apically.

Fig. 12. Tooth 13 before re-treatment

Fig. 13. Tooth 13 after re-treatment

Fig. 14. Tooth 21 before treatment at Dept of Endodontics

Fig 15. Tooth 21 after treatment

Prognosis

	Rotåpen	Lukket foramen
Emalje-dentinfraktur	3	
Komplisert kronefraktur *(Partiell pulpotomi)*	4	4
Rotfraktur	10	29
Konkusjon	0	4
Subluksasjon	0 ?	14
Ekstrusjon	7	55
Lateral luksasjon	10	79
Intrusjon	63	98
Eksartikulasjon *(replantasjon)*	66	100

Table 2. Occurrence of pulp necrosis according to type of trauma and specified in %. (Numbers from Scandinavian studies (1))

	Rotåpen	Lukket foramen
Kronefraktur	0	0
Rotfraktur	0	2
Konkusjon	0	0
Subluksasjon	0	1
Ekstrusjon	6	5
Lateral luksasjon	3	3
Intrusjon	38	38
Eksartikulasjon *(replantasjon)*	37	28

Table 3. Occurrence of external inflammatory root resorption according to type of trauma and specified in %. (Numbers from Scandinavian studies(1))

	Rotåpen	Lukket foramen
Kronefraktur	0	0
Rotfraktur	0	0
Konkusjon	0	0
Subluksasjon	0	0
Ekstrusjon	0	0
Lateral luksasjon	0	1
Intrusjon	13	32
Eksartikulasjon *(replantasjon)*	43	61

Table 4. Occurrence of replacement resorption related to type of trauma and specified in %. (Numbers from Scandinavian studies (1))

Concerning tooth 13*:* *Endodontic prognosis:* Good. Total: Good.

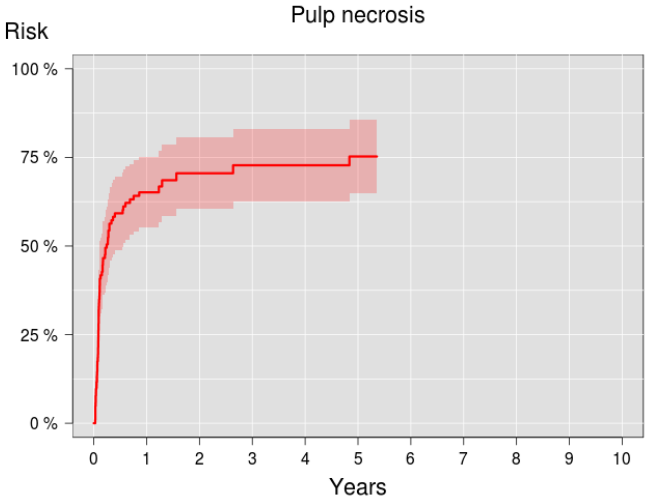

Figure 16. Data is based on 103 teeth with diagnosis lateral luxation in full root formation and no crown fracture. From (2)

Concerning tooth 21: Endodontic prognosis: Good. Total (long-term): Questionable.

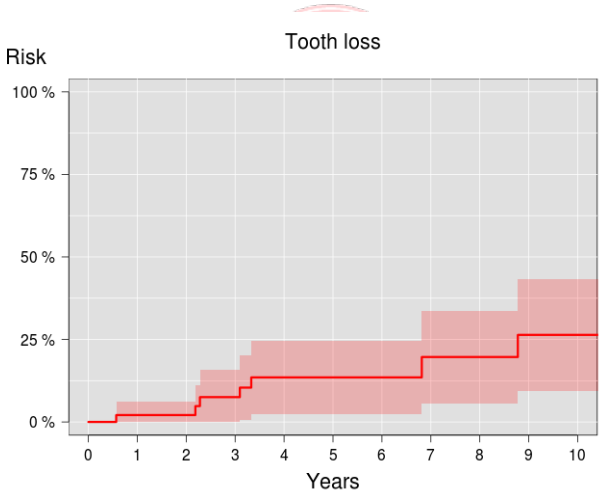

Figure 17.: Data is based on observation of 48 teeth with diagnosis exarticulation and replantation with fully formed roots with closed apices, dry time 0-4 min and wet time in physiologic media (saliva, Hank's balanced salt solution, saline, milk, culture medias) more than 5 min, as this patient. These teeth belong to 16 patients. The predicted risks of tooth loss are shown (from (2))

Prognostic aspects may depend on the length of root development at time of trauma. Tooth 21 was referred for treatment because of open apex. However, the trauma happened at a age where root development usually are completed. Possibility exist that resorption has taken place after replantation. The tooth is followed-up in terms of possible development of inflammatory and replacement root resorption. The short-term goal is to retain the tooth until the end of growth phase.

Follow-up

Figure 18. Frontal view, January 2012

The patient was asymptomatic, with normal mobility. Uncertainty exists whether the apical area has some degree of further resorption, no radiolucent zones or lacunae evident, but some rough and undefined lamina dura. Some doubt also existed about whether the percussion sound was normal or some degree of high-pitched, indicating ankylosis. The patient will be continued followed-up clinical and radiographical until resorption (inflammatory, infection-related resorption, or ankylosis-related replacement resorption) is confirmed or disproved. Implant treatment is planned in regio 11. He was more satisfied with his dental prosthesis and aesthetic appearance, which now was better adjusted by his pedodontist.

Fig.19-21. Radiographic follow-up 10 months

Discussion

The maxillary canine has no pulp horns but the smallest pointed incisal edge corresponds to the single cusp. A lingual shoulder is important to be aware of for optimal cleaning and shaping. The canal is of oval shape. According to Vertucci: one canal is present in 100%. Caliskan *et al*: one canal 98%, two canals: 2%. Average time of eruption: 10-12 years. Average age of calcification: 13-15 years. Average length: 26,5 mm. For description of the maxillary central incisior; se case 2.

Worldwide, 20–30% of 12-year-old children are experiencing dental trauma that may lead to damage of the developing dentition (3) . Boys experienced significantly more dental trauma to the permanent dentition than girls in most studies (4). The maxillary central incisors are found to be the most frequently affected teeth in both primary and permanent dentition (4). The patient in this case had a horizontal overjet significantly more than in normal occlusion. The risk of injury to anterior teeth tends to increase with increasing overjet and incomplete lip closure (4, 5). Bicycle accidents as a cause of the dental injury, as in this case, are reported in about 15% (4).For many years, there have been knowledge of the possibility of replanting an avulsed tooth. Much of the information about healing after replantation are from animal studies. Andreasen found that under ideal conditions, complete healing of the pulp and periodontium can

occur. This ideal conditions is not to be expected in real life situations in humans, and complications, as root resorption, are common (6). Extra-oral time and the way the tooth is stored in the mean time, are factors of most importance concerning prognosis. Appropriate storage media are Hanks balanced salt solution, milk, saliva or physiological saline.

Treatment of avulsed mature teeth with an extraoral dry time less than 60 min
Hold the tooth by its crown and irrigate the root surface with a gentle water spray
Remove the blood clot from the socket by irrigating with saline
Re-position any alveolar fractures
Replant the tooth slowly using light digital pressure
Verify that the tooth is positioned correctly, clinically and radiographically
Secure the tooth for 2 weeks with a flexible splint
Attend to gingival lacerations
Administer systemic antibiotics – doxycycline or penicillin
Refer patient to their physician to assess the need for a tetanus booster
Carry out root canal treatment at 7-10 days and prior to splint removal

Table 5, from (7)

An avulsed tooth is expected to have a necrotic pulp, especially if mature root development (1). The majority of non-vital pulps are infected (8), (9). Of importance is to disinfect the root canal system to promote periapical healing (10). The canal length is estimated with a parallel pre-operative radiograph with a file in place in the root canal, as well as use of an electrical apex locator (EAL). If immature root, light or no filing is performed with copious irrigation using sodium hypoclorite (NaOCl) to remove necrotic pulp tissue (11). Irrigation systems, as the EndoVac® (Discus Dental), and ultrasound, may be useful in the irrigation procedure (12). Calcium hydroxide $Ca(OH)_2$ (CH) is then used in purpose of establishing a bacteria-free environment and a mild inflammatory stimulus, initiating healing. Apexification using CH as an intra-canal dressing is widely used. There are however some drawbacks with this method. The treatment time frame can be unpredictable or at least prolonged, with possible loss of patient compliance. There may be a risk of bacterial contamination/ leakage through or loosing temporary filling. It is also shown to be an elevated risk of root fracture in teeth with long-term CH dressings (13).

If a tooth is not replanted in about 15 min, the PDL will most likely become necrotic, preventing its re-establishment. If the pulp tissue becomes infected and the root canal treatment is not initiated, infection-related external inflammatory resorption will destroy the tooth structure (7). When an injury damages Hertwig's root sheath or causes pulp necrosis, root development may be arrested. Teeth without mature root development and necrotic pulps and can be challenging for the treating dentist. One may expect problems with controlling the apical part of the root filling because of open apex and lack of barrier, managing the root canal infection without the standard root canal protocol. Thin and fragile root canal walls with risk of fracture may be present.

A size factor concerning PDL-damage exists; in animal experiments, defects less than 4mm^2 (fig. 22) showed either complete healing or a transient ankylosis site which was later resorbed and repair-related root resorption developed in these sites. In larger defects (i.e. exceeding 4 mm^2) (fig. 23), a permanent ankylosis site has been shown to be formed (14).

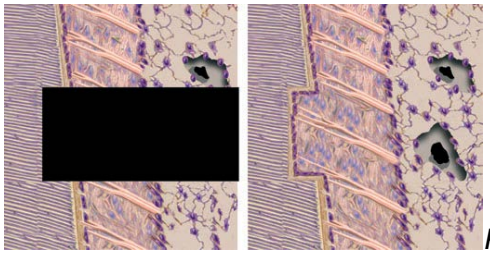

Fig. 22

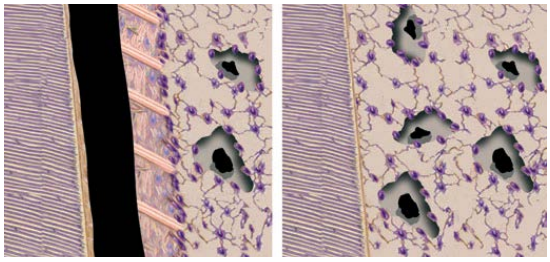

Figure 23 . Larger injury to the cemental part of the periodontal ligament has taken place. (b) A permanent ankylosis is formed (in contrast to fig. 22 where a small osteotomy plus removal of periodontal ligament (PDL) and cementum will give reformation of a functional PDL with new cementum

To reduce the likelyhood for resorption, the recommended guidelines for avulsion are to begin endodontic treatment 7-10 days after replantation (15). The tooth should be splinted for two weeks.

Factors aiding prognosis	Factors negatively affecting prognosis
Immediate replantation or less than 15 min extra-alveolar time	Prolonged extra-alveolar period (> 60 min)
The use of an appropriate storage medium during the extra-alveolar period	Dry storage or an inappropriate storage medium
Immature root formation	Failure to execute endodontic treatment at the appropriate time
Timely endodontic treatment 7-10 days after injury	

Table 6. Factors affecting prognosis of avulsed teeth(7)

Mineral trioxide aggregate (MTA) can be placed at the apex of teeth with open apices. Use of an artificial barrier as MTA, implies prompt obturation and restoration. When MTA has set, the remaining canal space may be back-filled with a termoplasticized filling material and reinforced with composite. MTA has been introduced as the material of choice for this technique. MTA is a root-end filling material introduced to endodontics by Torabinejad et al in 1993 (16). It has been shown to have an excellent sealing ability (17) and ability to promote osteoblast activity (17, 18). In a study in dogs, researchers showed that new cement was able to grow directly on the material, re-establishing cement and a PDL in contact with the intact PDL at lateral aspect on root surface (19). MTA is shown to have antibacterial properties (20). The constituents include calcium and silicate and a product of the setting reaction is calcium hydroxide. Hydration of the powder produces a colloidal gel that solidifies into hard structure of crystals embedded in an amorphous matrix. Initially MTA has a pH of 10,2, which rises to 12,5 after three hours (20). Cementum bridging is shown to form directly over the MTA (21). New research in this field reveals that regeneration processes are stimulated. MTA placed against dentin contributes to the triggering of adrenomedulline, TGFβ, glycosaminoglycanes and non-collagen protein, in addition to calcium and potassium. Components of MTA may recruit multipotency cells, capable of forming into hard-tissuedeveloping cells like odontoblasts, cementoblasts and osteoblasts(22). MTA may also affect inflammatory processes in infected pulp and surrounding tissues.

Generally, dental materials are subjected to leakage assessment and evaluation of marginal adaption as well as cytotoxicity and implantation tests. The in vitro cytotoxicity tests are inexpensive and give valuable information about which materials should be discarded or subjected to further testing. In addition to these test methods, many usage test studies of MTA have been performed in experimental animals. However, the observation periods often are short and may or may not represent clinical circumstances. Often statistical tests cannot be applied because of limited sample numbers. Concerning clinical studies of root-end filling materials, there are a lot of variables to assess. The number of cases, observation periods,

materials tested, different procedures and techniques used as well as the evaluation criteria are of significance (23). Most of these studies are retrospective, with some few exceptions (24, 25).

MTA ProRoot® (Dentsply Tulsa Dental, Tulsa, OK, USA) has gained popularity. Another commercial brand of white and grey MTA, is MTA Angelus® (Angelus Dental Solutions, Londrina, Parana, Brazil) has entered the market. This material claims to offer a faster setting time and improved handling characteristics. Apart from that the grey ProRoot® cement expands significant more than the white; the physical properties seems to be the same (22).

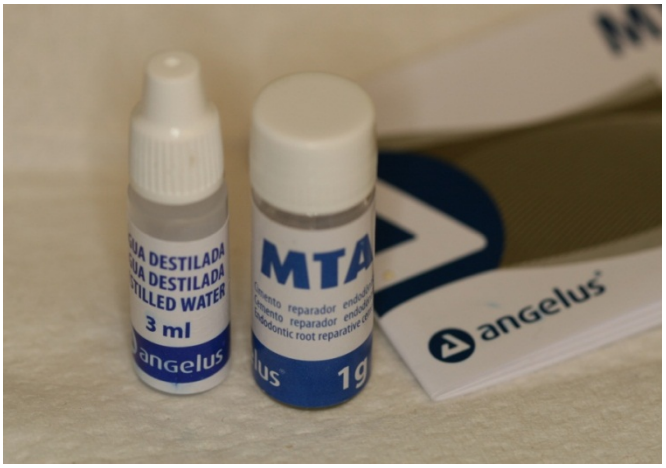

Fig. 24. Angelus MTA®

No difference in PAI outcome are found between the different brands of MTA. Apical barrier placement using both white MTA ProRoot® and white MTA Angelus® after an initial calcium hydroxide dressing showed similar favorable clinical and radiographic outcomes. There were no difference in PARL healing between the two different brands over time (average observation time 23 months, minimum observation period 18 moths. Both types of MTA showed excellent clinical outcomes. The combined success rates of both materials are found to be 95.5% (3).

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Case 6 – Endodontic treatment and retreatment of maxillary front teeth in dentition with attrition

Patient

43 year old white, Northern European male

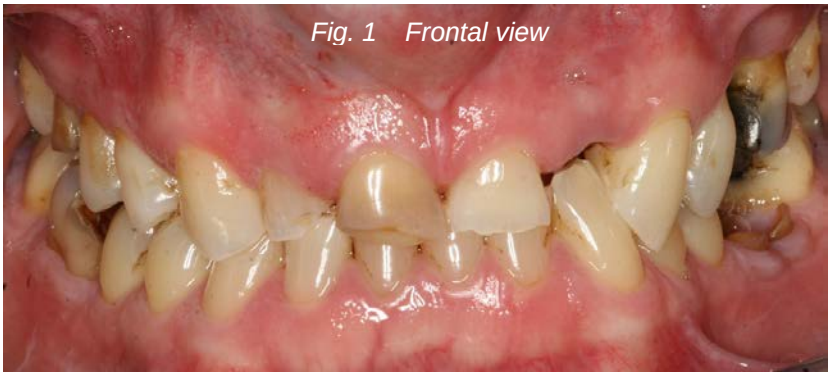


Fig. 1 Frontal view

Dental history & chief complaint

The patient had neglected his oral health for several years. He now felt discomfort at multiple sites in his dentition as well as a feeling of an unsatisfactory aesthetic appearance because of the fractured front tooth. Medical history non-contributory.

Clinical findings

Fig. 2 Occlusal view, maxilla

Fig. 3 Occlusal view, mandibula

Clinical findings, intraoral

	13	12	11	21	22
Cold	Yes	Yes	ND	Yes	No
Electrical test (0-80)	23	21	ND	31	ND
Percussion	No,	No	Yes, both horizontal and vertical	No	Yes horizontal
Palpation	No	No	No	No	Yes
Mobility	-	-	-	-	-
PPD (mm)	2	2	2	2	2
Restorations	-	-	Composite Previous endodontic treated	-	-

Table 1 Summary of clinical examination

Extraoral examination revealed normal conditions, including muscular conditions and palpation of lymph nodes, taken into concern multiple sites with potential infectious foci of dental origin in the jaws.

Radiographic findings 2010-10-24

Fig. 4 Courtesy of Clinical of clinical dentistry, Department of Maxillofacial Radiology 2010-10-24

Fig. 5, 6, 7 Radiographic status at time of examination 1st visit

13& 12: Tooth without previous treatment and intact lamina dura.

11: Tooth with radiopaque material in root canal and disrupted lamina dura in apical part of the root with a circular radiolucency of Ø12 mm.

21: Tooth without previous treatment and an intact or slightly widening of lamina dura apically

All teeth have radiolucent area confirmed to the coronal aspect consistent with lack of normal enamel thickness. The marginal bone level is normal.

Diagnosis

Pulpal

13: K04.a Healthy pulp

12: K04.a Healthy pulp

11: K04.19 Previous root-filled tooth

21: K04.a Healthy pulp

And K04.30 Tertiary or reactionary dentin

Apical

13: K04.b Healthy apical periodontium

12: K04.b Healthy apical periodontium

11: K.04.5 Chronic apical periodontitis

21: K04.b Healthy apical periodontium

Marginal

Physiological. Normal periodontal structure

Problem list

Concerning tooth 11: Previous treated tooth with open apex. Size of lesion and possible more resistent microflora due to prolonged contamination/leakage of restoration -may contribute negatively concerning the prognosis.

Treatment plan

Endodontic treatment of teeth prior to prosthodontic treatment, interdisciplinary collaboration. Vital orthograde treatment of teeth 13, 12, 21. Conservative re-treatment of tooth 11.

Treatment

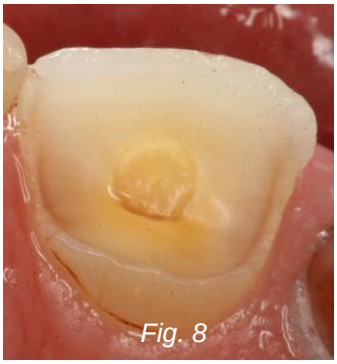


Fig. 8

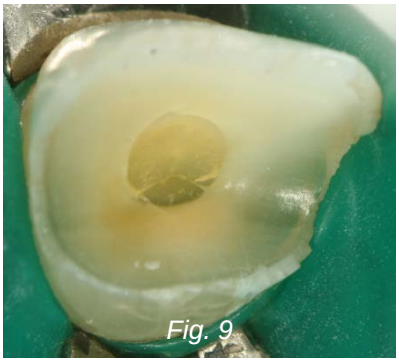


Fig. 9

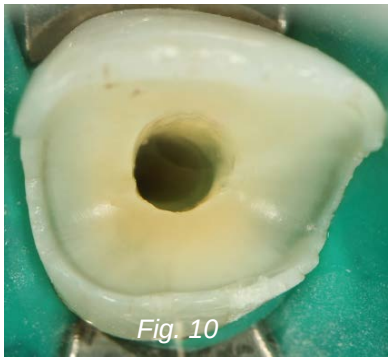


Fig. 10

2011-01-06: Rubber dam applied tooth 21. Aseptic regimen/ disinfection with solution of 0,5% chlorhexidine in 70% ethanol. Standard treatment of vital tooth. WL determined by apex locator Root ZX® (Morita Inc., Japan) and WL- radiograph. Instrumentation with NiTi hand files and BioRace rotary system. Irrigation with 1% NaOCl, 17% EDTA. Drying with paper points, master cone X-ray #60/ 18,5 mm, filling with gutta-percha and sealer AHplus, IRM as a plug and temporary coronal restoration.

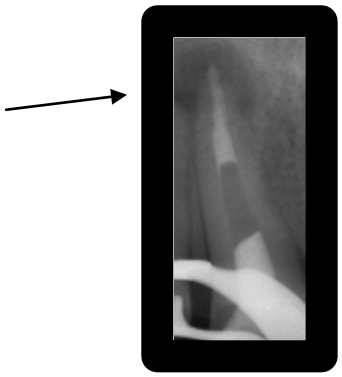

Fig 11 Close-up occlusal aspect


Fig. 12 Close up frontal aspect


Fig, 13 after chemomechanical instrumentation

2011-01-20: Removal of leaky composite filling tooth 11 and applying of rubber dam. After disinfection of tooth and operation field, gutta-percha removal was performed with LN-burs, PreRace NiTi rotary instruments, H-file and chloroform. Irrigation continuously with 1% NaOCl and 17% EDTA. 2% CHX was applied in the canal for 5 min with passive ultrasonic activation. Drying with paper points. Ca(OH)2 in the canal with a lentulo spiral. IRM plug

Fig. 14 MTA apical barrier as apical plug. In this case, ProRoot® was used, with a long setting time opposite to MTA Angelus, used in case 5. Therefore, a cotton pellet with sterile saline was applied over the mineral trioxide aggregate plug, with an IRM® seal until next appointment of varm, vertical technique coronal of the MTA material



2011-02-16: Rubber dam applied tooth 22. Aseptic regimen. One session treatment as tooth 21.

Rubber dam applied on tooth 11. Aseptic regimen. Removal of saline pellet, drying canal. Applying a thin layer of sealer AHplus to the wall of the canal. Varm, vertical compaction of gutta-percha with Sybron Endo Elements of Obturation® Unit and Buchanan hand pluggers. Cleaning and drying, IRM restoration.

2011-03-01: Rubber dam w/aseptical regimen. Vital treatment of tooth 13, as described of tooth 21. Epicrisis including treatment details was sent to the referral Department. The patient was informed about the planned appointment at Department of Endodontic next year to do follow-up of healing pattern of tooth 11.

Radiographs of all the teeth during treatment are shown below.

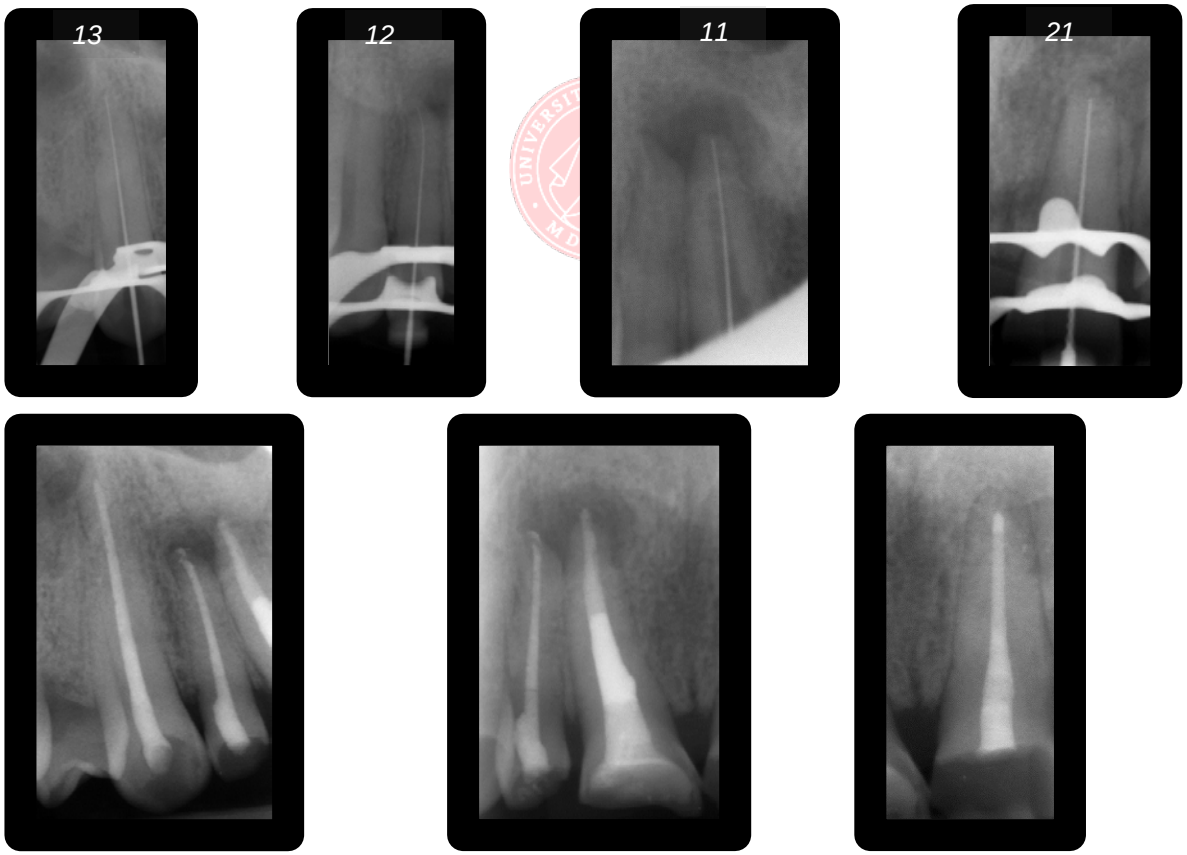


Fig. 15-21 During treatment (upper) and post treatment (lower)

Evaluation & prognosis. The endodontic treatment provided was performed under optimal conditions. One may therefore expect to have established a satisfactory, tight seal and prevent infection in teeth 21, 12 and 13, as well as cure the AP in tooth 11. With the prevention of periapical fluids from tracking into the canal to possible remaining bacteria, which also is assumed entombed, and that the patient is provided with optimal restorations coronally, the endodontic and general prognosis can said to be favourable.

Fig. 22 Before treament Oct 2010

Fig. 23 After treatment Jan 2011

One year follow-up examination March 2012

Fig. 24 Frontal view one year after treatment

Fig. 25 Occlusal view one year post tx

The patient had been treated with crown and bridge restorations at the post graduate clinic, Department of Prosthetics, UiO. He had an adequate level or oral hygiene and was free of symptoms. The periradicular radiolucency showed sign of healing with decreasing and fading of the previous larger and more circumscribed radiolucent zone apically, but the patient will be further recalled in a year to monitor the healing progress further.

Fig. 26, 27, 28 Radiographical examination at the one-year follow-up

Discussion

The maxillary lateral incisor may have two or no pulp horns present. The tooth is wider mesio-distally than bucco-lingually. The pulp chamber is centered in the root, and its shape may be triangular, oval or as in this case; round (fig 8-10). The lingual shoulder of dentin must be removed before instruments can explore the canal. According to Vertucci; one canal is present in 100%. Caliskan *et al*: One canal: 95%, Two canals: 5%. Average time of eruption: 8-9 years. Average age of calcification: 11 years. Average length: 22mm. For description of the maxillary canine and central incisor, see previous cases.

Dentin is not a barrier that completely prevents the pulp from the invasion of external noxious substances as bacteria and their by-products(1). This is due to its tubular structure, through which irritants may diffuse and affect the pulp. Studies from the 1970s showed that Class V cavity preparations in monkey teeth had pulpal neutrophil infiltration in the area below the cut dentin when bacterial products were sealed within the cavities. Little or no inflammation was evident in the area of the pulp below the cut dentin when bacterial products were not applied (2, 3). Different kinds of dentin (figure 1) do have different structure which may inflict on the properties.

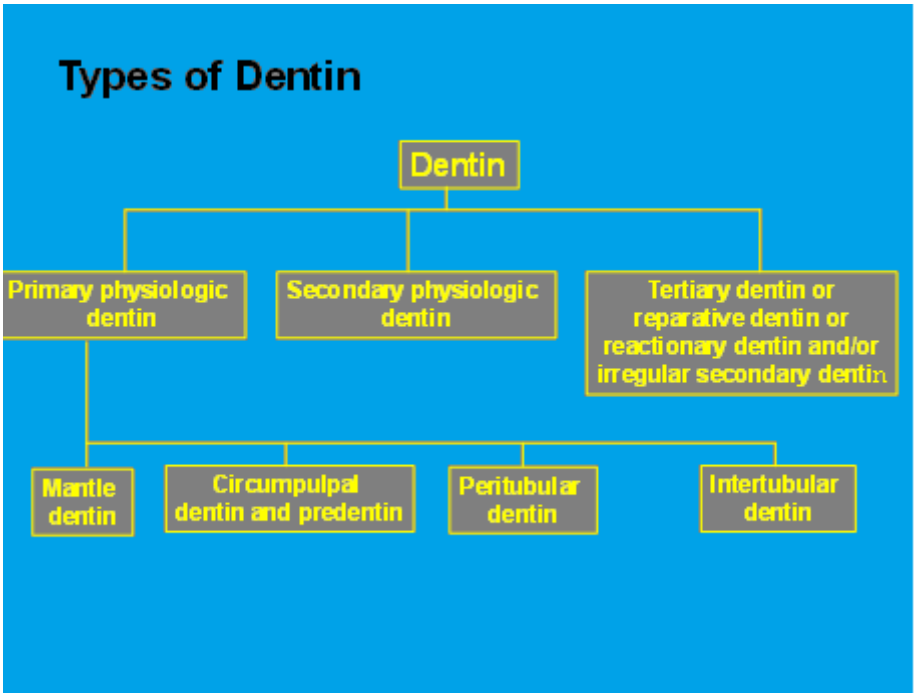


Figure 29 from (4)

Primary dentin is the regular tubular dentin formed prior to completion of the apical part of the tooth, secondary dentin is the regular circumpulpal orthodentin formed at a slower rate throughout life, and in tubular continuity with the primary dentin. Tertiary dentin represents the more or less irregular dentin, formed focally in response to stimuli.

Dentin is penetrated by millions of tubules with density from 15,000 at the dentinoenamel junction (DEJ) to 70,000 tubules per mm^2. Tubules are from 1 µm t 3 µm at the pulpal surface (1). The area occupied by dentin tubules is 1% at the DEJ, increasing to 45% at the pulp chamber . From an anatomical perspective, possible pulpal damage increases exponentially the deeper the toxins reach into the dentin. If the fluid of the dental tubules become contaminated with carious bacterial endotoxins and exotoxins, it may be a reservoir of injurious agents that can initiate pulpal inflammation (2).

Normally, there are distinguished microscopic zones in the pulp. The odontoblastic layer lines the outher pulpal wall and consists of the cell bodies of the odontoblasts. Secondary dentin may form in this area from the apposition of odontoblast. The odontoblasts form a single layer with cell bodies in the pulp and long cytoplasmic processes extending into the dentinal tubules. The cells are tall, columnar in the coronal pulp

and short, columnar in the midportion of the tooth and cuboidal to flat in the root portion. Nerve fibers, which are terminal axons from the plexus of Rashkow, pass between the odontoblasts as free nerve endings. The layer also is populated by Class II major histocompatibility complex (MHC) molecules expressing dendritic cells, detecting transdentinal antigenic stimuli (1). Collagen fibrils, proteoglycans, fibronectin and Korff fibers are identified between odontoblasts. The cell free zone of Weil has fewer cells than the odontoblastic layer. Nerve and capillary plexus are located here, a rich network of mostly unmyelinated nerve fibers. The cell rich zone of Höhl has increased density of cells compared to the cell-free zone, and also more extensive vascular system. The constitutents of this zone are like those of pulp proper; fibroblasts, undifferentiated mesenchymal cells, macrophages, lymphocytes, blood capillaries and nerves. The pulpal core is located in the center of the pulp chamber, with many cells and extensive vascular supply in the loose connective tissue. Larger vessels and nerves are present. Bundles of collagen fibers can be seen, especially in the apical part. The major constituent of the connective tissue of the pulp core is extracellular matrix, with proteins (collagen, elastin) and ground substance, proteoglycan. The fibroblasts are the principal cells in the connective tissue, but also to be seen are blood-derived defence cells as macrophages, undifferentiated mesenchymal cells, dendrittic cells and immunocompetent cells like lymphocytes for specifically recognizing antigens. B-cells -> plasmacells with importance in humoral immunity. T-lymphocytes, residents of the pulp, subdivided to helper ($CD4^+$) and cytotoxic ($CD8^+$). Activation via Class I and Class II MHC -> production of cytokines. If secreting IL-2; Th1-cells. If secreting IL-4, IL-5 and IL-6 as well as stimulation of B-cells; Th2 cells.

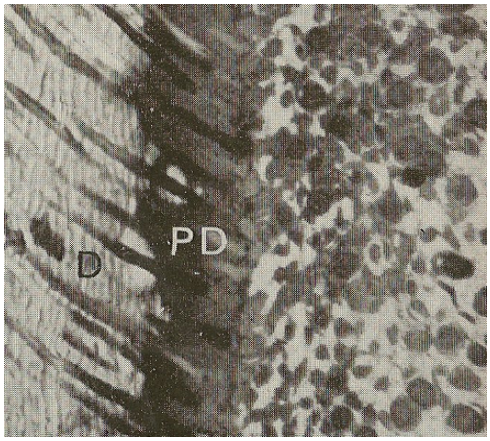


Fig. 30. Photomicrograph of undecalcified, toluidine blue stained section showing aspirated odontoblast nuclei in the predentine (PD) and dentine (D). X 640. From (5)

In connection with the caries process and procedures as cavity preparation and filling, alterations in the well organized cell zones may be present in the pulp and dentine(6, 7). Primary odontoblasts may be damaged or reversible or irreversible. Cavity preparation and/or desiccation of exposed dentin may cause a particular type of irreversible injury to odontoblasts, termed odontoblast aspiration (fig 30). In this reaction, the cell bodies of odontoblasts are sucked into the dentinal tubules, by rapid outward movement of fluid in the tubules. This will result in autolysis of odontoblasts. New, recruited secondary odontoblasts will produce tertiary dentin in response to the injury.

Although bacterial invasion is prevented in vital teeth, their products may dissolve in dentinal fluid and reach the pulp long before the bacterial cells themselves. As for dentin permeability (primary and secondary), toxic material does not irritate the pulp if dentin is at least 3 mm thick. (8)and even at 1,1 mm, the inflammatory response are shown to be negligible. Within 0,5 mm of the pulp, the extent of inflammation increased significantly(9). Tertiary dentin may be more unpredictable in morphology with cellular inclusions and poor quality reparative dentin structure (fig 32). Knowledge of the morphology of dentine and its permeability during the progression of wear is important for understanding dentine reaction under clinical conditions.

Senawongse *et al* found that the attrition resulted in various changes in dentine. Transparent dentine was typically observed in the worn teeth.

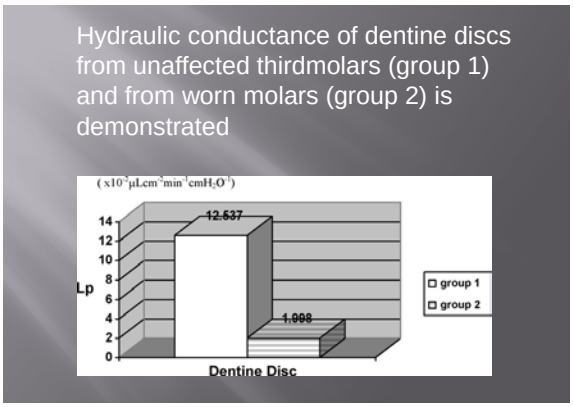


Fig. 31 Changes in dentine properties of worn and unaffected molars

The physiologic secondary dentine of worn teeth had a structure similar to that of unaffected teeth. Reactionary tertiary dentine was only observed in worn teeth. Two types of reactionary dentine were observed; tubular and atubular. The hydraulic conductance of dentine discs from worn molars was significantly ($p < 0.001$) less than that of unaffected third molars (10). The hydraulic conductance of transparent dentine from worn teeth was comparable to that of caries-affected dentine from a previous study.

In response to external stimuli and irritation caused by dental caries, cavity prepraration, erosion, abrasion or in this case, attrition; tertiary dentin (reactionary or reparative / irregular secondary dentin) is synthesized (11). If the injury is severe and causes odontoblast cell death, odontoblast-like cells synthesize reparative dentin the beneath the injury site to protect the pulp. Different from physiological dentin, the morphology of the reparative dentin varies a lot, and is often seen irregular and with cellular inclusions.

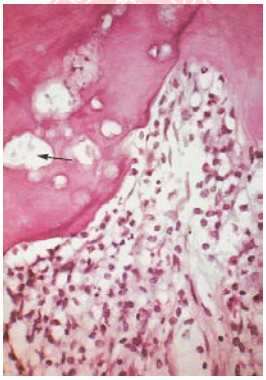


Figure 32. Poor quality reparative dentin with soft tissue (arrow) entrapped within dentin matrix. From (1)

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Case 7 - Endodontic-periodontal lesion. Alternative choice of obturation material

Patient

71-year-old, white, Norwegian male.

Fig.1. Frontal view

Chief complaint

Some diffuse discomfort related to the mandibular, left second molar.

Medical and dental history

Medical history non-contributory. The patient had quit smoking. The patient was referred by his dental undergraduate student because a detection of apical radiolucency on routine radiographical examination.

Clinical examination

Fig.2. Occlusal view, maxilla

Fig.3. Occusal view, mandibula

The tooth 37 had a composite restauration and decay on the root surface. Tooth 35 and 36 was extracted several years ago for reasons unknown. Tooth 34 had a amalgam filling, and later metal-ceramic crown.

Extraoral: Normal skin. Slightly enlarged submandibular lymph nodes bilaterally, the patient had gone through an infection with general illness one week ago. *Intraoral:* Normal mucosa. Mandibular left second molar: Neighboring teeth was extracted. A sinus tract was localized bucco-laterally, about 10 mm from the tooth 37. Periodontal: A general bone loss was present, furcation involvement class I.

	35	36	37
EPT	Positive	Extracted	Negative
Termal	Positive		Negative
Palpation	Negative		Negative
Percussion test	Negative		Horizontal/ vertical
Periodontal probing depth	4 mm		6 mm
Mobility			II

2008

Table 1. Summary of clinical findings

Fig. 4 showing antagonist

Fig. 5 tracing sinus tract

Fig. 6 showing gp occlusally

Radiographical examination

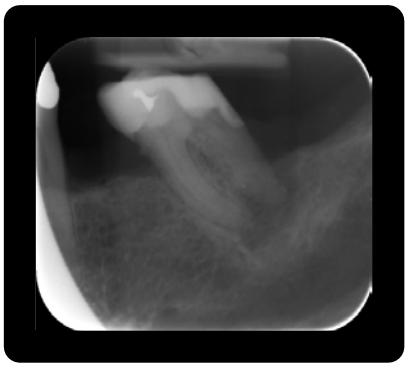

Fig. 7. Pre-treatment radiograph

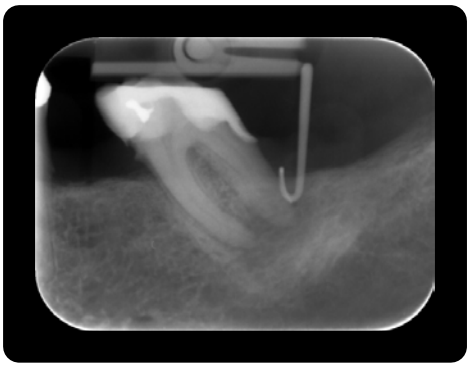

Fig. 8. Fistulogram

Radiographical examination showed radiolucent material consistent with composite restoration MOD coronally as well as on root surface with signs of secondary decay on root surface. Lamina dura can be followed at mesial aspect , widening in diffuse radiolucency periapical of both roots in about Ø 14 mm.

Diagnosis

Pulpal diagnosis: K04.11 Infected, necrotic pulp

Periapical diagnosis: K04.62 Apical periodontitis with a sinus tract to the oral cavity.

Periodontal diagnosis: K05.3 Chronic marginal periodontitis

Problem list

Reduced marginal bone level. The patient had started periodontal treatment before endodontic treatment procedure initiated.

Treatment plan

Conservative endodontic treatment of the necrotic mandibular left second molar.

Treatment

October 1st, 2008: The patient was before treatment informed about the questionable prognostic elements. An agreement was made to perform treatment. The patient had a wish for treatment without LA. Access. Caries excavation was done followed by composite restoration for securing clamp and rubberdam. Cavity preparation and three canals were found. Rubber dam was applied and disinfected. A WL radiograph was taken with aid of apex locator ProPex® (Dentsply International). Chemomechanical treatment with ProTaper® rotary and NiTi handfiles. ML: 20,5 mm/ # 45. MB: 20,0 mm/ # 45. D: 20,5mm/ # 55. Irrigation solutions: 1% NaOCl, 17% EDTA. Ultrasonic irrigation with Irrisafe for further cleaning of the canal. $Ca(OH)_2$ interappointment dressing, IRM top filling.

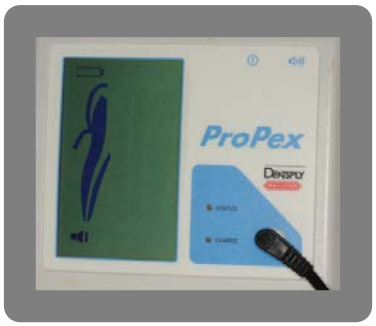

Fig.9 ProPex apexlocator

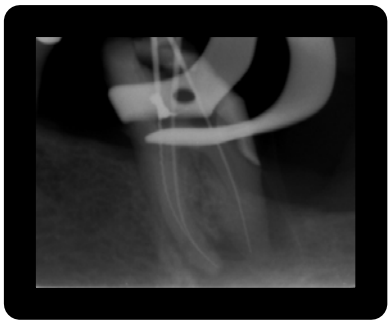

Fig.10 WL radiograph

October, 27th 2008: The tooth was asymptomatic and the sinus tract closed. Rubber dam applied, aseptical regimen. The tooth was filled with Epiphany® and Resilon®. IRM plugs, composite coronal until treatment with porcelain fused-to metal crown.

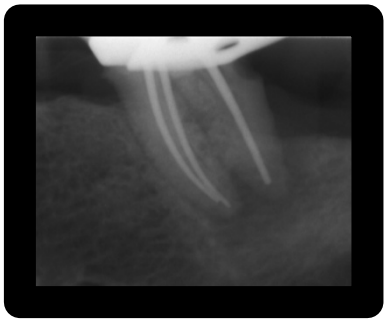

Fig. 11 Master cone radiograph

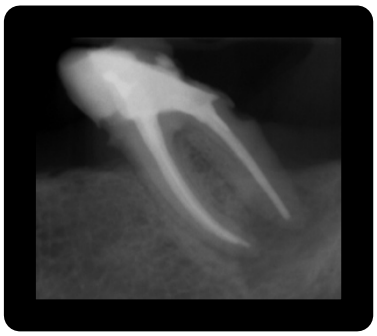

Fig. 12 Final radiograph

Evaluation

The obturation seemed dense and good, attempts to eliminate coronal leakage was performed. A coronal seal with a crown was recommended. The patient was informed about the causal relationships between smoking, bacterial plaque and progression of marginal periodontitis.

Fig. 13 Before:

Fig. 14 After

Prognosis

Endodontic: Good prognosis is to be expected because the root canal system were adequately disinfected and sealed.

Total: Uncertain, depending on the coronal restoration and possible progression of periodontal disease. The patient had quit smoking a few years ago.

Follow-up examination 2012-03-12

Fig 15. Frontal view on follow-up examination

Fig. 16 Occlusal aspect

Fig. 17. X-ray 3 years post-treatment

The patient met for follow-up examination 3 years after treatment. The mucosa where the sinus tract earlier was located, now could be diagnosed healthy (fig. 6 vs 16). No obvious pathology was evident on the radiograph, lamina dura could be followed around the mesial roots and at the apical level of the distal root with some degree of uncertainty concerning the distal root. Taken into concern the normal clinical picture with healthy soft tissue without sinus tract, no percussion or palpation tenderness and no subjective discomfort, the treatment was judged to be successful. The patient had kept the composite restoration, which was made with intension to be a temporary solution. The patient was reminded of the importance of a proper coronal seal, with the recommendation of a crown instead of the composite restoration present at the time.

The marginal bone level presented unaltered, but standardized radiographical technique with impression material on the film-holder was not used. Eggen film-holder with orthoradial exposure was performed post-treatment and at follow-up. The endodontic treatment seemed to have stabilized the marginal periodontitis situation. The patient mentioned that it was a long time since last periodontal treatment with depuration/ scaling. He was aware of the importance of optimal oral hygiene for preventing further marginal breakdown and presented with an excellent hygiene, but bleeding on probing due to subgingival calculus. The patient used the opportunity, when at the University Clinic, to schedule an appointment at the student clinic for general examination and professional plaque and calculus removal.

Discussion

For description of the morphology of the mandibular second molar, se case 3.The pulp and periodontal ligament (PDL) are close integrated in the dental papilla all from the beginning in the embryogenesis, and the soft tissue of the pulp has direct connection with the PDL through the apical foramen. The main routes

for exchange of microorganisms between the pulp and PDL are created by dentinal tubules, lateral and accessory canals, and/or the apical foramen. Exposed dentinal tubules with lack of cementum may serve as communication pathways between the pulp and the PDL. Exposure of dentinal tubules may be due to developmental defects, crack/infractions, disease processes, periodontal or surgical procedures. Lateral and accessory canals can be present anywhere along the root, and it is known that the majority of them are found in the apical third. Pulpal pathology may cause inflammatory reaction in the interradicular periodontal tissues and the presence of patent accessory canals is a potential pathway for the spread of microorganisms and their toxic byproducts from the pulp to the PDL and vice versa, resulting in an inflammatory process in the involved tissues. Bacterial byproducts and inflammatory mediators in a diseased pulp may exit through the apical foramen to cause periapical pathosis. The apical area may also serve as an entry point of inflammatory elements from deep periodontal pockets to the pulp (1).

There have been different opinions concerning if periodontal disease has effect on the pulp before it involves the apex or not. Mazur & Massler in 1964 found in histological studies no correlation between the pulp status and the severity of periodontal disease(2). It seems that a healthy pulp is usually not severely affected by periodontal disease until the periodontal tissue breakdown has opened an accessory canal to the oral environment (1). Langeland *et al* found that pulpal necrosis occurred only when all the main apical foramina involved (3). Seltzer reported disease caused by microorganisms through lateral/accessory canals and vice versa.

Concerning microbiology, problems exist in sampling and in cultivation of periodonto-pathogenic bacteria. Rupf *et al*.(4) studied the profiles of periodontal pathogens in pulpal and periodontal diseases associated with the same tooth. *Aggregatibacter actinomycetemcomitans, Tannerella forsythia , Eikenella corrodens, Fusobacterium nucleatum, Porphyromonas gingivalis, Prevotella intermedia*, and *Treponema denticola* were found in all endodontic samples. The same pathogens were found in teeth with chronic apical periodontitis and chronic adult periodontitis. It therefore appears that periodontal pathogens accompany endodontic infections and that endodontic–periodontal interrelationships are a critical pathway for both diseases.

The periodontal pocket and subgingival plaque have been extensively studied for many years; from the research by Waerhaug from the 50's and up to Paster *et al* which studied the diversity and nature of subgingival plaque with the new possibilities of the PCR-based technique. Many of the species or phylotypes that his researchers found, was found only in subjects with disease. In 1998, the researchers at Forsythe Institute by Sigmund Socransky *et al*, found that *Porphyromonas gingivalis, Tannerella forsythia* and *Treponema denticola* had the highest association with the severity of periodontal disease, as measured by pocket depth and bleeding on probing. They named the microbial consortium "the red complex" (RC). Studies concerning periodontal treatment have shown the importance of decreasing levels of the species in the red complex and other so-called complexes; the tooth proximity biofilm named "green/yellow complex", interspacial biofilm – "the orange complex" and the epithelial invasive biofilm "the red complex" (Table 2). His research has shown the more advanced the periodontal disease is, the greater percentage of red complex is present.

Red complex	*P. gingivalis* *T. denticola* *T. forsythensis*
Orange complex	*C. gracilis* *C. rectus* *C. showae* *E. nodatum* *F. nuc. nucleatum* *F. nuc. polymorphum* *P. intermedia* *P. micros* *P. nigrescens* *S. constellatus*
Yellow complex	*S. gordonii* *S. intermedius* *S. mitis* *S. oralis* *S. sanguis* *Streptococcus. sp.*
Green complex	*A. actino. a* *C. gingivalis* *C. sputigena* *C. ochracea* *C. concisus* *E. corrodens*
Blue complex	*Actinomyces species*
Purple complex	*A. odontolyticus* *V. parvula*

Table 2. Different complexes of periodontal pathogens

Cultural studies have demonstrated that most of the putative periopathogens have not commonly been isolated from endodontic infections. However, Rôchas *et al* in 2001 used the same method of analyzing as Socransky *et al*, and their results suggested that the RC also could participate in the pathogenesis of periradicular diseases. The lack of detecting the species in earlier studies, could have been the lack of cultivable microorganisms and therefore a previous underestimation (5). Kipioti & Kobayashi also found similar microorganisms in periodontal pockets and root canals. RC bacteria were associated with pain and higher frequency of intracanal/ intrasulcular pus drainage. Involvement of RC bacteria in symptomatic periapical disease should be suspected in the presence of particularly severe clinical pain and pus drainage.

An important aspect of endodontic-periodontal lesions is the timing of the different treatments; endodontic treatment should be initiated first so that the cementum and cells of PDL remain intact, a prerequisite for healing. It is known that removal of PDL and underlying cementum during periodontal therapy adversely affects healing, root planning/ subgingival scaling should be awaited for a period of time. Dunlap performed an in vitro study, and extrapolation the data to a clinical situation indicated that normal healing may be expected after periodontal surgery on tissues adjacent to root planed endodontically-treated teeth (6).

We can imagine a lot of different scenarios concerning endodontic and periodontal lesions, overlapping each other and to be present at different times. Criteria for the assessment of healthy conditions are not discussed here. In lesions with primary endodontic etiology, there are drainage from the gingival sulcus and/or swelling in the buccal attached gingiva. A sinus tract may pass through PDL area, producing a radiolucent zone along the entire root length. It can be treated by endodontic procedures alone. What happens with primary endodontic and secondary periodontal lesion after a period of time, is that the primary endodontic lesion (if untreated), may become secondarily involved with periodontal breakdown. This will requires both endodontic and periodontal treatment. Prognosis depends on the periodontal aspect (assumed the endodontic treatment is optimal). If only endodontic treatment was undertaken, no more than a part of the lesion may heal. With primary periodontal lesions, the pulp is likely to be vital, and the prognosis is depending entirely on the periodontal treatment. If primary periodontal lesion and secondary endodontic; the periodontal lesion progresses from the marginal area toward apex, thereby exposing lateral or accessory canals, which can lead to necrosis of pulp, as mentioned. Prognosis depends on periodontal treatment *after* the endodontic treatment has been done. Both endodontic and periodontal therapy must here be performed.

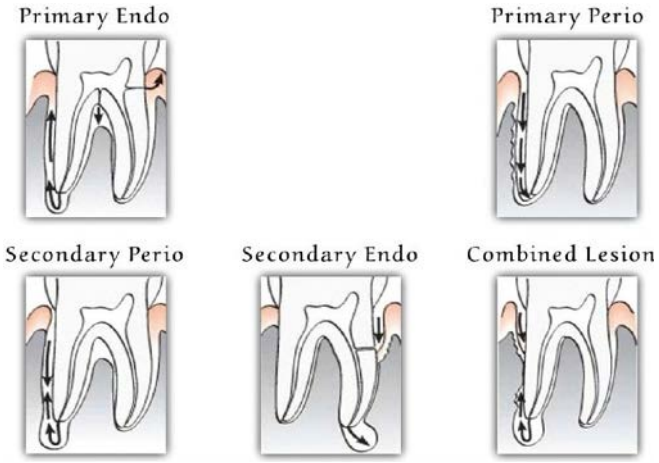

Fig. 18 Diagrammatic representation of possible endo perio problems based on the classification of Simon et al 1972 (7)

It is found that endodontic infection in mandibular molars is associated with an additional attachment loss in the furcation area. This may be considered to be one of the risk factors influencing the prognosis of molars in patients with marginal periodontitis (8).

Differential diagnosis is may be demanding when a sinus tract originating from the endodontic lesion drain along the PDL, giving the appearance of periodontal breakdown. It is also important to be aware of that the radiographical appearance of an endo-perio lesion may mimic a VRF.

One of the important factors of success of endodontic treatment, depends on completely filling the root canal system (9). The goal is to fill the entire space using materials that have ideal physio-chemical and biological properties. The bond strength of endodontic sealer to dentine is important for maintaining the integrity of the root canal seal. Ørstavik *et al*. suggested that a direct relationship can be found between the endodontic sealer bond and leakage. Gutta-percha has been used as the solid material in endodontics in association with different types of sealers. However, gaps may be present between the sealer and the root canal dentin and give failure of endodontic therapy (10). In 2004, the core material Resilon® was introduced, in conjunction with an adhesive system, Epiphany® (Pentron Clinical Technologies, LLC, Wallington, CT, USA). Resilon® is a synthetic, thermoplastic radiopaque polymer, with cones that follow the same ISO sizing as gutta-percha. It contains methacrylate resin, bioactive glass, barium sulphate and bismuth oxychloride. The accompanying sealant Epiphany/RealSeal is a dual-curable resin based composite (RBC) sealer. The matrix is a mixture of Bisphenol A epoxy (Bis-GMA), urethane dimethacrylate (UDMA) and hydrophilic dysfunctional methacrylates, while the filler consists of calcium hydroxide, barium sulphate, barium glass and silica. According to the manufacturer, this system is capable of forming a single and compact block of filling, without gaps. The idea of this concept, was to bond these together as well as the intraradicular dentin. Studies have shown less leakage with Resilon compared to gutta-percha(11), it has been shown to have a higher in vitro resistance to fracture (12) and easier to remove if re-treatment is necessary (13). Concerns have however been raised about the strengthening effect of the Resilon/Epiphany system as the modulus of elasticity between dentine and Resilon differs which could lead to breakdown of the adhesive bond. While most studies have found the leakage to be less than gutta-percha, some studies have found no difference, or more leakage. Different findings are also shown concerning biocompatibility. Most studies are in vitro, with clinical relevance to be questioned,- long-term evaluations and clinical studies should be performed. It is assumed that in the future, randomized clinical outcome studies comparing gutta-percha to Resilon will be published. When the results of these outcome studies, perhaps through large multi-centered trials, are available, we will be able to tell if they will show Resilon as an evidence-based alternative or replacement for gutta-percha.

Periodontically compromised teeth are shown to be at risk of be extracted short time after endodontic treatment(14). However, the in the treatment planning phase, the patient was informed of prognostic aspects and he had a wish for attempting treatment. The tooth was shown to be retained three years after treatment and presents with a healed situation. The patient carries out an optimal hygiene regimen and was therefore advised to have a crown as coronal restoration, supported by the literature, as endodontically treated teeth not crowned after obturation were lost at a 6.0 times greater rate than teeth crowned after obturation (15). This finding has been confirmed by others (16).

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UNIVERSITAS OSLOENSIS MDCCCXI

Case 8 - Retreatment of obliterated tooth with removal of post and crown

Patient

84 year old Northern European female

Fig.1. Frontal view

Medical history

Healthy, no medications or allergies. ASA group II (age).

Dental history & chief complaint

Conservative treatment at GDP and student clinic, Institute of Clinical Dentistry, UiO. The patient had always taken good care of her dentition and was earlier a regular attendant at dentist for annual examination and maintenance, but for some years now, she had not sought dental treatment. She then contacted the Student clinic, Dental Faculty, UiO, for screening and treatment. The patient had a desire to keep as much teeth as possible. The tooth 25 was referred to the Endodontic Department, postgraduate clinic, by the dental student. The tooth was endodontic treated 15-20 years ago, according to the patient. Tooth 26 was extracted short time ago. The patient had no complaints.

Clinical findings 1st appointment 2011-05-04

	23	24	25	27
EPT (0-80)	34	-	-	33
Cold	Yes	Yes	No	Yes
Palpation	No	No	No	No
Percussion	No	No	No	No
Pocket depth	2 mm	2 mm	2 mm	2mm
Restoration	Composite	Crown	Post & crown with secondary caries	Comp & am fillings
Intraoral exam	WNL	WNL	WNL	WNL
Extraoral exam	WNL	WNL	WNL	WNL

Table 1. Clinical examination form

Radiographic findings

Figure 2. Metal crown with post and radiolucent area; caries underneath crown margin. No root canal obturation material can be seen.

The periapical radiograph shows the region from maxillary left first premolar to second molar.

Maxillary left first premolar: Has a radiopacity at the coronal aspect, consistent with a crown restoration. Lamina dura can be followed around the tooth without any disruption.

Maxillary left second premolar: Has a radiopaque crown and post restoratiton. A radiolucent area; carious lesion, is seen at the distal aspect below the crown margin. A droplet-shaped radiolucency can be seen at the apex, with a periodontal ligament tapering into the normal areas at the lateral aspects of the root and the lamina dura absent. When this is associated with findings confirming a necrotic pulp, it is pathognomonic the diagnosis (1), se below. Sclerotic obliteration visible in the root, no root filling material.

Maxillary first molar: Radiopacity of approximately 7x8 mm is seen in the jaw bone, consistent with a root fragment persisting after extraction procedure.

Maxillary second molar: Radiopaque filling materials at MOD consistent with composite-like materials and amalgam occlusally. Normal lamina dura.

Diagnosis

Pulpal: Infected, necrotic pulp K04.11. Possible previous attempted root canal filled tooth K04.19

Periapical: Chronic apical periodontitis K04.50

Periodontal: Within normal limits

Problem list

- ✓ Removal of post with possibility of weakening, root structure
- ✓ Obliteration of pulp space may bring difficulty in disinfection and obturating orthograde

Treatment options

Root canal re-treatment, surgical endodontics or extraction.

Considerations: The periapical lesion can certainly be defined as being a non-healing situation. Retention was the patient's preference. She had newly extracted tooth 26 and did not want another extraction. Her teeth had always been important to her. Since the crown had secondary caries, a new crown had to be made and the existing crown to be removed anyway. Radiographically, obturation material in the root canal space is absent. Orthograde treatment was the first choice of treatment in this case. The disadvantage would be the risks concerning post-removal before endodontic re-treatment and increasing of the treatment

time compared to endodontic surgery. I chose to call the treatment re-treatment, since a foreign object is present in the root canal, even though there may not be root canal obturation material present.

Treatment plan

Maxillary, left second premolar: Removal of crown. Removal of post. Orthograde re-treatment.

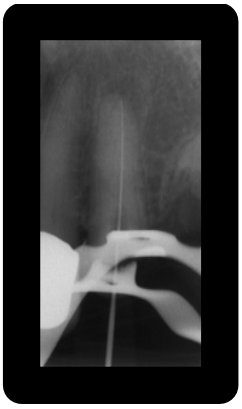
The patient was informed about treatment and prognosis including obliterated root canals and aspects of post removal procedures.

Treatment, 2nd appointment 2011-05-19

Anaesthesia 1,8 ml Carbocain “Dentsply” (mepivacaine). Removal of crown with hard metal fissure bur. Removal of post with LN-burs and Satelec ultrasonic device.

Fig. 3 Ultrasonic device used to remove post

Rubber dam applied, disinfection with solution of 0,5% chlorhexidine in 70% ethanol. Localizing two narrow, separate canals in the SOM, heavily obliterated pulp space. Chemomechanical instrumentation with 17% EDTA, 1 % NaOCl, 2% CHX, Irrisafe®, NiTi files and ProTaper® (Dentsply-Maillefer, Ballaigues, Switzerland) rotary system (fig.6). Thorough irrigation with EDTA and drying with paper points before applying the CHX was done in order to avoid formation of a precipitate.



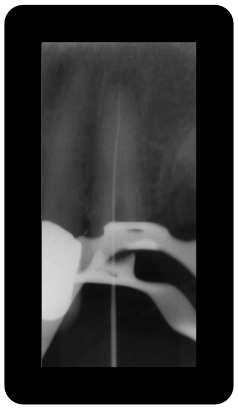


Fig 4, 5. Working length radiographs

Fig. 6. ProTaper rotary NiTi files

A glide path was created with K-file ISO #06 and #08. Hand instruments ISO 0.02 tapered sizes #10 and #15 K-files used with the Endolift (Kerr, Karlsruhe, Germany) working in alternating quadrant movements. ProFinders/scouting files were not available at the Department at the time of treatment. The shaping files were used in brushing movements to remove gross amounts of dentin in the coronal two-thirds. The three shaping and three finishing instruments were used at maximum torque (520 g/cm) and at 275-300 rpm. The sequence S1/S2 was used initially to pre-enlarge the coronal two-thirds of the canals. SX has gold ring, S1 shaping instrument has purple identification ring, S2 has white identification ring and D0 of 0.17 and 0.20 mm respectively. These shaping files have small-sized tips, guiding the path of the canal previously secured with hand files. The three finishing instruments with stronger and more active blades, F1, F2 and F3, have yellow, red and blue identification rings on their handles corresponding to D0 diameters and apical tapers of 20/07, 25/08 and 30/09, respectively. F4 and F5 are also available. The files were used in a non-pecking motion, but with light, inward pressure. The progressively tapered design reduces the number of recapitulations needed to achieve length in the small diameter root canals like in this case. Dimensions of instrumentation: B : #45/15,5 P: #40/16,0. $Ca(OH)_2$ as an interappointment dressing. Cavit G (3M, ESPE), IRM (Dentsply International, Caulk division, Milford, DE) temporary coronal seal.

3rd appointment 2011-05-26

The patient had no symptoms after treatment, the root canals were dry. The irrigation regimen was repeated, as in 2nd appointment. Canals dried with paper points. The tooth was filled with gutta percha/ AHplus (Dentsply, DeTrey International). IRM plugs. The patient was referred back to the undergraduate student clinic for further treatment, coronal sealing with crown.

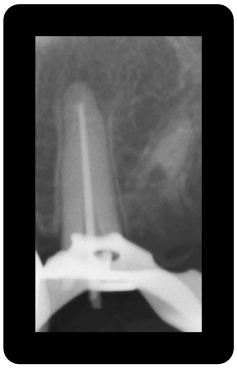


Figure 7 (left): Master cone radiograph

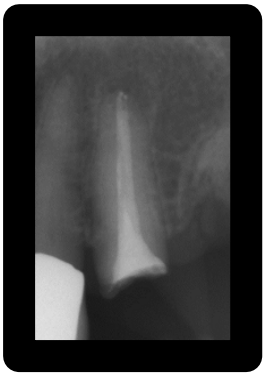


Figure 8 (right): Final radiograph

Evaluation before and after treatment, prognosis

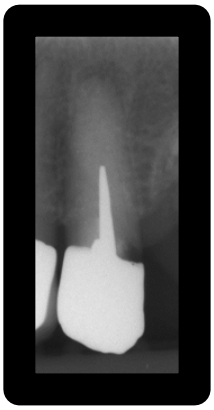


Fig. 9 (left), 10 (right).

Before, fig. 9, and after, fig. 10, treatment.

Resolution of apical radiolucency.

Endodontic: Good

Total: Favourable

8 months follow-up

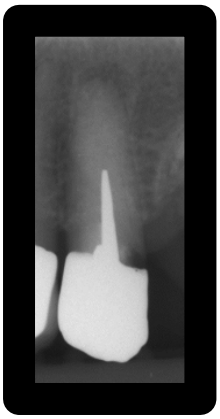
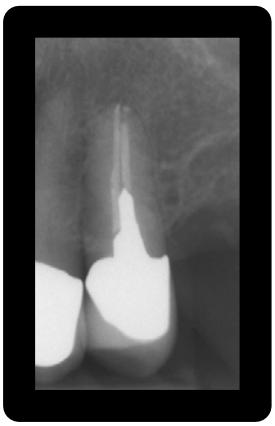


Fig 11.

<- 2011-05-04

Fig 12.

2012-01-12 ->



Periapical radiolucency and PAI score 3 before treatment. Normal lamina dura at follow-up radiograph. The patient was free of symptoms and the tooth had been restored with a metallic ceramic/ porcelain restoration. The root fragment which earlier was persistent from extraction of tooth 26, was now removed.

Fig. 13 and 14. Clinical follow-up photos show an optimal coronal seal and adequate oral hygiene.

Discussion

The maxillary second premolar may have one, two or three root canals. Two or three canals may occur in a single root. A buccal and palatal pulp horn are present, the buccal pulp horn is larger. A single root is oval and wider bucco-lingually than mesio-distally. The canal(s) remain oval from the pulp chamber floor and taper rapidly to the apex. Apical curvature of the root(s) is common. The proximity of this tooth to the sinus maxillaries can lead to drainage of a periradicular abscess into the antrum and exposure of the sinus during apical surgery. This tooth could be prone to mesio-distal root fractures and fractures on the base of the cusps, usually the buccal one(2). Full occlusal coverage should be in mind after endodontic treatment to prevent cusp or crown/root fracture. According to Vertucci; one canal is present in 75%, two canals: 24%, three canals: 1%. Caliskan *et al*: one canal: 72%, two canals: 28%. Average time of eruption: 10-12 years. Average age of calcification: 12-14 years. Average length: 21,5 mm.

European epidemiological studies show that the number of teeth with AP and of teeth with root fillings increased. Despite the improvements in the general oral health, the prevalence and incidence of AP in the general population are shown to be unaffected (3). There have been a need for re-treatment of endodontically treated teeth because of AP due to non-optimal intitial treatment (4). It has demonstrated a significant correlation between the technical quality of root canal obturation and the periradicular status (5). Case selection for re-treatment is based on restorability, periodontal conditions, and the capability of try to overcome challenges as anatomic anomalies and unusual canal morphology. The strategic value of the tooth as well as alternative treatment options must be considered. As long as these factors are assessed favorably, the first treatment consideration for endodontic failure should be a retreatment. Teeth with post-treatment lesions, or with no initial lesions, that increase after treatment or remain unaltered for 1-2 year,

are candidates for re-treatment or surgery (6). Some authors have found better outcome in surgical compared to orthograde retreatment (7), while others have found no differences, only in the time aspect (8). Kvist & Reit compared outcomes of nonsurgical re-treatment vs periradicular surgery in cases followed for 4 years. Surgery resulted in a significantly higher healing rate at 1-year recall but no significant difference was observed at 4-year recall. Bergenholtz *et al* reported a success rate of 78% in teeth with periapical pathologies and 94% in teeth without (9). The success rate in well-treated teeth seems to be about 85-90%, while that of poorly treated teeth and inadequate coronal restorations may be as low as 40-50% (6).

Non-surgical endodontic retreatment may include the following: coronal disassembly, locating previously missed canals, removing obturation materials, negotiating blocks, bypassing ledges, managing transportations, repairing perforations and removal of posts and broken instruments (10)

Important aspects of successful re-treatment are strict asepsis, complete chemomechanical preparation using antimicrobial irrigants, intracanal medication, adequate root canal obturation and proper coronal restoration as soon as possible.

If these measures are followed, endodontic re-treatment should be successful in 2/3 of all cases (11). The root canals in this particular case were heavily obliterated. The patient is 84 years old. Aging is evident also in the pulp. Continued formation of physiologic secondary dentin over the years will lead to reduction in the size of the pulp chamber and the root canal. Histologically, one can observe a reduced or missing odontoblastic layer in teeth from older individuals. The odontoblasts decrease in size and number, a progressive reduction in the number of nerves and vessels are evident (2). Fibrosis is seen, with a reduced number of cells between the collagen fiber bundles as well as increased incidence of calcification, tertiary dentin formation and pulp stones (12). The thick collagen fibers may act serve as foci for pulpal calcification (2). Arteriosclerotic changes may occur in the pulp vessels, capillaries and nerve endings may calcify(13). The main changes in dentin is associated with increase in the peritubular dentin, dentinal sclerosis and the number of deat tracts. Dentinal sclerosis produces a decrease in dentinal permeability as the dentinal tubules become progressively reduced in diameter. Irrigation with the chelating agent EDTA may be helpful in teeth like in this. The actions of EDTA include its chelating properties, which assist in negotiation of narrow or sclerosed canals by demineralization of root dentine and help removal of compacted fibrous tissue from uninstrumented canal anatomy. It may also facilitate deeper penetration of sodium hypochlorite solution into dentine by removing the smear layer from the instrumented surface and opening up dentinal tubules, and lastly it may help detach or breakup adherent biofilms. The synergistic effect of sodium hypochlorite and EDTA are known from previous clinical microbiological study (14). It is shown that use of 17% EDTA solution for irrigation had a marginal effect on the success of primary treatment but had a profound effect on secondary treatment (15) . A possible explanation of the apparent difference in effect may be that the additional use of EDTA irrigation may help by aiding removal of contaminated materials and opening up accessory anatomy and blocked canals. In contrast, the smear layer and debris generated from instrumentation of untreated canals during 1RCTx should be more accessible to and relatively easily decontaminated by sodium hypochlorite solution alone. Of relevance may also be the microbial composition of the re-treatment flora, where EDTA may have an effect to a higher degree. Removal of the smear layer has been an issue of discussion. Arguments for removal of smear layer includes the opening of dentinal tubules to the intracanal medicaments, removal of microbes and substrates as well as opening for sealer into the tubuli. Many recommend the smear layer to be removed prior to the insertion of the root filling (16). Argument against the removal of the smear layer includes the fact that the removal will not secure the adhesion in all cases and it could possibly increase ingrowth of microorganisms between treatment sessions and after obturation.

Most cases of endodontic treated teeth are filled with gutta-percha and sealer. This case was an exception; possibly, the dentist performing the initial RCT, was not able to find the canals without a SOM. However, I decided to define this as re-treatment since some intervention had already been performed in the root canal; a post was present. The obturation materials usually present in retreatment cases are usually

removed by Gates Glidden drills, Hedström files, rotary files/ re-treatment systems, ultrasonic activated instruments or/and an organic solvent as chloroform or eucalyptol. There have been some discussion concerning if these solvents are safe to use, due to evaporation to the surroundings. However, utilizing common endodontic treatment methods employing chloroform, reports have found no negative health effects to the dentist or assistant, with air vapor levels well below Occupational Health and Safety Administration mandated maximum levels. The most widely used solvent in Norway, chloroform, can be a useful and safe adjunct in the practice of endodontics. To ensure increased canal cleanliness, disinfection and disruption of possible persisting biofilm, the root canal should be enlarged to sizes larger than those used in the previous treatment (6).

Retreatment is sometimes performed in teeth without AP. The success rates in these non-diseased teeth are high, ranging from 93-98% (11, 17-19). On the other hand, studies have demonstrated that retreatment cases with AP have a lower healing rate, 62-85%, compared with primary treatments (8, 11, 17, 19-21). In a study from 2004, Gorni & Gagliani found that the success of re-treatment cases was dependent on the degree of which the root canal morphology was respected or altered during the initial treatment. Overall success was 69.03%. Success in the root–canal–morphology-respected group was 86.8%. Success in the rootcanalmorphology-altered was group 47% (22).

Farzaneh et al 2004	78 %
Sundqvist et al 1998	74 %
Sjögren et al 1990	62 %
Strindberg 1956	84 %

Table 2. Success rate of re-treatment as determined in well-controlled outcome studies

Age is by some authors found to influence the outcome (23), while others have not found age to be a parameter to influence success rate (18). It is, though, agreed that the outcome of re-treatment is better in teeth with inadequate primary treatment in terms of length and density (17, 18). Inadequate treated teeth are shown to have 22% better chance of healing than adequate initial treated teeth (88% vs. 66%) (17). The background for this is that the microbes of inadequately treated teeth are more like primary infections and more susceptible to antibacterial procedures. As mentioned, in this case no root filling material could be detected, one may assume that the microbial composition is more like an untreated canal; a polymicrobial flora dominated by anaerobes. This in contrast to mostly monoinfection dominated by Gr + facultative and obligate anaerobes in previously filled canals where common isolates are *Enterococci*, *Candida* and *Streptococci.* They share resistance to antimicrobial measures and have an ability to survive in the low-nutrient environment of the filled root canal (24). For microorganisms to survive in the root-filled canal and cause post-treatment AP, many challenges must be overcome. They have to survive antibacterial treatment, root-filling, starvation and find substrates for growth. They also have to endure host defence and induce and maintain periapical inflammatory response. In failed cases, one may suspect resistant microorganisms with these properties.

Enterococcus faecalis is a microorganism that has been isolated more often from failed root-filled teeth (21, 25). They are able to invade dentinal tubules and adhere to collagen in the presence of serum. The routine intracanal dressing with calcium hydroxide (CH) may not be efficient for microorganisms as *E. faecalis*, *Actinomyces* species and *Candida albicans*. *E. faecalis* forms biofilm resistant to defence cells and antibiotics, proton pump resists the high pH of $Ca(OH)_2$. Portenier *et al*. concluded that *E. faecalis* cells in the growth phase were the most sensitive to CH, and killed within 3 s to 10 min. Cells in a stationary phase were more resistant. Cells in the starvation phase were the most resistant and were not totally eliminated during the 10-min test period (26). Several studies have showed ineffectiveness of CH in eliminating bacterial cells. Haapasalo & Ørstavik reported that a $Ca(OH)_2$-paste failed to eliminate *E. faecalis* in dentinal tubules (27). Sathorn *et al.* evaluated eight clinical trials including 257 cases. They concluded that CH had limited effectiveness in eliminating bacteria from human root canals when assessed by culture techniques (28). In a PCR-study, the effect of root filling with or without

prior CH or 2% chlorhexidine (CHX) on the persistence of bacterial DNA in infected dentinal tubules was evaluated (29), 2% CHX treatment followed by filling was more effective in removing the DNA of *E. faecalis* than CH (29). It could therefore, as done in this case, be beneficial to use CHX (6). CHX has a wide antimicrobial spectrum and is effective against both Gram-positive and Gram-negative bacteria as well as yeasts. In vitro studies indicate that the effect of CHX against *E. faecalis* (and *Candida*) is superior to that of NaOCl, which is relevant since these microorganisms are expected to be more prevalent in retreatment cases.

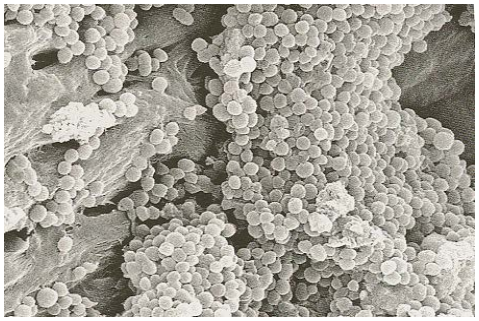


Fig. 15. Colonization of the root canal wall with E. faecalis

However, to be noted: The combination of NaOCl and CHX results in the formation of a precipitate which is recommended to avoid formation of until this precipitate is studied further.

Before judging a treatment result as failure, one should be aware that an assumed failure after treatment could be due to incorrect diagnosis; as misinterpretation of anatomic landmarks as the mental foramen near apex of premolar or the incisive canal, various cysts, tumors or physical injuries to bone as traumatic bone cyst. A few lesions may also heal by scar tissue, which on follow-up radiographs may be confused with persistent AP. None of these differential diagnoses were relevant in this case.

This case showed healing radiographically within one year. Most AP lesions heal within 6 months to 2 years after RCT, but the healing process may take up to 4 years. If the lesion has not healed after this time, one should not expect this to happen and retreatment is indicated (6). Sometimes surgery is the best option, this is further discussed in the surgical topics in this case book.

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Case 9 – Treatment of necrotic tooth with apical periodontitis and sinus tract

Patient

58 year old Scandinavian male was referred to the Department of Endodontics, University of Oslo from his dentist, general practitioner.

Figure 1. Frontal view

Medical history

Non-contributory, ASA group I

Dental history & chief complaint

Multiple fillings, mostly amalgam restorations from the 70s and 80s. Later years, the patient had a low caries incidence and a satisfying oral hygiene. Diffuse discomfort lower jaw, left side, for which the patient was referred. The patient also mentioned that he regularly felt a fluid-filled blister in his right cheek.

Clinical findings

The clinical examination at Department of Endodontics revealed a sinus tract bucally of the maxillary, right molars.

Fig. 2 occlusal view, maxilla

Fig. 3. Occlusal view, mandibula

Clinical examination, findings

	17	16	15	14
EPT (0-80)	31	80	24	28
Thermal test	Yes	No	Yes	Yes
Percussion	No	Yes, vertical	No	No
Palpation	No	No	No	No
PPD	WNL	WNL	WNL	WNL
Soft tissue	WNL	Sinus tract bucc	WNL	WNL
Restoration	Am	Am/comp	Am	Comp
Lymphadenopathy	Negative			
Mobility	No			

Table 1. Summary of clinical findings

Fig. 4. Photo of sinus tract

Fig. 5. Gp insterted sinus tract for fistulogram

Radiographic findings

Tooth 17 had a MOD radiopaque filling material consistent with amalgam, intact lamina dura. Tooth 16 had radiopaque filling material OD and a radiographic appearance of composite restoration MO. Periapical radiolucency, PAI 5, Ø 14 mm. Tooth 15 has radiopaque filling material consistent with MOD amalgam restoration and intact lamina dura. Marginal bone level within normal limits.

Fig. 6. Radiograph of teeth 17, 16, 15

Fig. 7. X-ray tracing of sinus tract.

Diagnosis

Pulpal: Infected, necrotic pulp K04.1

Periapical: Chronic apical periodontitis with sinus tract to oral cavity K04.62

Periodontal: Within normal limits

Treatment plan

Endodontic treatment of non-vital pulp 16

Treatment 2011-12-06

Cuspal reduction

Fig. 8 before reduction of cusps

Fig. 9 after reduction of cuspal length

Fig. 10, 11 working length radiographs

Anaesthesia 1,8 ml Carbocain “AstraZeneca” (mepivacaine). Reduction of cuspal length for prevention of fracture. Amalgam and composite restorations were removed using fissure bur on a high speed hand piece. Access cavity was prepared and three canal orifices were localized. Rubber dam clamp and rubber dam was applied in order to isolate the tooth and ensure an aseptical procedure. The operation field/ rubber dam was disinfected with a solution of 0,5% chlorhexidine in 70% ethanol. Long neck (LN) (Dentsply Maillefer, Ballaigues, Suisse) -burs and Gates Glidden (GG) (Sybron Endo corp, Orange, CA 92867) -burs were used to open the root canal orifices. Chemomechanical instrumentation with 17% EDTA, 1 % NaOCl, CHX, Irrisafe®. BioRace® (FKG Dentaire, La Chaux-de-Fonds, Switzerland). BR0 – 25/0.08 was used opening the canals coronally. A working length radiograph was taken with a NitiFlex K-file #15 in the mesiobuccal root canal (MB1), a NitiFlex K-file #15 in the distobuccal root canal, and a Hedstrøm file #20 in the palatal root canal. The instrumentation lengths were found using Root ZX II® (Morita apex locator prior to the radiograph. A fourth mesiopalatal canal (MB2) was then found by using microscope and a X-ray with NitiFlex K-file #15 in place together with the one in the MB1 was taken (fig. 11). This canal joined with the MB1. Working lengths: MB1: 22, MB2: 21,5, DB: 21,5, P: 22,5. The root canals were then instrumented with NSK’s Endo-Mate TC2 cordless handpiece. This motor has the Auto Reverse & Alarm function with audible alert when the preset torque level has been reached, allowing the operator to unload the file even before the Auto Reverse function engages. Endo-Mate TC2 features 5 programmes for different file systems, as BioRace, used in this case. The mesiobuccal root canal was instrumented up to NitiFlex K-file #40, 40, distobuccal root canal up to NitiFlex K-file #45, and the palatal root canal up to NitiFlex K- file #60. The canals were dried with sterile paper points and an intra-canal dressing was packed with in all the root

canals. The access cavity was then sealed with a Cavit temporary cement (3M Espe) and IRM temporary restoration (Dentsply).

Treatment, contd. 2011-12-14

Figure 12. Master cone radiograph, gutta percha

The patient returned to the clinic a week later. The tooth was asypmtomatic. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. Temporary coronal seal and calcium hydroxide were removed with irrigation, files and ultrasound, and root canals were fully instrumented by using standardized technique and irrigated with sodium hypochlorite and EDTA. All root canals were dried with sterile paper points. A master cone radiograph was taken with gutta-percha cones size #40/40 in the mesiobuccal root canals, a gutta-percha cone size #45 in the distobuccal root canal, and a gutta-percha cone size #60 in the palatal root canal. All canals were obturated with gutta-percha and AH Plus sealer using standardized lateral condensation technique. The access cavity was then sealed with a IRM temporary restoration

Day 1	Treatment of the non-vital tooth. Chemomechanical instrumentation. Intracanal calcium hydroxide dressing
1 week later	Asymptomatic. Sinus tract beginning to close. Obturation
3,5 months follow-up	Asymptomatic. Physiologic mucosa with scar tissue, sinus tract closed. Healing evident radiograhpically

Table 2. Treatment summary

Result

Figure 13, 14 Final radiographs

Comment:

In the same patient, tooth 34 was earlier endodontically treated, but one canal was missed in the initial treatment and a radiolucency present in the radiographs. The re-treatment of the tooth with localization and obturation of the missed canal was also done by me, but I choose not to go into details of this treatment.

Fig. 15 occlusal view 34

Fig. 16 pre-treatment

Fig. 17 post-treatment

Prognosis

Endodontic: Good

Total: Favourable

3,5 months follow-up

The patient was free of symptoms. The soft tissue appeared healthy (fig. 18). Some degree of scar tissue evident at the earlier location of the sinus tract. The radiographs show a healing situation. He was informed about the importance of and need for permanent restorations to obtain an optimal coronal seal.

Fig. 18

Fig. 19

Fig. 20

Discussion

The maxillary, first molar is the largest tooth in volume and one of the most complex in root and canal anatomy. The pulp chamber is widest in the bucco-lingual dimension and four pulp horns are present. An imagined line can be drawn to connect the three main canal orifices MB, MD and P, to form a triangle, known as “the molar triangle”. The tooth has three individual roots, where the palatal is the longest and with the largest diameter. The palatal root often curves buccally at the apical one third, this is important to keep in mind if there seem to be a discrepancy between the radiograph and the apex locator. The distobuccal root is conical and the mesiobuccal root is oval if only one canal is present and more circular if two or three canals are present. Important to note is the concavity at distal aspect of the MB root, which implies that the root is thinner in this part. The location of the MB2 orifice may vary, but generally it is located on, or mesially of a line between the MB1 and P orifices.

Fig. 21. Illustration photo, example of location of MB2 (from another of my cases)

Not all MB2 orifices lead to a true canal. A ledge of dentin often covers the orifice of MB2 and the pathway of the canal often takes one or two abrupt curves. According to Vertucci; the mesiobuccal root has one canal in 82% and two canals in 18%. Caliskan et al: One canal in 75%, two canals in 25%. Distobuccal canal; Vertucci: One canal: 100%. Caliskan et al: One canal: 98%, two canals 2%. Palatal canal, Vertucci: One canal 100%. Caliskan et al: 96%, two canals: 4%. Average time of eruption is 6-7 year of age. Average age of calcification: 9-10 years. Average length: 20,8 mm.

To be noted: In recent years, many studies have been published concerning the morphology of the maxillary, first molar. A wide variety of methods are used in these studies, as laboratory studies with various types of clearing using decalcification with injection with ink or other dye, plastic or metal castings, in vitro endodontic access and with radiography and instruments, scanning electron microscope, examination of pulp floor, grinding or sectioning and so on. These studies, with better equipment, have reported presence of two canals in the MB root in up to as much as 95%. In addition to the methods used as mentioned, this wide range of variation in the literature with respect to frequency of occurrence of the number of canals and incidence of fusion may be because of different ethnic background and age of the population studied. It is generally accepted that the most common form of the permanent maxillary first molar has three roots and four canals, but Cleghorn *et al* in 2006 reviewed data from 34 studies on the canal morphology of the mesiobuccal root with a total of 8399 teeth. They concluded that the mesiobuccal root of the maxillary first molar contains a double root canal system more often than a single canal, in most studies. More specific; the incidence of two canals in the mesiobuccal root was 56.8% and of one canal was 43.1%. The incidence of two canals in the mesiobuccal root generally are higher in laboratory studies (60.5%) compared to clinical studies (54.7%). A single apical foramen is reported 61.6% of the time, while two separate apical foramina were present 38.3%. It is documented that illumination and magnification significantly aids detecting the MB2. In a study by Buhrley, the MB2 canal was found in 41 of 58 teeth or 71.1% when using SOM. The group using loupes found MB2 in 55 of 88 teeth or 62.5%. The lowest incidence of MB2 was in the group performing RCT without any magnification; MB2 was found in only 10 of 58 teeth or 17.2% (1).

Already in 1894, the American dentist Miller, working in Kochs laboratory, published a study reporting the association between bacteria and apical periodontitis (AP) (2). In 1919, Henrici and Hartzell reported that the normal, vital pulp is sterile. It was not before many years later, in the 1960s, the causal relationship between bacteria and periradicular disease was demonstrated. This was in the historical study where pulps were exposed in germ-free rats and no pathologic changes were evident. Dentinal bridging was evident even if the pulp was severe damaged and the pulp exposed. This was in contrast to pulps exposed in rats with normal microbial flora – these animals got pulpal necrosis and periapical lesions. Classic studies in monkeys and humans have documented the microbial etiology of AP (3-6) and are further confirmed by other authors (7, 8). Infection of the root canal can develop after pulp necrosis, which may be caused by bacteria originating from caries, microleakage through restorations, infractions after trauma (9) , exposed dentinal tubules, periodontal disease or operative procedures (10). Because of the tubular structure, the pulp is put to a risk of infection if dentin is exposed. Dentinal tubules are widest near the pulp (mean 2,5 µm diameter) and narrowest in the periphery near the enamel or cementum (mean 0,9 µm diameter) (11). The smallest tubule diameter is compatible with the cell diameter of most oral bacterial species (range 0,2 to 0,7 µm).

Bacterial invasion of dentinal tubules is found to occur more rapidly in non-vital teeth than in vital ones (12). In vital teeth, outward movement of dentinal fluid and tubular contents can delay invasion of bacteria or their products. Fungi, arachea and viruses have been found in association with endodontic infections, but bacteria are the primary microorganisms implicated in the pathogenesis of AP. More than 460 bacterial species have been detected in the different types of endodontic infections (11). The number of microorganisms within an infected root canal system may vary from 10^2 to more than 10^8 (13). It appears to be a degree of variation in the extent to which dentine is invaded; cervical tubules are invaded to a greater

extent than the mid-root tubules, and the mid-root tubules more than those in the apical area. Studies have also found a positive correlation between the number of bacteria in an infected root canal and the size of periradicular radiolucency (4, 14).

For a given microorganism to establish itself in the root canal system and to further participate in the pathogenesis of periradicular disease, the microorganism must be present in sufficient numbers, it must possess an array of virulence factor and must be located in the root canal system in such a way that its virulence factors can gain access to the periradicular tissues.The root canal environment must permit the survival and growth of the microorganism and provide signals that stimulate the expression of virulence genes. Inhibiting microorganisms must be absent, or present in low numbers in the root canal environment.

It is reported that teeth with infected root canals after cleaning and at the time of filling have poorer outcome than root canals where no culturable microorganisms could be detected (table 3) (15-19). In the study by Sjögren et al 1997; 55 teeth with AP were cleaned and bacterial sampled. 94% success in the group of no bacteria after cleaning and 68% success in the group with bacteria detected after cleaning (17).

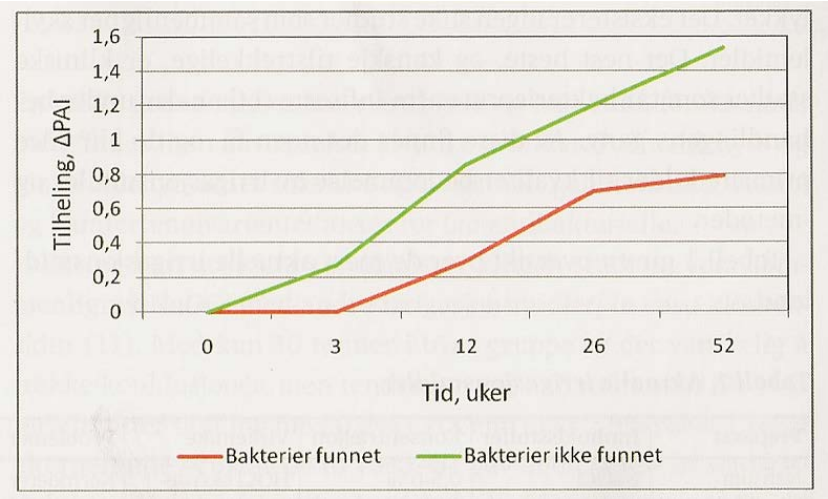

Table 3. Healing of AP in teeth where bacteria was detected (red) and not detected (green) before root-filling. Positive change in PAI score is a measure of healing. (18)

100% removal of bacteria by instrumentation alone is unlikely to occur (20, 21). Through our treatment, we aim to ensure that the conditions for bacterial establishment mentioned above are not fulfilled, and that the bacterial load, if not eliminated; reduced to a minimum.

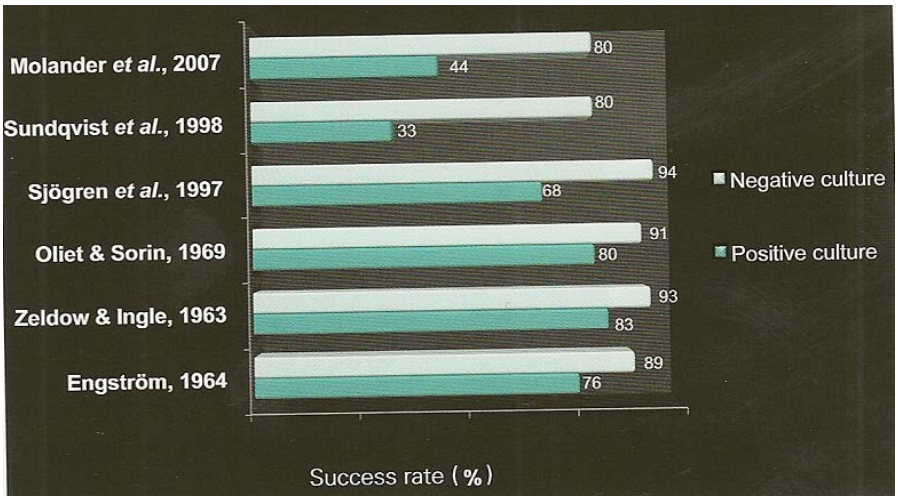

Fig. 22. Treatment outcome relative to the occurrence of positive and negative cultures at the time of root canal fillings. From (11)

When a tooth is diagnosed with AP, the treatment goal is to restore the periradicular tissues to health. This goal is reached by root canal treatment, retreatment or surgical endodontics in cases of post-treatment AP. In this case, primary treatment was the issue. In cases where different treatment options exist, these should be explained and discussed with the patient. The likely prognosis should be presented and recorded in the journal. It is good practice to provide the patient with written information (22). It is also recommended to record that the patient accepts to the treatment and the cost.

As mentioned, in a necrotic tooth, the protective functions and defense apparatus to fight infections are not present. The microorganisms must be assumed to have reached the apical part and the ramifications of the canal. It is advisable to treat root canals containing necrotic pulp as infected canals, even though apical radiolucency may not be detectable(11). The microorganisms are likely to be in close contact to the apical foramen and the periradicular area (23-25). Therefore, the length of instrumentation in infected cases is of importance. Where the pulp is necrotic and infected, the apical limit should be placed within the 1 mm of the radiographic apex(26). It is also called the “critical territory” (11), because the periradicular tissues can serve as a source of nutrition for the pathogenic bacteria. It is also critical area for the host defenses, which are working to prevent the infection from spreading further into the bone of the jaw. The infection process is a dynamic situation between microbial factors and host defence, at the interface between the infected radicular pulp and the PDL. The microbes may be located in positions protected from the phagocytic host defence cells and molecules as complement and antibodies. A sort of equilibrium state is reached, and a local, chronic inflammation process will result in resorption of hard tissues, destruction of other periapical tissues and formation of periapical lesions (27).

Endodontic bacteria are often subgroups of bacteria found in periodontal pockets, it is therefore a possibility that the sulcus is a source of bacteria in root canal infections (28). While in periodontal diseases, one can distinguish between pathogens and normal microbiota, in endodontics this is not an issue because there exist no normal flora in the pulp, but sterile connective tissue. See also case 7.

In the root canal, the microorganisms can utilize necrotic pulp tissue and components of tissue fluid and exudate as sources of nutrients. Products of the metabolism of other microbes may be utilized as well. It is known that microorganisms occurs in certain combinations and have intercellular communication molecules/ autoinducers or quorum sensing. This is described in both Gr+ and Gr- bacteria (11).

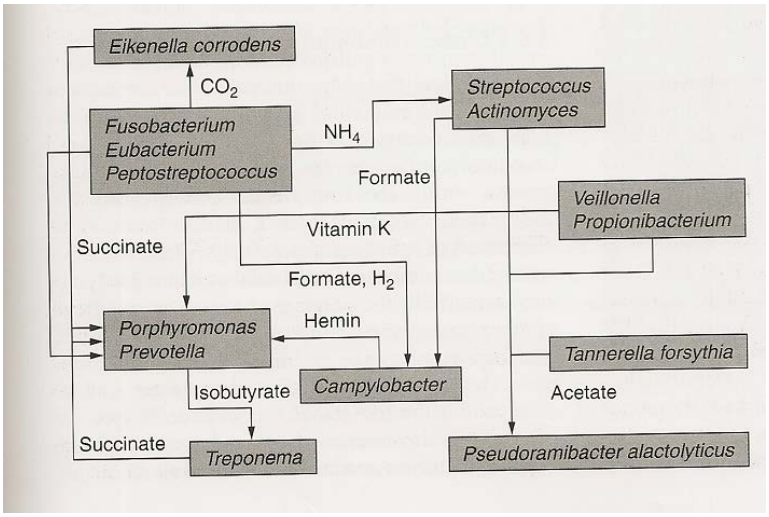

Fig.23. Nutritional relationships that can occur between bacteria in an endodontic infection (10).

The microbiota of the root canals in the tooth with a primary infection consists of a different flora than in retreatment cases with post-treatment disease, which may be more difficult to eradicate than primary infections (29, 30). The flora in primary root canal infection is polymicrobial, often 10-30 species, dominated by anaerobic bacteria (31). Generally, Gram-negative species such as *Porphyromonas,*

Prevotella, Fusobacterium, Filifactor, Campylobacter and *Treponema* are present. Gram-positive anaerobic bacteria, *Peptostreptococcus, Eubacterium* and *Pseudoramibacter* and facultative or microaerophilic streptococci can also be found (10).

Different bacterial species dominate depending on the technique used for identification, and in different locations. Most prevalent in primary infections detected by PCR*: Pseudoramibacter alactolyticus, Treponema denticola, fusobacterium nucleatum.* Most prevalent in primary infections detected by checkerboard DNA-DNA.hybridization: *P. alactolyticus, bacteroides sp, Streptococcus sp*. Most prevalent in primary infections detected by cultivable techniques*: P. intermedia/nigrescens, P. buccae, Peptostreptococcus anaerobicus, Veionella parvula (32) .*

As for the population density, each canal can harbor from 10^3 to 10^8 bacterial cells in CAP cases and from 10^4 to 10^9 in acute forms of disease (33). Root canals associated with large apical lesions harbor a more diverse and populous microbiota.

The bacterial population is then changing over time. Bacteria that are strict anaerobic grow in an environment with low oxidation-reduction potential in absence of oxygen, and the bacteria lack the superoxide dismutase and catalase enzymes. The environment gets selective for anaerobes by the tissue fluid, breakdown products of the necrotic pulp tissue, serum, low oxygen tension, redox potential, microbial interactions and the bacterial by-products. Further on this issue of retreatment, see Case no. 8.

In this tooth, several pulp stones, also called denticles, were evident (fig. 24). The pulp stones are mineralized structures within the pulp tissue. A single tooth may have one or as many as twelve pulp stones , with variable sizes from tiny particles to large masses occluding most of the pulp space. The prevalence of pulp stones are found to be significant higher in molars than in premolars, in both genders (34). Many of the prevalence studies are radiographic, - true prevalence is likely to be higher if histologic methods added. The pulps stones are most often localized in the coronal part of the pulp, but may be found in the radicular part as well.

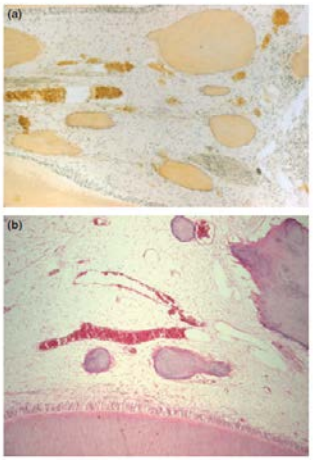

Figure 24, 25. Clinical image from this case, with pulp stone (left). Pulp stones of variable sizes localized in the loose connective tissue of the pulp, from Kardos & Kieser 2006 in (35)

Pulp stones are classified according to location as free, attached or embedded. On the basis of their structure, true pulp stone exhibits typical dentin structure while false pulp stones do not (36).

Some causative factors are proposed, as periodontal disease (37), carious process (38) and cavity preparation. True pulp stones with dentin structure probably develop from fragmented portions of Hertwigs epithelium. Odontoblasts may be differentiated from immature cells and intitiate denticle formation. Dentin fragments introduced into the pulp following pulp exposure may also act as foci for formation of pulp stones (36).

In this case, an intraoral sinus tract was present. It is shown that out of 160 teeth with preoperative status of periradicular inflammation, 29 teeth (18.1%) had an odontogenic sinus tract, which correlates to almost one

in five teeth with periradicular inflammation having a sinus tract (39) . Another study, retrospective, found that 107 of 348 teeth (30,8%) with preoperative status of periapical inflammation and radiolucency had a sinus tract (40). Of a total of 728 teeth, independent of diagnosis, 107 (14,7%) had a sinus tract of odontogenic origin. No significant differences of occurrence were found between genders.

When an acute periapical abscess forms, draining along a path of least resistance is most likely. If odontogenic abscess spread to deeper tissues, it may cause fascial space infection or it may establish an intraoral or extraoral drainage in the form of a sinus tract. Whether there is an intraoral or extraoral sinus-tract opening depends on the location of the perforation in the cortical plate by the inflammatory process and its relationship to facial-muscle attachments. A sinus tract implies that periapical exudates drain to a body surface. The sinus tract may be asymptomatic and the patient unaware of it. Because of the lack of pressure build-up under periosteum and adjacent tissues, there is no, or mild, pain. Swelling is also minimal when a sinus tract is present in conjunction with AP (41). Most often the sinus tract will drain in the mucosa adjacent to the tooth, but there could also be some distance from the involved tooth. It is therefore important to perform a thorough diagnostic examination with radiographic tracing of the tract with an opaque object as a gutta percha cone (Fig. 7). With adequate disinfection of the root canal and resolution of the periapical inflammation, the epithelium of the tract, if present, will in most cases disintegrate. If the sinus tract does not heal after a few weeks, one may suspect that the infection is located extraradicularly and surgical treatment may be necessary.

Mechanical debridement combined with antibacterial irrigation (sodium hypochlorite NaOCl), are shown to give 40-60% bacteria negative (17, 42). Historical, NaOCl has been and is the most commonly used endodontic irrigant (43, 44). It has been used and tested in strengths from 0,5% to 6% (45). Studies comparing the antibacterial effectiveness of different strengths of NaOCl have not found an increase in potency with increased concentration in vivo (43, 46). Even after thorough chemomechanical instrumentation with appropritate disinfectants, bacteria may as mentioned remain in some cases (42, 47). Interappointment dressing with calcium hydroxide (CH) is recommended to eliminate bacteria or prevent them in repopulating (47, 48). Even with CH-dressing, some microbes may survive and re-grow (49, 50) and it may even not effective against all endodontic microorganisms (51) . Remaining bacteria may be unharmful when entombed by complete obturation with gutta percha and sealer (52). The materials itself have some antimicrobial effects and their nutrition source and space to multiply is eliminated in the well-obturated root canal. Sealers are shown to have some degree of antibacterial effects. In an in vitro study, Grossman's sealer and AHplus were shown to be the sealers most effective in killing *E. faecalis* in dentinal tubules (53). *E. faecalis* is known to be able to penetrate tubules, cause secondary infections and later become persistent (11).
Roots associated with apical periodontitis often lack a distinguishable apical constriction (54). An excess of sealer may more often be the result. AHplus was used in this case. Sealer excess is evident on final radiographs. Extruded AHplus is not found to prevent periapical healing, but could represent a delaying factor for healing in children (55). This patient was 58 years old.

In this case, a second mesiobuccal canal was present (Fig, 26 & 27).

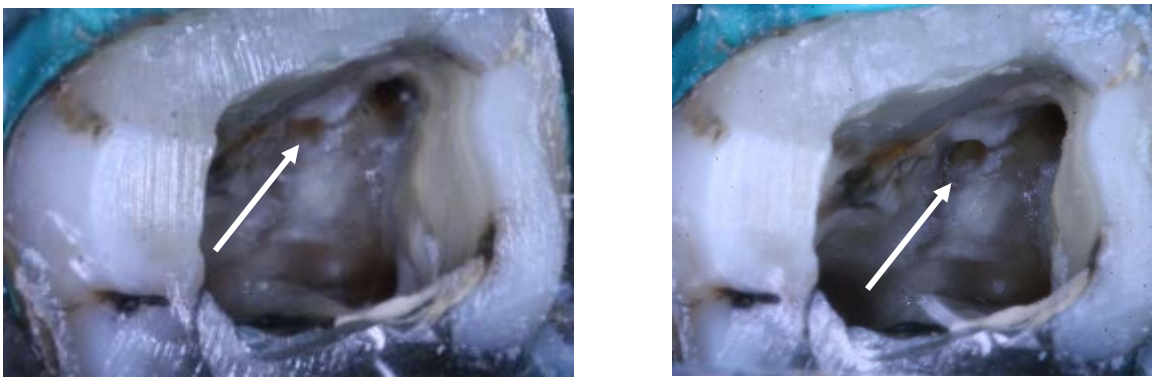

Fig 26,27. Opening up fissure with LN-burs, exploring MB2

The two-canal system of the mesiobuccal root of the maxillary first molar has a single apical foramen roughly twice as often in proportion to the two-canal and two-foramen morphology.

Factors concerning prognosis will be pre-treatment factors, such as the presence of deep periodontal pockets. Treatment-related factors could be apical extent of filling and apical enlargement. Post-treatment factors, such as coronal restoration will be of relevance. Some studies have reported a poorer outcome in teeth with sinus tract present (56, 57). Others have reported comparable treatment outcome for asymptomatic teeth and for teeth present with preoperative symptoms (58, 59).

Concerning size of apical radiolucency: Ng *et al* 2011 (57) found that this significantly influenced the success rate on both 1st and 2nd RCT. This was in agreement with two previous studies (60, 61). However; Strindberg (62), Byström (16), Sjögren et al.(17, 26) found no significant difference in success rates between teeth with small (<5 mm) or large (≥5 mm) lesions.

Radiographic and clinical follow-up has been performed (62-64), as well as well as histological studies of the apical region and periapical area in experimental treatment (65). Most studies have found that the length of the filling material in relation to the radiographic apex is of relevance concerning outcome (26, 66). Other studies do not confirm this (61, 67). The background may be that infected dentine chips but not extruded sealer may be the reason for persisting infection with apparent overfilling.

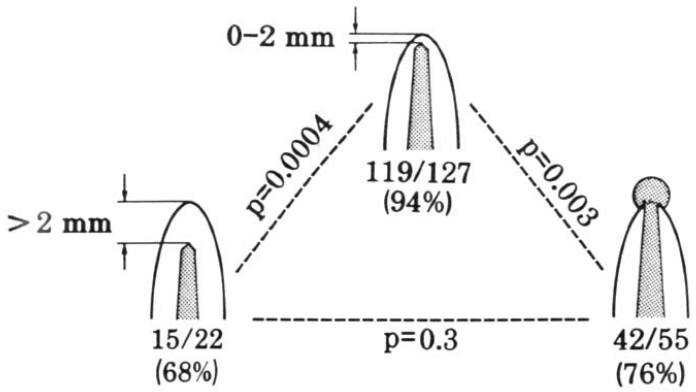

Fig. 28. Outcome of primary endodontic treatment according to the level of root filling in teeth with diagnosis pulp necrosis and apical periodontitis (AP) preoperatively. From(26)

On the follow-up examination, the patient still has temporary restorations on the teeth endodontically treated 3-4 months ago. The patient was reminded of the influence of an adequate coronal seal on the prognosis (68).

Root canal treatment should be assessed at least after one year. If radiographs reveal that a lesion has remained the same size or is only diminished, it is advised to continue observation of the lesion until it has resolved or for a minimum period of four years (22).

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Case 10 - Interappointment flare-up

Patient

34 year old Nordindic female

Fig.1. Frontal view

Medical history & dental history

Healthy patient, no known allergies, ASA group I. The patient had a low caries prevalene, the small amalgam restorations and the porcelain fused-to metal crown on tooth 15 was made several years ago.

Clinical findings

Fig.2-4. Occlusal views (left and middle), and lateral view (right)

	16	15	14	13
Thermal test	**Yes**	**No**	**Yes**	**Yes**
Electrical pulp test (0-80)	**34**	**80**	**24**	**21**
Percussion	**No**	**Yes, vertically**	**No**	**No**
Palpation	**No**	**No**	**No**	**No**
Mobility	**-**	**-**	**-**	**-**
Restoration	**O am**	**Crown**	**OD am**	**-**
Soft tissue	**WNL**	**WNL**	**WNL**	**WNL**

Table 1. Summary of clinical findings.

Radiographic findings

Fig 5. Pre-operative radiograph

Maxillary right first premolar: Radiopaque area OD on coronal aspect consistent with amalgam restoration. Lamina dura could be followed around the tooth without any disruption.

Maxillary right second premolar: Radiopaque appearance consistent with metal-ceramic crown at coronal aspect. Lamina dura could be followed at mesial aspect to the apical area where it widens in a circular, well-defined manner with a diameter of 1,4 cm at the distal aspect of the root, extending to mesial aspect of the first molar.

Maxillary right first molar: Small restorations occlusally, consistent with amalgam restorations. The lamina dura is intact.

The height of marginal bone is within normal limits.

Problem list/ differential diagnosis

Root morphology with the possibility of straightening and non-optimal instrumentation including removal of infected tissue and debris. Large, well-defined circumferential radiolucency, other diagnosis than K04.5 cannot be ruled out; odontogenic or non-odontogenic cyst being present is possible, but the unilocular appearance implies that most likely it is a granuloma, cyst or different kind or a benign fibro-osseous lesion.

Diagnosis

Pulpal: Necrosis K04.1

Apical: K04.5 Chronic apical periodontitis

Marginal: Within normal limits

Treatment plan

Endodontic treatment of non-vital tooth 15

Treatment

2011-02-23: At the 1st appointment the patient was examined, radiographs with parallel technique and two angulations performed. The patient was informed of the diagnosis, treatment plan, prognosis and cost.

2011-03-03: At the 2nd appointment, the treatment was initiated. An access cavity was prepared through the metal-ceramic crown with a hard metal fissure bur. Two root canal orifices identified with an endodontic probe under aid of a Zeiss Opmi Pico® SOM. Root canals with a bacterial smell and necrotic appearance was revealed. Rubber-dam applied and the tooth and operation field disinfected. Straight line access was established with LN-burs and BioRace® rotary system BR0. The instrument was used in gentle, brushing

strokes and the flutes cleaned regularly for orifice shaping and pre-flaring prior to use of the apex locator RootZX® to decide the working length (WL). Manual instrumentation with 0.02 taper K files from # 08 to #15 to full WL. The BioRaCe basic set was used in this case (BR0-25/0.08, BR1-15/0.05, BR2- 25/0.04, BR3-25/0.06, BR4-35/0.04 and BR5-40/0.04) . Irrigation with 1 % sodium hypochlorite NaOCl and chelating agent 17% EDTA.

Fig.6. A WL radiograph was undertaken with file #15.

The endomotor NSK wireless ENDO MATE TC was adjusted to to 550 rpm/ 1 Ncm. In the instrumentation phase, the WL was reached with BR1 to BR3. Because the curvature of the canals, instruments BR4C and BR5C was used to prepare the apical canal. The buccal root canal was instrumented up to a size #45 and the palatal root canal up to a size #40. Copious irrigation with irrigant solutions performed throughout the treatment, especially large volumes of NaOCl. After irrigation with EDTA and drying of the canal, 2% chlorhexidine-di-gluconate was applied as an inlay for 5 min. The canals were dried with sterile paper points and packed with intra-canal dressing calcium hydroxide. The access cavity was then sealed with sandwich technique Cavit G® and IRM® temporary restoration.

The patient called after two days, reporting severe pain and a high degree of swelling in her right cheek. She was away and not able to meet at the clinic. A flare-up or exacerbation was to be assumed on the background of the information given by the patient. The local pain and swelling was accompanied of a reduced general condition with fever. Antibiotic phenoxymethyl penicillin 660 mg 1+1+2 daily for seven days against infection, non-steroid anti-inflammatory drug Ibuprofen 600 mg 1+1+1 combined with Panodil 1 g 1+1+1 daily against pain, were prescribed.

2011-03-24: At the 3rd appointment, after three weeks, the patient came back to our clinic. She had not sought dentist for incision while she was away, but the swelling subsided the day after she had started the antibiotic therapy. The patient was now free of symptoms. Rubber dam was applied and disinfected. IRM and calcium hydroxide were removed and root canals and irrigated with 1 % sodium hypochlorite and EDTA. Drying with sterile paper points. The root canals were free of exudation. A decision to obdurate the tooth was made. A master point radiograph was taken with gutta-percha cones: B #45, P #40. Canals were obturated with gutta percha and AH Plus® sealer using the standardized technique with cold lateral condensation. The coronal parts of the canals and the access cavity were sealed off with IRM plugs/ IRM. No microbiological analysis had been performed in this case.

Fig.7. Final radiograph

Evaluation and prognosis

Extrusion of sealer was evident on the final radiograph. Necrotic tissue and debris may have been pushed out apically. Because of the root morphology, a possibility of sub-optimal cleaning and/or obturation may be present. The patient was informed about prognostic aspects and that apicectomy procedure later on was possible. The radiographic appearance was a large, unilocular lesion, making it probable to be a granuloma, cyst or different kind or a benign fibro-osseous lesion (not typical appearance). This, in contrast to if it had been multiloculary radiolucency which could indicate a myxoma, ameloblastoma, central giant cell granuloma, hemangioma or odontogenic keratocystic tumor.

Fig. 8. OPG; Courtesy of Department of Maxillofacial Radiology, UiO

One year follow-up 2012-03-10

Fig. 9, 10, 11. Follow-up clinical photos 1 year after treatment

Asymptomatic patient with a healthy soft tissue, no clinical symptoms and radiographic signs of healing.

Fig.12 Pre-op radiograph

Fig.13 One-year follow-up radiograph

Discussion

For description of the maxillary, second premolar, see case 8.

Mild postoperative pain is relatively common even when the treatment has followed acceptable standards, and this should be explained to the patient so that he or she is aware of this before the treatment is intitiated. Most often, the patient can bear the discomfort or make use of common analgesics, which are usually effective in relieving symptoms. A prospective clinical study on post-treatment pain, it was found that 21% of the patients reported slight pain, 15% had moderate pain and 7% experienced severe pain (2).

A flare-up, or interappointment pain of severe intensity, accompanied or not by swelling, has been demonstrated not to be expected more than in about 2,5-16%(3). A larger discrepance in the prevalence are reported from other authors, mostly due to differences in interpretation of the term “flare-up”. Many of the studies are based upon teeth that were symptomless before treatment, which may give an underestimation. The development of pain and swelling then develops within a few hours or days after root canal procedures and will be of sufficient severity to require an unscheduled visit for emergency treatment and/or the prescribing of medicaments as analgesics and antibiotics.The American Associaton of Endodontists (AAE) defines an endodontic flare-up as “acute exacerbation of asymptomatic pulp or periradicular pathosis after the initiation or continuation of root canal treatment” (4). The balance between the microbial load and the host defence is disrupted in favor of the microorganisms. An acute inflammatory response is initiated by the host, to re-establish the equilibrium state(3).

The etiology of post-instrumental pain is usually multifactorial, but a possible scenario could be an incomplete instrumentation, or failure to detect all root canals, permitting bacteria or their endotoxins to release pain mediators. Inflammation has been defined as "the local reaction of vascularized tissue to injury". Inflammatory mediators, as histamine, serotonin, bradykinin, prostaglandins, and cytokines, leukotrienes, neuropeptides and lysosomal enzymes have been shown to produce or mediate the pain response directly, or indirectly, by causing vasodilation and increased vascular permeability. The result is a net fluid outflow with increased pressure at the site of inflammation. The background for these post-instrumental reactions are usually multifactorial, but the amount of irritants and a foreign body reaction could contribute to the symptomatology. The most likely predisposing clinical condition for occurrence of a flare-up appears to be asymptomatic necrotic pulp with periapical lesion(5). Flare-ups comprise both mechanical and chemical factors, and/or microbial injuries to the pulp, as well as extrusion of irrigants or contaminated debris into the periradicular tissues (1, 6). A hypothesis is selective growth of certain bacterial species inside the root canal as a result of ecologic changes during endodontic therapy(7). The major contributing cause seems however to be the violation of the periapical tissues in infected cases (8, 9).

Investigations have been done to find if there is a correlation between flare-up and the number of treatment sessions, intracanal medication, host resistance, gender, age, dental group, presence of preoperative pain of periapical origin, pulpal diagnosis, periradicular diagnosis, type of treatment, initial treatment or retreatment, apical extrusion of debris and whether or not apical patency was maintained during preparation (10, 11).

The literature have no evidence that pain is worse or more frequent with treatment option one-visit or two-visits (12). Recorded on a pain scale after 24 hours: In the group of single visit, there were no pain in 91% of cases vs 89% in multiple-visit group. In the group of single visit, 9% had severe pain vs 11% in multiple visit group (all non-significant).

Zuolo and Imura found a positive correlation of flare-ups and presence of radiolucent lesions (13). The frequency of flare-ups have in most studies been reported to be significantly higher in necrotic pulp cases (presumably infected) than in vital pulp cases (presumably uninfected) (14). In addition, fear of dental treatment, anxiety and other psychological factors could influence the patient’s pain perception and reaction thresholds.

Fig. 14 Black-pigmented anaerobic bacteria have been associated with endodontic symptoms, including cases of flare-ups. From (1)

It has been suggested that the presence of certain bacterial spe post-treatment problems than others; *Porphyromonas* species have been found to be associated with symptomatic periradicular lesions including abscessed teeth (15, 16). *Fusobacterium nucleatum* has also appeared to be associated with the development of interappointment endodontic flare-ups (17). Synergistic associations with other pathogenic bacteria, such as *Prevotella intermedia*, *Porphyromonas gingivalis*, and *Peptostreptococcus micros* are found with *F. nucleatum*. Many researchers have tried to find a single or at least a group of major species that are associated with acute symptoms in endodontic infections. Research indicates that *Treponema* species to a larger extent than previous believed may be involved in the pathogenesis of acute periradicular abscesses, particularly *T. denticola* and *T. socranskii*. However, evidence accumulated over the years from studies with diverse methodologies, suggests a complex background and not a single or even a small group of bacterial species involved, when it comes to endodontic symptomatology (18).

In this case, a large radiographical radiolucency was present. A better long-term prognosis of endodontic therapy has been reported for small lesions, up to 5mm in diameter, than for larger lesions (19-22). A correlation is shown between the size of the lesion and the number of root canal microorganisms (23). This fact could possibly affect differences in outcome. Other studies have shown no significant differences concerning the lesion size and outcome (23-25). One explanation for this, may be that some of the studies did not have long enough follow-up time to show adequate healing.

Prophylactic measures to avoid a situation of post-treatment flare-up, is not to introduce bacteria into the periapical tissues. Restricting instrumentation to the canal and initiating the treatment with fine files to avoid extrusion of bacteria into the periapical tissue are of importance, as well as selection of instrumentation techniques that extrude less amounts of debris apically, completion of the chemo-mechanical procedures in a single visit, use of an antimicrobial intra-canal medicament between appointments in the treatment of infected root canals, not leaving teeth open for drainage and maintaining the aseptic chain during intra-canal procedures (7). A history of preoperative pain and/or swelling, particularly in cases of necrotic and infected pulps, is one of the best predictors of inter-appointment flare-ups (6, 14, 26).

Concerning treatment, the first thing is diagnosis, there could be other reasons than the newly treated tooth, and other conditions mimicking endodontic or odontogenic pain. It must also be ruled out that the original endodontic diagnosis was incorrect. Information is gathered concerning when the post-treatment symptoms began, if they are intermittent or continuous, degree of pain, swelling and if anything exacerbate or alleviate the symptoms. It is assumed that the medical and dental history was reviewed prior to the treatment. It could be advisable to re-enter the root canal system to further eliminate the original etiologic factors via debridement, give release of pus through the root canal, irrigation and the placement of an antimicrobial dressing. Incision, if present localized fluctuant or indurated swelling, will evacuate pus, microorganisms and toxic products from the periradicular tissues. If non-localized abscess, poor drainage, trismus, cellulitis, fever or lymphadenopathy; prescription of systemic antibiotics is recommended. It is important to be aware of and keep in mind the spaces where infection in the different areas possibly can spread; as the buccal space with source from the maxillary posterior teeth, dependent of position of the roots in relation to the buccinator attachment. Another example is the infraorbital space if exudates from the maxillary canine or 1st premolar breaks through the cortical plate and apex lies above the attachment of the

levator anguli oris. In mandibula is the submental, submandibular and sublingual spaces of concern, if the cellulites advance to the pharyngeal and cervical spaces resulting in airway obstruction.

In a prospective study, no benefits to prophylactic antibiotics for reducing flare-ups were found(14). It is reported that either short-term (1 week) or long-term (3 months) treatment with penicillin had any effect on healing of periapical lesions (27). The use of systemic antibiotics for the control of post-treatment endodontic pain, is found to be without justification (28). Non-narcotic analgesics, NSAIDs and paracetamol, are recommended used to treat the endodontic pain patient (8). These drugs produce analgesia by actions in both the peripherally inflamed tissues as well as in certain regions of the brain and spinal cord. The results of several double blind placebo-controlled trials in endodontic pain patients indicated that both 400 mg ibuprofen or 50mg ketoprofen, produce significant analgesia as compared to placebo. Ibuprofen may be said to be the prototype of NSAIDs and has a well documented efficacy and safety profile (8). There are different opinions concerning if occlusal reduction will be beneficial for preventing post-endodontic pain. Research has demonstrating that in teeth with pain upon biting, occlusal reduction was effective in reducing the postoperative pain. Sensitivity to biting and chewing may be due to increased levels of inflammatory mediators that stimulate periradicular nociceptors (29).

In a study by Marshall and Walton in 1984, fifty patients participated in a controlled double-blind study. The results showed that, when compared with a placebo, injection of the steroid (dexamethasone, 4 mg) significantly reduced both the incidence and severity of pain at 4 h post-treatment and reduced pain at 24 h. Other patient and treatment factors such as age, sex, tooth number, pulp and periapical status, and number of appointments had no effect on post-treatment pain. However, as other studies later have confirmed (ref above), post-treatment pain did correlate with the presence of pretreatment pain in both incidence and severity (30).

It has been demonstrated that a flare-up has no significant influence on the outcome of endodontic treatment (19, 24, 31, 32).

In this case, healing was evident radiographically after one year. Since the reversal of the healing process is not to expect (19, 33), prolonged observation of teeth that demonstrate signs of healing at one-year recall is not necessary (33).

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UNIVERSITAS OSLOENSIS MDCCCXI

Case 11 – Musculosceletal pain and treatment of non-vital tooth 37 with alternative rotary system

Patient

62 year old white, Norwegian male

Figure 1 Frontal view

Chief complaint

Diffuse discomfort left side and a feeling that a tooth in the lateral segment lower jaw is “to high”, especially in the morning. The symptoms have persisted for 2 years.

Medical history

TIA (transient ischemic attack) 2004. Albyl-E® (acetylsalicylic acid) 160 mg x 1, Lipitor® (atorvastatin calcium) 60 mg x1. In addition: Herbal medicaments; phytomedicine, which refers to using plant's seeds, berries, roots, leaves, bark, or flowers for medicinal purposes. Meditative techniques are also used by the patient to get rid of his medical as well as spiritual problems.

Dental history

The patient had earlier gone through treatment with periodontal depuration and periodontal surgery in the the actual area, 1,5 years ago by his GPD. His symptoms persisted despite this treatment and his phytomedical/ meditation procedures. He therefore had a wish for a second opinion of his condition.

Clinical findings

Fig. 2 Occlusal view, maxilla

Fig. 3 Occlusal view, mandibula

	34	35	36	37
EPT (0-80)	**28**	**34**	**80**	**-**
Cold	**Yes**	**Yes**	**No**	**No**
Palpation	**No**	**No**	**Yes**	**No**
Percussion	**No**	**No**	**Yes, vertically**	**No**
Pocket depth	**2 mm**	**2 mm**	**2-3 mm**	**2-3 mm**
Restoration	**Porcelain fused crown**	**Porcelain fused crown**	**Composite**	**Composite**
Intraoral examination	**Sinus tract located buccaly of mandibular molars, left side**			
Extraoral examination	**Moderate to high level of discomfort during palpation of masticatory muscles**			

Table 1 Summary of clinical findings

On a pain assessment scale, the patient ranges his discomfort as 5 out of 10. He points as the whole cheek and describes that the affected area to be localized from the lower border at the corpus of mandibula, up to the coronoid process, where the *M. temporalis* attaches to the lower jaw. When assessing functional movement, no trismus was evident, but deviation of jaw to the right during closing movement. When palpation the masticatory muscles, the degree of discomfort reported by the patient was moderate tenderness on palpation *M. pte lat* and severe of the *M. masseter prof*. Application of heat or cold stimuli or LA injection not performed.

Radiographic findings

Fig. 5, 6. Fistulogram. The opening of the sinus tract in the oral cavity is tracked to the apical area of tooth 36

Mandibular, left second premolar: Radiopaque restoration consistent with metal-ceramic crown. The lamina dura can be followed intact along the root surface.

Mandibular, left first molar: (Possibly second molar if first molar extracted in childhood but the patient has no memory of this). Radiopaque crown restoration coronally. The lamina dura can be followed without any disruption at the mesial aspect of the roots. In the apical area, PDL is widened to a radiolucent lesion of approximately 5x12 mm up along the distal aspect of the tooth.

Mandibular, second molar: Radiopaque restorations of alloy (amalgam) and composite or glass ionomer is seen at the occlusal aspect. The root canal system presents with a radiopaque filling material. The lamina dura is intact.

Diagnosis

Pulpal: K04.11 Infected, necrotic pulp

Apical: K04.62 Apical periodontitis with sinus tract to oral cavity

Periodontal: Within normal limits

Other: K07.4 Malocclusion, cross-bite. Suspected musculosceletal disorder

Problem list

Long-standing, well-established infection with extensive radiolucency. As much pain of 5 on a VAS scale is seldom reported when CAP with sinus tract is the diagnose. Symptoms are likely to be due to dysfunction in the musculoskeletal tissues and/or malocclusion, and the separate conditions may both cause some degree of symptoms in adjacent areas. Concerning the patient's own ability to judge which tooth hurts; this is shown not to be reliable because of several mechanisms involved, including referred pain, possibly from muscular sites in this case. However, seldom referral across midline.

Treatment plan

Endodontic treatment of non-vital tooth 36. Anti-inflammatory medication for 7 days and exercise program, referral to Specialist in prosthetics. The patient was informed about diagnosis, treatment and prognosis.

Treatment at 2nd visit 2011-01-13

Fig.7, WL radiograph distal root canal

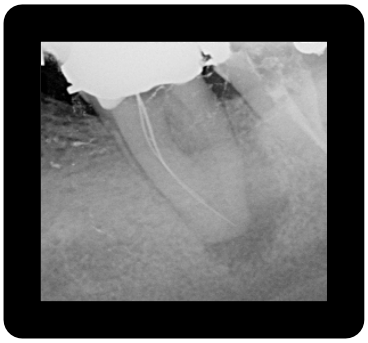

Fig. 8 WL radiograph mesial root canals

According to the treatment plan, endodontic therapy of the non-vital tooth was initiated. Access cavity through the metal-ceramic crown with fissure bur. The mandibular, right first molar was isolated with a rubber dam, opening and pre-flaring with LN and GG-burs. Microbiological sampling conducted. The WL was electronically Root ZXII® (J Morita, Irvine, CA) and radiographically determined (fig. 7, 8) and the instrumentation was completed using nickel-titanium rotary files NiTi-TEE® (Sjöding Sendoline, Kista, Sweden) MB: #45/21 mm, ML: #40/24 mm, D: #60/20 mm. The canals fused apically. The irrigation solutions used were 1% sodium hypochlorite, 17% EDTA, 2% CHX and the intracanal medicament was

$Ca(OH)_2$. Irrisafe® ultrasonic tip, designed for safe removal of dentin debris and bacteria, was used during passive ultrasonic irrigation. Non-cutting rounded end prevents damaging the apical constriction. It was used with a low to medium power setting.

Result of the microbiological analysis:

Tester / funn

DNA-DNA Hybridisering:

Porphyromonas gingivalis	(G- anaerob sortpigmenterende stav)
Fusobacterium nucleatum subsp vincentii	(G- anaerob stav)
Actinomyces viscosus	(G+ anaerob stav)
Prevotella nigrescens	(G- anaerob sortpigmenterende stav)
Tannerella forsythia	(G- anaerob stav)

Treatment at 3rd visit 2011-11-21

The patient reported no increase in post-treatment symptoms. Removal of the temporary filling under aseptic procedure. $Ca(OH)_2$ removed using hand files, 1% NaOCl and 17% EDTA. Canals dried w/ paper points. No exudation evident in the root canals. Master cone radiograph, fig 9.

Fig. 9. Master cone radiograph

The root canals were obturated with cold lateral condensation using gutta-percha and epoxy-based resin sealer AH26® (Dentsply Maillefer). IRM plugs in the canal openings. The patient did not receive antibiotic treatment in either treatment session.

Result

Fig. 10 Final radiograph 2011-11-21

Evaluation after treatment

The obturation seemed dense and good, the sinus tract was closed. The patient was still a bit tender on muscular palpation. He was referred to a specialist in prosthetic dentistry.

Prognosis

Endodontic: Good

Total: Good

Follow-up examination

January 2012: The patient had healthy soft tissue conditions and the tooth did not feel “too high” anymore. He had got an appointment at the specialist in prosthodontics but decided to cancel this because his symptoms had decreased. The patient was informed that his musculosceletal symptoms could return and about the independence of the tooth which had been treated for CAP. Exercises were demonstrated and written explanation with suggestions for exercise to do at home delivered to the patient, since he had cancelled his appointment at the prosthodontics specialist.

Fig. 11. Pre-op photo with sinus tract

Fig. 12. Follow-up photo with healthy conditions

March 2012: The patient had done exercises on a daily base. Together with his own “mind-controlled relaxation therapy” and herbal medicine, he now claimed to be free of symptoms. The mucosa presented healthy, radiographs showed signs of healing.

Fig.13 X-ray January 2012 with initial healing

Fig.14 X-ray March 2012 with further osseous healing

Discussion

For morphological description of the mandibular, first molar, see case 1.

Concerning pain of musculoskeletal origin, epidemiological data are difficult to obtain because of the lack of consensus about the diagnosis of the condition. Musculosceletal pain has been reported to be in the level of 9% in a control population (risk occupations higher)(1). As one of the non-odontogenic sources of pain,

myofacial or more specific, musculosceletal pain, is usually described as steady, aching and deep, often diffuse, or sometimes referred.

It may be exacerbated by the palpation of trigger points. ‘Trigger point’ are defined as ’a hyperirritable nodule within a taut band of skeletal muscle that when is palpated is tender and produces referred pain’ (1). Pain in the upper portion of the superficial layer of the *M. masseter* may refer towards maxillary posterior teeth. Pain in the lower portion often refers towards mandibular posterior teeth. Molars are the teeth most frequently subjected to referred pain. The masseter muscle is the major cause of referred pain from muscle or trigger point palpation(2).

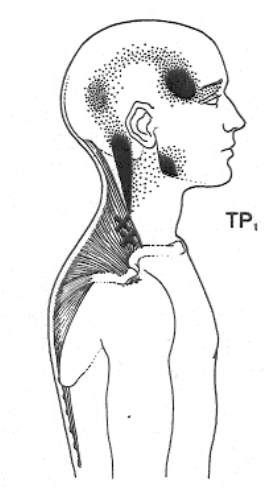

Fig. 15. Referred pain. The pain may be projected to, but also from teeth

During the examination, it is valuable to ask the patient if the pain they are experiencing is similar to that described in the chief complaint. Important aspects to assess are; the words used by the patient to describe the pain, if it is diffuse or may be pointed out, if the location varies (muscle pain tends to be fixed in location), how intense the pain is experienced and also if the patient has parafunctional behavior as grinding at night or nail biting, habits concerning foreign bodies etc during day. Questions should also be asked as if the patient has experienced injury to the face or mouth and if jaw movements or chewing hard foods hurts; painful muscles get tired easily. The onset of pain after chewing may also tell something about the etiology; as immediate onset suggests an inflamed joint, whereas jaw muscle pain tends to hurt more after meals rather than during the meal(3).

The aim of the treatment in this case was to cure the AP (4). The microbial factors in the intiation, development and persistence of AP is well documented (5-10). The main goal of endodontic therapy is therefore to clean, disinfect and shape the root canal system by chemo-mechanical means. The success of the treatment is dependent on the control of the infection before root filling (11); microorganisms, remaining in the root canal after filling or re-colonizing the earlier treated canal system, are the main cause of endodontic failure (12). Antisepsis, which is the attempt to remove all microorganisms, is the key issue in non-vital cases, as we know that the pulp space of non-vital roots with radiographic signs of periapical pathological changes always harbors cultivable microorganisms (10).

The main purpose of instrumentation is the mechanical debridement of the root canal system and the creation of space for delivery of antimicrobial medicaments and materials. A well-shaped root canal system facilitates the proper placement of a tight root canal filling to prevent re-colonization by oral microbiota (13).

An optimal root canal preparation should shape and clean the root canal system effectively whilst maintaining the original configuration without creating any iatrogenic events such as instrument fracture, external transportation, ledge, or perforation (14). Traditional stainless steel instruments often fail to achieve the tapered root canal shapes needed for adequate cleaning and filling, especially if severely curved canals are present. Straightening of curved root may be a result. In order to reduce canal aberrations, nickel-titanium (Ni–Ti) instruments have been developed. Ni–Ti instruments for rotary endodontic treatment have during the last decades been an important part of the endodontic armamentarium. Rotary Ni–Ti systems have greater flexibility (15) and have been shown to maintain the original root canal curvature well (16-18).

Multiple engine-driven systems are available, for vertical movement, reciprocal rotation, lateral oscillations, or most commonly; 360^{o} rotation. In this case, Sendoline Ni-Ti TEE® (Sjöding Sendoline, Kista, Sweden) rotary files were used. In a comparative *in vitro* study with NiTi-TEE and K3 (Sybron Endo, Orange County, CA, USA), these Ni-Ti systems were shown to have a good maintenance of root canal curvature and centering ability. No of the systems were able to remove debris and smear layer completely. Both systems were safe to use (19).

Irrigating regimen is an important part of effective root canal disinfection mentioned above (20). The irrigaton solutions primary function is to enhance bacterial elimination from the root canal (planctonic or biofilm), as well as lubricating the canal, which is very important to avoid un necessary instrument separation, dissolving the pulp remnants, washing out debris created by canal instrumentation and cleaning the smear layer (most studies favour removal of this layer of debris).

Irrigants should ideally (21)

- ✓ destroy microorganisms and neutralize their products without damaging host tissues
- ✓ disinfect and penetrate dentin tubules
- ✓ dissolve pulp tissue
- ✓ inactivate endotoxins
- ✓ offer long-time antibacterial effect
- ✓ remove the smear layer
- ✓ be non-antigenic
- ✓ non-toxic
- ✓ non-carcinogenic
- ✓ no adverse effect on dentin and the sealing ability of filling materials
- ✓ be inexpensive
- ✓ be convenient to apply
- ✓ cause no discoloration

Some of the relevant irrigants are: sodium hypochlorite of concentrations 0,5 -5.25%. This has a high degree of bactericidal cytotoxicity and dissolution of organic material ability. EDTA (ethylene diaminetetraacetic acid) 17% for smear layer removal, chlorhexidine (CHX) 0.2% for bacteria removal, citric acid 50% for smear layer removal, MTAD (doxycycline, citric acid, Polysorbate 80) or distilled water that clean canals of all remnants of any solutions.

NaOCl is the most commonly used root canal irrigant and are recommended as the main irrigant (21). This is because of broad antimicrobial spectrum as well as unique capacity to dissolve necrotic tissue remnants. Although NaOCl has been widely used in endodontics as an irrigant, there are no consensus regarding the ideal concentration to be used. Data concerning the antimicrobial effectiveness of different NaOCl concentrations have also revealed conflicting results and several countries use the “full-strength” variant of 5,25%. In vitro studies show better antibacterial effect with increasing concentration (fig. 15).

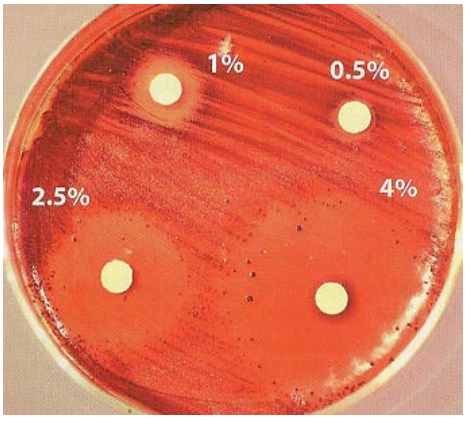

Fig 16. Antibacterial effects of different NaOCl concentrations against Prevotella nigrescens in an agar diffusion test. From (22)

The reduction of intracanal microbiota, on the other hand, is not shown to be any greater when 5% sodium hypochlorite is used as an irrigant, compared to 0.5% (23, 24). The risk-benefit ratio should be considered during the choice of irrigant solutions, and extrusion of NaOCl into periapical tissues should be avoided because of its cytotoxity (25). We know that continuous renewal of NaOCl fluid because of inactivation in the root canal is of importance, but the optimal time that a hypochlorite irrigant at a given concentration needs to remain in the canal system is an issue that needs to be further looked into.

Free chlorine in NaOCl dissolves vital and necrotic tissue by breaking down proteins into amino acids. Reactive chlorine in aqueous solution at body temperature can take the form of hypochlorite (OCl^-) or hypochlorous acid (HOCl). Above a pH of 7.6, the predominant form is hypochlorite, below this value it is hypochlorous acid. Both forms are extremely reactive oxidizing agents. Pure hypochlorite solutions as they are used in endodontics have a pH of 12, and thus the entire available chlorine is in the form of OCl^-. However, at identical levels of available chlorine, hypochlorous acid is more bactericidal than hypo- chlorite. One way to increase the efficacy of hypochlorite solutions could thus be to lower their pH. However, buffering hypochlorite with bicarbonate renders the solution unstable with a decrease in shelf life to less than 1 week.

This was a case with necrotic tooth and CHX was chosen as one of the irrigation solutions because of its antimicrobial properties and its relatively low toxicity. Its activity is pH-dependent and reduced in the presence of organic matter (26) . CHX It has a broad antimicrobial spectrum and shows substantivity, i.e. it is retained on dental surfaces and may exert its action for a prolonged period (27). Unlike NaOCl, it cannot dissolve organic substances and necrotic tissue. Like NaOCl, it is not able to remove the smear layer.

There are many options concerning irrigation systems; The Endovac, ultrasonic irrigation/ Irrisafe, sonic irrigation/endo activator, Sonic max, Rinsendo, IrriVac, Max-i-Probe, PUI Endosoft from EMS, Laser-activated irrigation (LAI) and Photon-initiated photoacoustic streaming (PIP). One of the systems available in Norway is the Endovac® (Discus Dental) with apical negative pressure; literature shows that post operative endo pain is less when Endovac® has been used (28). Laser-activation is based on cavitation in water but need to be further studied.

Research evaluating canal cleanliness compared to apical one-third shape, has shown that the taper need to be 0,06 to ensure that a sufficient volume of irrigant over an adequate interval of time can with enough efficacy circulate and clean the root canal (14). The rotary system used in this case met this requirement.

Because studies have demonstrated that 40-60% of the root canals still contain detectable levels of cultivable bacteria after chemomechanical procedures, using either NaOCl or chlorhexidine as an irrigant and the use of an antimicrobial intracanal dressing to enhance root canal disinfection before filling has been recommended (11, 23, 29). In this patient, irrigation was performed with 0,5% NaOCl, 17% EDTA and in addition, chlorhexidin di-gluconate irrigation was performed as a 5 minutes inlay with passive ultrasonics. The first use of ultrasonics (US) was reported by Richman in 1957. The use of US as an adjunct in disinfection of the root canal was first proposed by Martin in 1976 (20). US has become increasingly more useful in applications such as gaining access to canal openings, cleaning & shaping, removal of intracanal materials and obstructions, in irrigation procedures and in endodontic surgery. Ultrasound is sound energy with a frequency above the range of human hearing, which is 20 kHz. Common US devices are driven by magnetostriction or piezoelectricity, resulting in oscillation (25–40 kHz). In this method the rapid vibration are transmitted from a power source through hand piece to endodontic instrument. The ultrasonic device generate two types of physical effect in liquid media; caviation and acoustic microstreaming, described by Ahmad *et al* (30). Cavitation may be described as “the oscillation movement of gas or vapour filled bubbles in liquid medium” (31). Due to ultrasonic energy, the violent oscillation of bubble collapse result in generation of short wave in liquid media which help in effective cleaning of root canal walls. The acoustic streaming result in production of large hydrodynamic shear stress along the file which is more capable of disrupting most biologic material. All together, these mechanisms help moving the irrigant into areas of complex anatomy and irregularities of the canal. The fact that the antibacterial solution is warmed up during the UL-procedure may enhance the antibacterial effect (20).

Calcium hydroxide (CH) was used as an interappointment, intracanal medicament. An endodontic, intracanal medicament is defined as an antimicrobial agent that is placed inside the root canal between treatment appointments in an attempt to destroy remaining microorganisms and prevent re-infection (32). The goal is to kill bacteria, reduce inflammation, eliminate apical exudation and prevent contamination between appointments (33).

When intracanal medicaments were not used between appointments, bacterial numbers increased rapidly (34). CH is usually the anti-bacterial medicament of choice. CH was introduced by the German dentist Bernhard Hermann in 1920. CH is a white odorless powder and is chemically classified as a strong base with a pH of approximately 12,5. In the presence of water, CH dissociates into hydroxyl and calcium ions. Most of its biological effects are related to its alkaline pH (the hydroxyl ions). The lethal effects of hydroxyl ions on bacterial cells are probably due to damage to the bacterial cytoplasmic membrane, protein denaturation and damage to the DNA. Another important feature of $Ca(OH)_2$ is that it inactivates endotoxin, in vitro and in vivo(33). The pH gradient of the cytoplasmic membrane is altered by the high concentration of hydroxyl ions from calcium hydroxide acting on the proteins of the membrane (protein denaturation) (33). The vehicle to which calcium hydroxide is added, affects the physical and chemical properties of the compound. In our clinic, water-soluble agents are used. Sjögren *et al*. demonstrated that a 7-day application of a CH medicament was sufficient to reduce canal bacteria to a level that gave a negative culture (35). Shuping *et al*. showed that placement of CH for at least 1 week rendered 92.5% of canals bacteria free (29).

CH placed as a medicament has to be removed before the canal is filled. Calt & Serper 1999 found in a laboratory study that remnants of $Ca(OH)_2$ may hinder the penetration of sealer into the dentinal tubules. Kim& Kim found that CH may increase the apical leakage of root fillings. It seems that ultrasonic methods are more efficient in removing CH remnants than passive irrigation (33).

After chemo-mechanical disinfection of the root canal, obturation of the space is performed with a bacteria tight sealing in all the parts of the root canal (36).This was in this case achieved by use of gutta percha and sealer AHplus®. Sealers serve as an aid to prevent re-infection because the gutta percha does not adhere to the dentin walls. The sealer will entomb remaining bacteria and fill out irregularities in the canal system (37). Requirements and characteristics of a good sealer according to Grossman was: tacky when mixed to provide adhesion to canal wall, able to create a hermetic seal, radiopaque, particles of powder should be fine so that they mix easily with liquid, should not shrink on setting, should not stain tooth, bacteriostatic (or at least not encourage bacterial growth), slow setting, insoluble in tissue fluid, tissue tolerant (non-irritating to PA tissue), soluble in a common solvent. Additional requirements, added by Ingle; it should not provoke an immune response and should be neither mutagenic nor carcinogenic.

Different types of sealer have been introduced to endodontics, including those based on zinc oxide eugenol, calcium hydroxide-based, glass–ionomer cement and a range of resins. Epoxy resin-type sealers have been used for many years, and these have in several studies showed higher bond strength to dentine. Investigations of the bond between sealer and the canal wall, the effect of the smear layer on bond strength and ‘push-out’ tests have been described to measure the bone between sealer, canal wall and core material. Some authors have reported a higher interfacial strength of gutta percha/AHplus than Resilon/Epiphany, whereas others have found the opposite. The question has also been rised concerning how essential property the bond strength really is concerning leakage.

Most sealers are toxic before setting. Methods of testing sealers for tissue tolerance would be a cytotoxic evaluation; as on HeLa cells or fibroblasts in culture, simple and inexpensive. Subcutaneous implants: needle injection under skin or in Teflon cups of animals is another way of testing. The results would be similar to cytotoxic studies. A third way of testing material will be osseous implants where the material is directly implanted into bone or at last; the most complicated way; in vivo tissue tolerance tests in humans: the best test method, but often dangerous, expensive and unethical. Many in vivo tests on lab animals have to be perfomed before this step.

The coronal seal is of importance for avoiding recontamination of the root canal. Kirkevang *et al* found that inadequate root canal and coronal restorations were associated with an increased incidence of AP (38). Ray& Trope 1995 reported that the technical quality of the coronal restoration was significantly more important than the technical quality of the endodontic treatment for apical periodontal health (39). On the other hand, Bergenholtz *et al* 2000, found that the problem of coronal leakage may be of a lesser clinical importance as implicated by numerous studies in vitro, provided instrumentation and root fillings are carefully performed (40).

The patients treated at the the Department of Endodontics, UiO, are all being recalled for clinical and radiographical follow-up. The assessment of the incidence and prevalence of CAP in different populations are important for defining treatment needs and to relate treatment outcome to various technical and clinical factors of endodontic intervention (41). Since Goldman *et al.* (42) demonstrated poor inter- and intraobserver reliability in interpretation of periapical radiographs, attempts have been made to improve evaluation procedures. In order to define a more reliable criterion for 'success' and 'failure', the PAI index (43-45) may be used to describe periapical tissues.

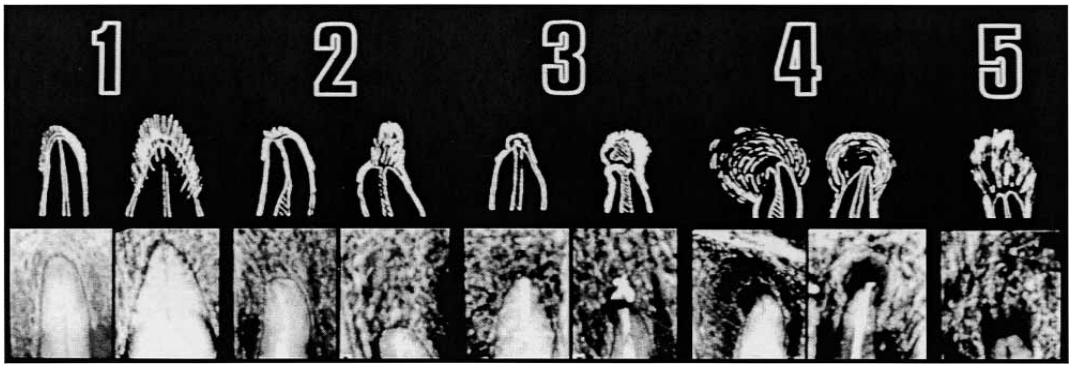

Fig. 17. The periapical index. 1, Normal periapical structures 2, Small changes in bone structure. 3,Changes in bone structure with some mineral loss. 4, Periodontitis with well-defined radiolucent area. 5, Severe periodontitis with exacerbating features (46).

The PAI scoring system has been modified and applied to epidemiological and clinical comparative studies of treatment outcome. The possibility of comparisons among studies carried out with calibrated observers makes this system attractive.

Fig. 18 Sendoline rotary files

Fig. 19 Sendoline rotary device

In this case, Sendoline rotary system, intital kit, was used. Dental technician, John Sjöding, founded Sendoline in 1917. He developed the H-file, in the 1940's in collaboration with the Swedish doctor Gustav Hedström.

Fig. 20 Cross-sectional images of H-file and S-file

In 1990, Sendoline launched its first Nickel Titanium files along with the NiTi-TEE® Rotary file system. The system consists of five files. The coronal and middle sections of the canal are prepared with S5 file no.1, motor setting 1 (torque 4,0). File no. 2 is then used with motor setting 2 (torque 3,0). This often reaches a depth of at least 2/3 of the root canal. File no. 3 is then used working toward the apical section of the canal (torque 2,3). With file no. 4 and motor setting 4 torque 1,2), the working length is normally reached. If needed, file no. 5 is used, with motor setting 5 (torque 0,5).

The system is cordless, weigh 120g and comes with Li-IO battery that provides 2,5 h of work time. It has a constant rotational speed of 300rpm, auto-reverse and autostop. The torque control is adjusted so that a warning light indicator is shown when 75% torque is reached. The head of the endo motor is small compared to device of other brands, made for maximum visibility. The file system is available in 23 mm and 28 mm with a shank length of 13 mm and a S-diameter profile. “A retreatment kit” and a “Big apical file”-kit up to ISO 50 exists.

Concerning which device or instruments are the one of choice, many of the studies available in the literature. The focus is often on the comparison between two instrument types and in many cases these investigations have been performed by different operators. Research has found that the clinical outcome of endodontic treatment is significantly affected by preoperative diagnoses, but not by the specific choice of an instrumentation system (47, 48).

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Case 12 – perforation repair

Patient

26 year old South Asian female

Figure 1. Frontal view

Chief complaint

Pain lower right jaw

Medical history & dental history

See case 3

Clinical findings (see summary of clinical findings case 3)

Fig. 2 Occlusal view, maxilla

Fig 3. Occlusal view, mandibula

Fig.4 Lateral view

Fig. 5 The restoration had coronal leakage.

Radiographic history from student clinic

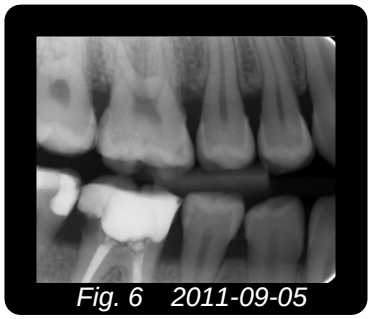

Fig. 6 2011-09-05

Fig. 7 2011-09-05

Fig. 8 2011-12-02

Radiographic findings in post graduate clinic

Fig. 9 2012-01-10

Fig. 10 2012-01-10

The patient had a normal marginal bone level generally in her dentition, but in relation to the mandibular, first molar, intraradicular radiolucency was evident

Diagnosis

Pulpal K04.19 Root filled. Strip perforation distal aspect of mesial canals

Periapical Within normal limits

Marginal Localized marginal/ interradicular bone loss

Problem list

Risk of extrusion of the filling material into the adjacent periodontal structures. Localization of perforations, time aspect (the perforations had been left untreated for 1,5 months).

Treatment options

Non-surgical perforation repair of the tooth without revision of root canal treatment. Root canal re-treatment of the tooth with non-surgical or surgical perforation repair. Extraction.

Treatment plan

The patient wished to try to keep the tooth. Revision further apically was decided not to be performed, as the tooth from the beginning was asymptomatic and had physiological conditions apically. The indication for starting the endodontic re-treatment was carious lesion/ possible leakage into the gutta-percha, prior to treatment with crown restoration. The perforation repair should not be postponed any further concerning the prognosis. A surgical approach would be challenging as a lingual flap would have to be raised, possibly difficult moisture control and limited access. A non-surgical technique/ internal repair was chosen as the perforations were accessible and could be visualized in the SOM. MTA was the material of choice for

perforation repair; its biocompatibility, antibacterial properties and setting in presence of moisture was expected to create the best possible seal. In addition, some material was expected to be extruded into the periodontal structures, therefore the properties of MTA were desired.

Treatment

The perforations were localized after applying rubber dam with disinfection, removal of temporary filling, irrigation, use of the SOM and inserting paper points into the root canals. The level of blood on the paper points indicated the level of the perforations.

Fig. 11. Angelus MTA was used in this case.

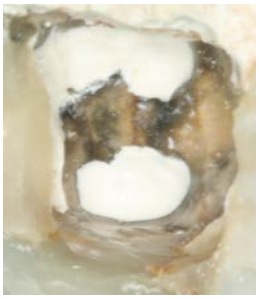

Fig. 12 The orifices sealed with IRM plugs

Result

Fig. 13 2012-01-19 Radiograph after MTA obturation

Evaluation and prognosis

Concerning the time from iaterogenic perforation until repair, the localization and the relatively large-sized defects, the prognosis was set to be questionable.

Follow-up examination 2012-04-11

The patient met for re-examination after three months, free of symptoms. The tooth had an intermediate restoration, but this was of adequate quality with a good coronal seal (fig. 16).

Fig.14. Frontal view on follow-up exam

Fig.15. Lateral view

Fig. 16. Occlusal aspect

The patient presented with apparently healthy gingival conditions. Light probing was done around the mandibular, right first molar. She had been provided with a temporary crown with post in distal canal from the student clinic. Mandibular, right second molar had composite restoration as coronal restoration.

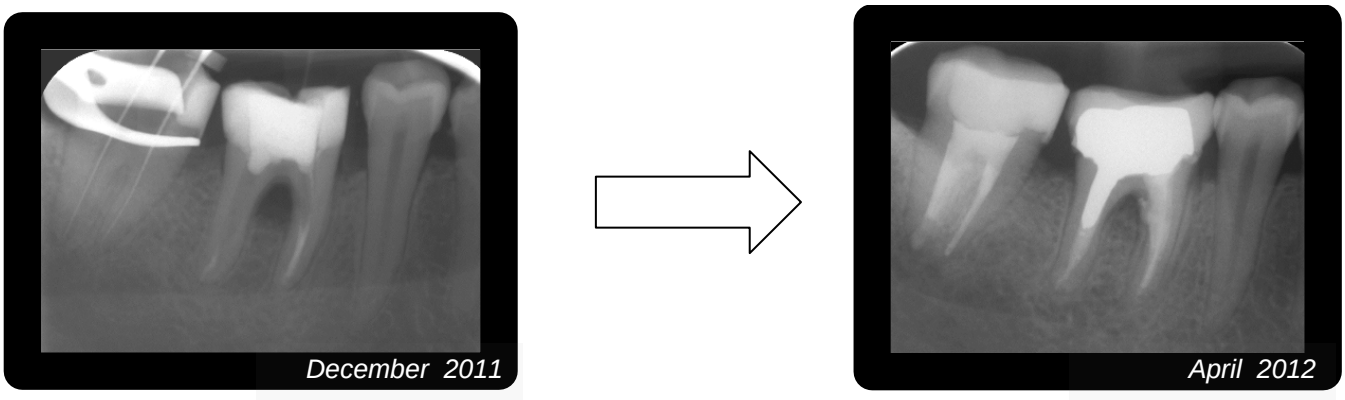

Fig. 17, 18. Radiographs for comparison before treatment and 4 months after treatment

Discussion

For morphological description of the mandibular first molar, see case 1.

A root perforation is defined as “mechanical or pathological communications between the root canal system and the external tooth surface” (1). Root perforation has traditionally a poor prognosis, and breakdown of the periodontium, bone resorption and formation of granulomatous tissue may ultimately lead to loss of the tooth if left untreated (2).

The incidence of perforations is quoted in the literature as being between 3 and 10 percent. 47% are induced during routine endodontic treatment, the remaining during preparation of posts (2) . The complication is reported to occur 73% in the maxillar and 27% in the mandibular arch.

Diagnostic signs of perforations	
Clinical	**Radiographic**
Patient feels sudden sharp pain when perforation occurs during treatment	Radiolucency at the site of perforation (long-standing infected case)
Profuse bleeding from injury site	Clear deviation from the path of the root canal
Electronic apex locator indicates ”apex” prematurely as file comes in contact with perforation site	Small file may be used to confirm presence of the perforation
Periodontal pocket at injury site	

Table 1. Clinical and radiographic diagnostic signs of perforations (3)

If the patient suddenly experiences pain, or an unexpected bleeding occurs during treatment, a perforation is to be suspected. An apex locator most likely will confirm or disprove this. Multiple, angulated radiographs including bite-wings are also helpful for accurate diagnosis. Sometimes a CT or CBCT could be valuable in diagnosing and localizing a perforation defect.

Iaterogenic strip perforations are often associated with thin and curved roots, caused by over-zealous use of endodontic files, post-preparation drills, or as in this case, Gates Glidden drills.

The aim of perforation management is to maintain healthy periodontal tissues against the perforation site, without persistent inflammation or loss of periodontal attachment (2). Non-surgical treatment is indicated, whenever possible.

$Ca(OH)_2$ has been suggested as a traditional agent to manage perforations, and its use is still indicated to control infection, arrest bleeding and as a temporary solution when insufficient time is available to perform a permanent repair. However, MTA, like used in this case, now appears to be the material of choice for the permanent repair of perforations from both a conservative and surgical approach (4). Properties of a furcation repair material should include good sealbility, biocompatibility, antibacterial effect and good handling properties.

The time lapse between the perforation and its repair is critical (5),- immediate closure carrying the best prognosis. Other factors of importance in relation to management and prognosis outcome include the periodontal status, level, location and the size of the perforation as well as the material used (6). The access and visibility in the SOM has in recent years given new opportunities in treatment in these situations.

← Good prognosis	Poor prognosis →
Fresh	Old
Small	Large
Apical/coronal	Crestal

Table 2. Factors on the left suggest a good prognosis, while factors on the right point towards a poor prognosis (from (2))

Both in vitro studies (6-8), animal studies (9, 10) and clinical studies (11-13) have shown good results concerning MTA as a material for repair of root perforations. It seems that MTA actively promotes hard tissue formation rather than being inert or acting like an irritant like other materials.

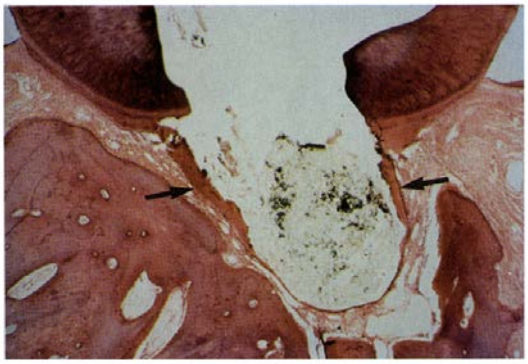

Figure 19. Furcation perforation of a mandibular dog premolar, repaired with MTA. Formation of cementum is evident and there are lack of inflammation in the periodontal ligament even after extrusion of MTA into the furcation (14).

In a study of perforation repair of 21 teeth with MTA, 86% were classified as healed. The patients were followed up 12-65 months. They concluded that MTA appears to provide a biocompatible and long term effective seal for root perforations in all parts of the root (15).

It has been reported that of the factors significantly affecting the success rate of the re-treatment, as in this case, was the presence of a pre-operative perforation (16). Concerning tooth-survival, absence of an iaterogenic perforation was one of the parameters found to improve this.

Some aspects of relevance for prevention of perforations to happen would be an adequate knowledge of the location and dimensions of the pulp chamber and roots, and understanding of anatomical variations of the specific tooth. Prior to the treatment, careful examination of radiographs need to be undertaken. Available equipment for magnification and illumination are of importance. Avoiding over-enlarging/flaring is also a key point.

The referral student was recommended to provide the tooth with a crown. An association between crown placement and the survival of endodontically treated teeth has been reported (17, 18).

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Case 13 - Patient with neuropathic pain condition

Patient

53 year old Northern European female

Figure 1. Frontal view

Chief complaint

The patient had a high level of fear and anxiety because of earlier painful dental experiences, which eventually evolved into a long-standing pain condition. Her level of pain at the moment is lower than earlier.

Medical history

The patient was diagnosed with “monosomy X”, Turner Syndrome (TS). Diabetes type I. Medications: Insulin inj, Rivotril® (clonazepam) and Surmontil® (trimipramine) since 1993. ASA group II

Dental history

Elevated pain level over a long period of time, approximately two decades. Persistant pain of varying intensity, especially left side. According to the patient, previous extractions were mostly due to pain, no information exists concerning diagnosis at the time of extractions. Some weeks after the extractions; the experience of pain was aggravated with a “tightening sensation” (patient’s own words). The level of pain is described to be low in the morning, higher during the day and especially in the evening. The painful area felt smaller in the beginning – larger area after some time, now also involving the tongue with a burning sensation. She described to have had less symptoms for many years before the removal of mandibular, left first molar 6 months ago, this exacerbated the pain once again. The patient was worried that a similar situation would happen at her right side, because of some discomfort on cold stimulus in lower, right jaw segment. Frequently use of Corsodyl® (GlaxoSmithKline) antiseptic mouthrinse, multiple times a day, ‘prophylactic against pain’ as phrased by the patient. She claims that this pain condition is the reason why she cannot work and feels depressed and stressed in her everyday life

Clinical findings

The patient patient expressed anxiety about our potential findings of pathological changes in her right, lower jaw, but was also worried that we would find nothing, she cried most of the time during the appointment. EPT (0-80) and thermal test (Endo Ice®) within normal limits. PPD within normal limits. Normal soft tissue and gingiva intraorally. Extraoral examination within normal limits. Semi-optimal restorations. Chronic carious lesions. Attrition, abration and signs of erosion are evident.

Figure 2. Dental attrition evident.

The patient denied grinding of teeth during day or night. Tongue appears normal, no atrophy. Her oral mucous membranes were apparently well-moistened. Negative findings concerning trismus or deviation when opening/closing of mouth. No sounds or dislocation of discus found. Muscles not palpated adequately because of lack of patient compliance. The patient did not want percussion or palpation tests to be performed because she was afraid of pain triggering. Autonome symptoms not observed.

Figure 3-6 occlusal view showing attrision, possible erosion

Clinical photography was complicated to perform in this patient, mostly due to her fear of getting worse after being at the dentists consultation and her wish for avoiding pulling in lip and cheek. Gentle and careful clinical as well as radiographical examination was attempted. An OPG could be of value in this case.

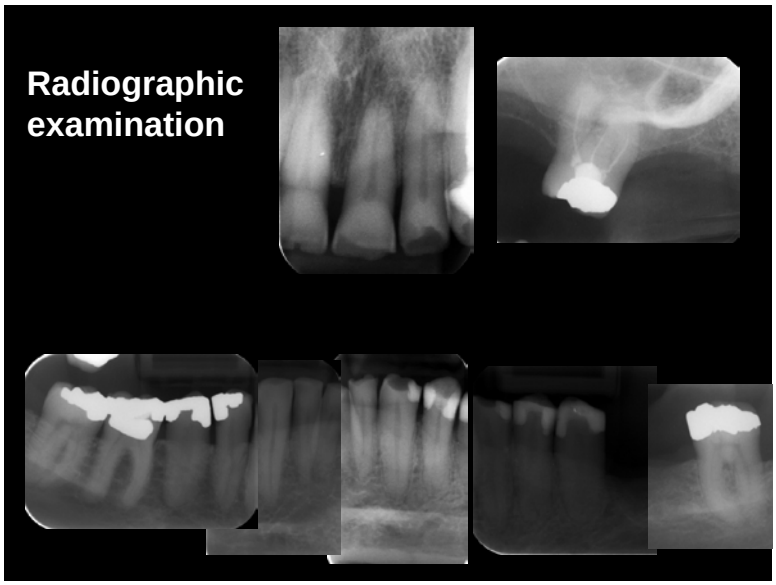

Figure 7. The radiographs possible to achieve, did not reveal any pathological condition. Because the fear of triggering pain when placing intra-oral film, an OPG is planned at the next recall.

Diagnosis

Pulpal: Within normal limits

Periapical: Within normal limits

Periodontal: Within normal limits

Pain of non-odontogenic origin, central sensibilization likely

Problem list

Psycological problems/ anxiety. Diabetes. The non-curative diagnosis of neuropathy. Sub-optimal restorations should have been more adequate treated but the patient wants as little intervensions as possible due to possible recurrence of the pain level earlier experienced.

Treatment plan

Observation every 6-12 months, after wish from the patient

Collaboration with general practitioner, confirming that the diabetes is well controlled

OPG on next appointment

CT sin max and MR Caput with increasing symptoms

Salivary secretion test, monitoring the level and quality/ buffering capacity

Prognosis

Uncertain. Since the pain condition already has existed for a long time, one may assume that the symptoms will persist at some level. If further examinations reveal a situation of uncontrolled diabetes, this could possibly worsen the situation of numbness, burning or pain in the oral tissues as well as her being more prone to xerostomia. This would be unfortunate because of the already existing excessive tooth wear, as diabetes is known to be associated with xerostomia, which in turn will lead to even more attrition and erosion. An uncontrolled diabetes situation would also imply that the patient would be more prone to gingival problems, infections, candidiasis and poor wound healing.

If an uncontrolled diabetes situation is ruled out and no invasive procedures are performed, it is possible that the symptoms will diminish or at least remain at a low level.

Follow-up

The patient had no increasing symptoms, but a strong wish for continued observational appointment at our clinic.

Follow-up phone call February 2012: The patient wanted to delay the appointment until spring 2012 because of no further development of symptoms. Her medication had remained unchanged. The patient is scheduled for a new appointment according to the treatment plan in May 2012.

Discussion

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage(1) . It is described as an unpleasant sensation of discomfort, distress or suffering, which arises when noxious stimuli act on specialized nerve endings. Pain may be localized, or may be referred to parts other that in which it originates; also called referred pain (2).

Examples of odontogenic sources of pain (3) are carious lesions, dentin-hypersensitivity, pulpitis (carious, traumatic), gingivitis/marginal periodontitis, pericoronitis or apical periodontitis.

Any of these sources may give peripheral stimulation of nociceptive nerve fibers in tooth pulp, by *acute dentinal pain* that according to the hydrodynamic theory cause fluid movement in exposed dentinal tubules and result in the stimulation of nociceptive nerve fibers. *Pain with inflammation* is associated with the synthesis or release of mediators as prostaglandins, bradykinin, substance P and histamine. The interrelationships of these inflammatory mediators form a positive feedback loop, allowing inflammation to persist beyond the cessation of the dental procedure (4).

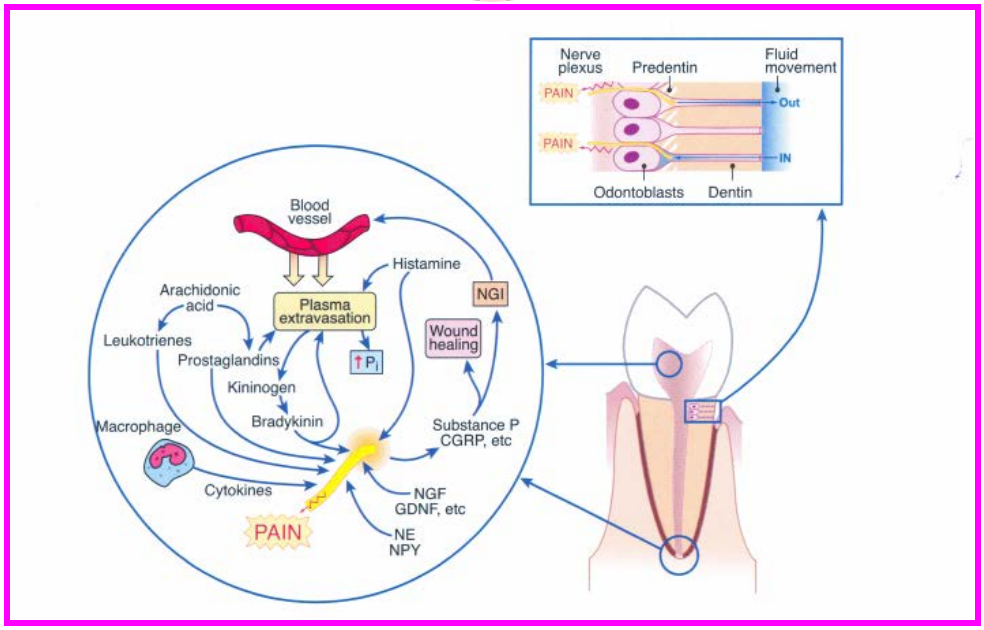

Fig 8. (4) Mechanisms for the peripheral stimulation of nociceptive nerve fibers in tooth pulp. Acute dentinal pain – the hydrodynamic theory. Pain with inflammation – inflammatory mediators and the positive feedback loop allowing the inflammation to persist beyond the dental procedure.

Intensity of pain; mild, moderate or severe, has relationship to the frequency of firing, number of nerves and the type of nerve fibers involved. Fast-conducting myelinated Aδ fibers have a conduction velocity of 12-30

m/s while the slow-conducting unmyelinated C-fibers have a conduction velocity of 0,5-2 m/s (5). Sharp, prickling sensation, like produced by an electric pulp tester (EPT), are due to stimulation of the Aδ fibers. Deeper, burning, aching and a more diffuse type of pain, results from stimulation of the C-fibers. C-fibers have a higher excitability threshold than the Aδ fibers. Differences in excitability between myelinated and unmyelinated nerve fibers are illustrated in table 1.

Symptoms and reactions	A-fibers	C-fibers
Conduction	Fast	Slow
Pain	Sharp	Dull
Cold	Yes	No
Heat	Yes	Yes
EPT	Yes	No
Localization	Good	Poor
Referred pain	No	Yes
Inflammatory mediators	No	Yes

Table 1. Differences in excitation of Aδ and C-fibers(5)

Some non-odontogenic sources of pain are (3, 6) sinusitis/ nasal mucosal, myalgia/myofacial/ TMJ, referred pain, neuropathic pain disorders including neuralgia, neuroma, neuritis, neuropathy, herpes zoster, multiple sclerosis, tumors, neurovascular etiology/ migraine, cluster headache, salivary gland disorders, cardiac/ angina pectoris or psycogenic sources.

If a patient presents with pain, there are several pain scales or pain assessment tools to help the patient describe the intensity of the pain and help diagnosing or measure the level of pain. These include numerical scales, verbal scales, visual scales or multidimensional pain assessment tools.

Numeric rating scales.(fig. 8) use numbers from 0-10 (0 being no pain and 10 being the worst pain) to rate the intensity of the pain.

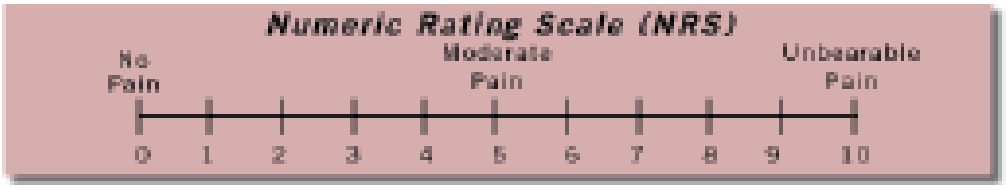

Fig. 9. Example of NRS

The NRS can be used by the clinician or at home by the patient as part of a pain diary that serves as a record of pain intensity at fixed times throughout the day.

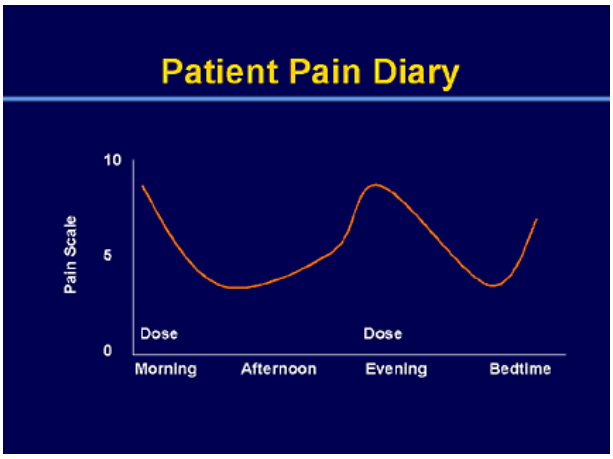

Fig. 10. Example of pain diary (7)

Verbal scales are pain assessment tools that contain commonly used words such as "mild", "moderate" and "severe" to help describe the severity of the pain.

Visual analog scale, VAS, consists of a 10-cm line with one end labeled “no pain” and the other end labeled “worst pain imaginable.” The patient marks the line at the point that best describes the pain intensity. The length of the line to the patient’s mark is measured and recorded in millimeters. The main advantage of the VAS is that it does not limit pain to 10 discrete levels of intensity, and to get a more detailed rating of pain.

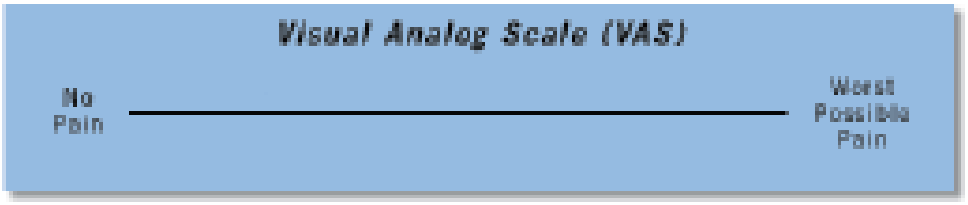

Fig. 11. Example of VAS scale

In this category of visual scales, there are pain assessment tools that use aids like pictures of facial expressions to help explain the pain severity. One type, the Wong Baker Faces Pain Rating Scale, shows six different facial expressions from happy (no hurt) to agony (hurts the worst). This scale may be useful in young children, in patients who have mild to moderate cognitive impairment, or patients with other language barriers.

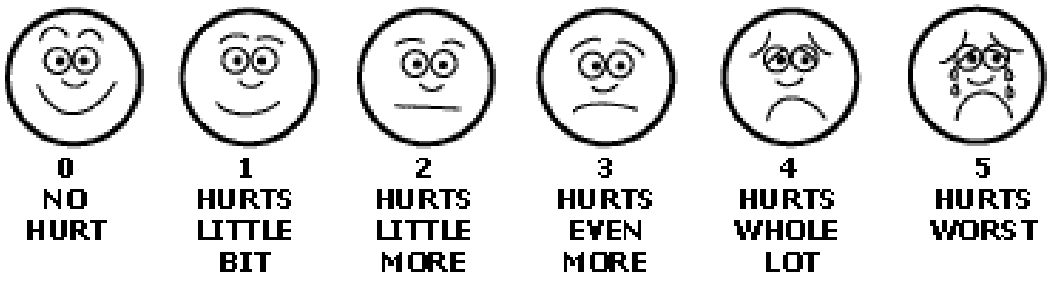

Fig. 12. The Wong Baker Faces Pain Rating Scale

Multidimensional pain assessment tools such as the McGill Pain Questionnaire (MPQ) and the Brief Pain Inventory (BPI), have been developed to quantitate different aspects of pain, including location and quality of pain and its effect on mood and function. The MPQ is a validated multidimensional clinical tool that assesses pain in 3 dimensions—sensory, affective, and evaluative—based on 20 sets of words that patients select to describe their pain. The words selected by the patient can be used to describe the quality of their pain, such as burning, shooting, electric, or pins and needles, and as throbbing, aching, or heavy. The description of these types of pain can suggest underlying nociceptive or neuropathic mechanisms. The MPQ takes between 5 and 15 minutes to complete, and is more often used in pain research rather than clinical practice.

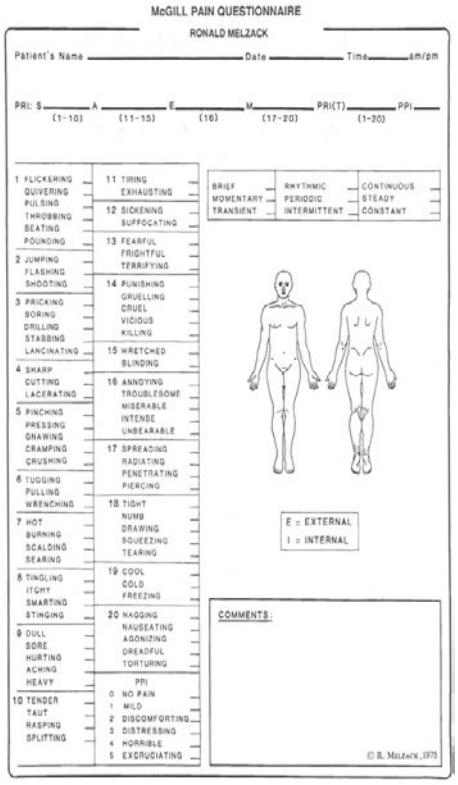

Fig. 13. The McGill pain questionnaire

Patient history, some elements: The chief complaint, or if more than one; prioritize complaints. Onset/ how long has the pain persisted? Induced/ non-induced from stimuli? Aggravating factors or relieving factors? Characteristics of the pain, quality and behavior. Localized or not? Intensity, VAS. Progression? Time of day/ night? Sleep disturbances. Duration (sec, min, hours)? Use of medications/ analgetics? Swelling, other signs, especially autonome, as secretion? Extraoral, intraoral. Inspection, palpation, percussion, sensibility, cold, (hot). X-ray (radiopacities, radiolucencies, lamina dura, sinus maxillaries, normal anatomy vs pathology). Selectiv anesthesia.

Pain can be divided into different these four types (8):

- Physiological pain
- Pathological pain, peripheral sensitization
- Pathological pain, central sensitization
- Pathological pain, neuropathic

In *physiological pain*, there are little or no tissue damage. Mechanical or thermical stimulation of pain receptors on thin, myelinated Aδ fibers activates nociceptor-specific in the n. tractus spinalis of the brain stem (fig. 14). A short, intense pain activates groups of muscles with protective reflexes. When the stimuli ceases, the pain is gone.

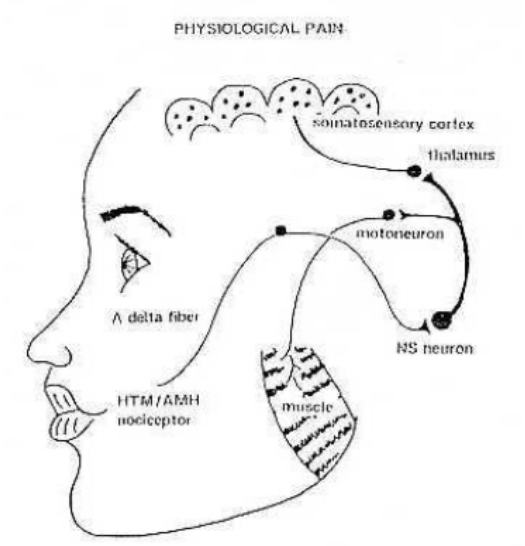

Fig 14. (8)Physiological pain activates HTM/AMH rec on Aδ fibres. The central neuron (NS) is nociceptive specific – it conveys only pain impulses. The pain is sharp and of short duration, associated with a protective reflex.

Pathological pain, peripheral sensitization is a nociseptive pain that occurs with pain or inflammation. The nociceptor reacts on inflammatory mediators and mechanical or thermal stimulation. Inflammatory mediators that give rise to pain is called algogenes. Important algogenes are bradykinin, prostaglandin, ions and cyclic nucleotides. Pain will be felt faster than without these algogenes. Nociceptor is located on thin unmyelinated C-fibers and the peripheral neuron has synapsis with wide dynamic range (WDR)-neuron in n. tractus spinalis (fig.15).

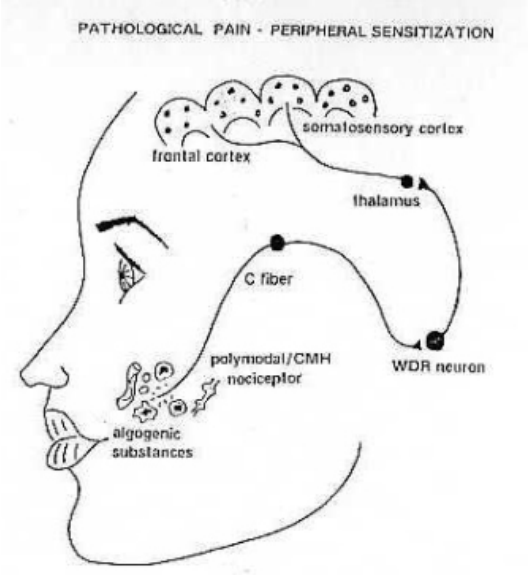

Fig 15.(8)Pathological pain with peripheral sensitization – associated with trauma, inflammation and release of algogenic substances. The central neuron is multireceptive WDR, it receives impulses from other somatosensoric nerves.

Pathological pain, central sensitization is a continuing of pain with peripheral sensitization. With intense and high-frequency stimulation of the WDR-neuron; this neuron sends pain impulses to the cerebral cortex, even after the peripheral stimulation ceases. The WDR-neuron will after some time lack the ability to distinguish between different sensory inputs. Somatosensoric impulses will now be interpreted as pain by the cortex.

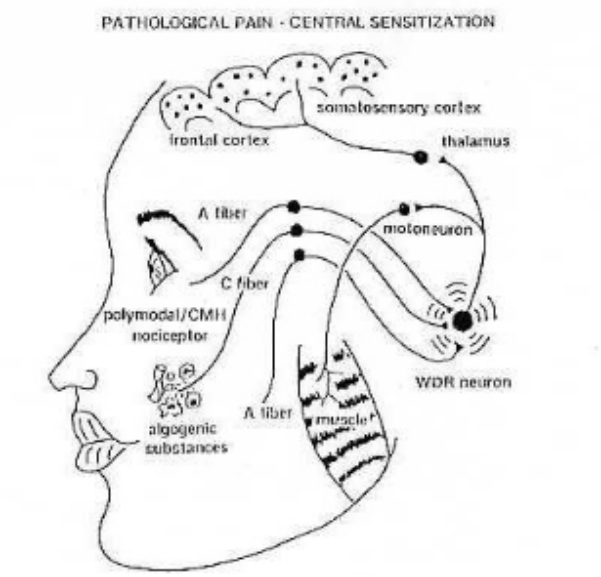

Fig 16. (8)Pathological pain with central sensibilization. Persistent pain stimulation will activate NMDA rec and give a wind-up. Inactive synapses with WDR neuron is activated. The painful area is more painful.

Pathological pain of neuropathic character is not mediated by C-fibers but thick, myelinated Aβ fibers, which usually mediates sensory qualities as touch and pressure. Biochemical changes may take place in the centrally neuron and lead to permanent neuroplastic changes and chronical pain. Activity in ion channels give rise to depolarization (Na+ with displacement of Mg2+ and Ca2+ influx) and activity in the methabolic receptors (glutamate/ NMDA rec, substance P/ NK-1 rec) give rise to permanent changes. Pain conditions may consist of several of the patophysiological types of pain.

Neuropathic pain is initiated or caused by a primary lesion in the peripheral or central nervous system. Infection, trauma and neurological diseases are common triggers for the diagnosis (9). It is important that clinicians recognize these patients as early as possible to avoid unnecessary and invasive dental procedures which will not lead to any relief of symptoms, but maybe even give increased levels of discomfort for the patient. More complex treatments may require referral to multidisciplinary pain clinics with expertise in this field.

Concerning etiology, deafferentation, damage on peripheral or central nerves with sensoric information to cortex, may give rise to hyperactivity and neuroplastic changes leading to pain. After amputation of limbs, 35% may feel phantom pain. After amputation of the pulp, 3-5% may expect to feel this kind of pain. Long-term nociceptive stimulation may lead to a wind-up activating of the NMDA glutamate receptor and permanent changes may be evident. Patients that are experiencing nociceptive pain over a long period of time may therefore develop neuropathic pain. Increased sympathetic activity by prolonged NA and then production of prostaglandin, will affect the primary afferent neuron and possible development of neuropatic pain. Also, lack of inhibitory mechanisms after prolonged nociceptiv pain or nerve damage may give rised activity in the central WDR-neuron. Spontanous neuroplastic changes may also happen, as with trigeminus neuralgia.

1. Please use the scale below to tell us how intense your pain is. Place an "X" through the number that best describes the intensity of your pain.

0 1 2 3 4 5 6 7 8 9 10

No Pain — **the *most intense* pain sensation imaginable**

2. Please use the scale below to tell us how sharp your pain feels. Words used to describe "sharp" feelings include "like a knife," "like a spike," "jabbing" or "like jolts."

0 1 2 3 4 5 6 7 8 9 10

No Sharp — **the *sharpest* sensation imaginable (like a knife)**

3. Please use the scale below to tell us how hot your pain feels. Words used to describe very hot pain include "burning" and "on fire."

0 1 2 3 4 5 6 7 8 9 10

No Hot — **the *hottest* sensation imaginable**

4. Please use the scale below to tell us how itchy your pain feels. Words used to describe itchy pain include "like poison oak" and "like a mosquito bite."

0 1 2 3 4 5 6 7 8 9 10

No Itchy — **the *itchiest* sensation imaginable**

5. Which of the following best describes the time quality of your pain? Please check only one answer.

( ) I feel a background pain all of the time and occasional flare-ups (break-through pain) some of the time.
Describe the background pain: _____
Describe the flare-up (break-through) pain: _____

( ) I feel a single type of pain all the time. Describe this pain: _____

( ) I feel a single type of pain only sometimes. Other times, I am pain-free.
Describe this occasional pain: _____

Source: Reference 22

Table 2. (8) In addition to the clinical pain assessment tools described above, there exists a scale, the "Neuropathic Pain Scale", mostly used for research purposes.

Neuropathic pain lacks peripheral pathology. The pain is as mentioned maintained from activity in Aβ-fibers which leads somatosensoric impulses as pressure and touch. WDR-neuron will in these cases lack the ability to distinguish between different sensoric modalities, and will interpret everything as pain.

This patient feels that the affected area with a higher pain level has increased during time. This may be explained by a central convergence of peripheral neurons against the one and same WDR-neuron as well as activation of earlier inactive synapses (8).

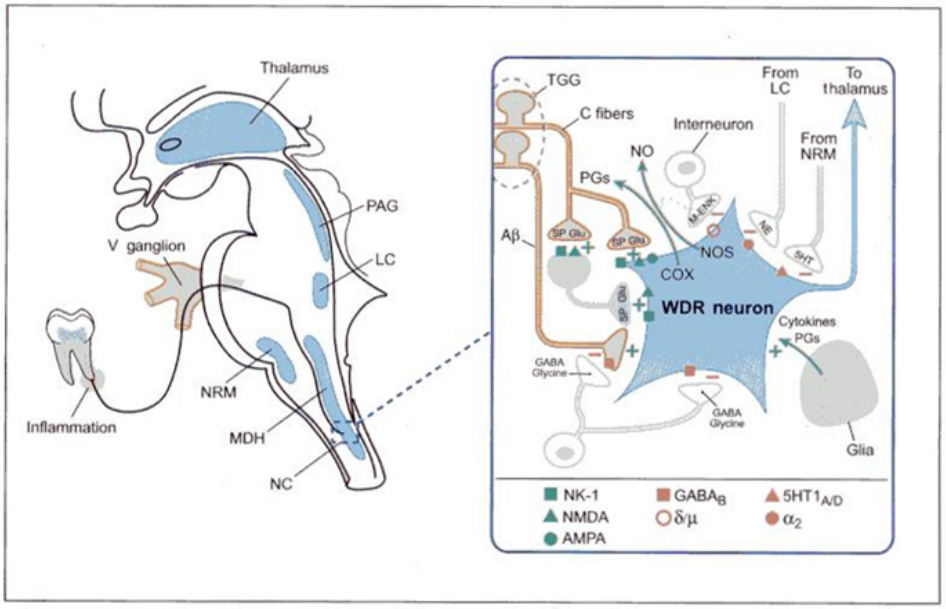

Fig. 17. Functional processing of nociceptive input in the nucleus caudalis of the medullary dorsal horn (MDH). Activation of pulpal C-nociceptive fibers which leads to Glu and SP-release, conveyed across a synapse to a WDR-neuron (4)

Some diagnoses with increased prevalence of neuropathic pain are postherpetic neuralgia, trigeminal neuralgia, poststroke pain (about 10% of people with strokes will end up with persistent pain), diabetic neuropathy and chemotherapy-induced neuropathies.

Neuropathic pain, meaning pain caused by a lesion or disease of the somatosensory nervous system, are in the literature divided into four subgroups; neuralgia, neuroma, neuritis and neuropathy (6). To distinguish between these groups, some common features can be mentioned:

Neuralgia: Trigeminus neuralgia is often known to give instense, sharp, shooting pain, often with specific trigger zones. Slight pressure on a trigger zone may result in severe pain. The trigger area has no sensory abnormalities as dystesthesia or paresthesia. The pain attacks may last from hours to months, with variable periods of remission. It typically presents in age groups over 50 years. Patients with multiple sclerosis (MS) will develop trigeminal neuralgia more frequently than the general population (6). If the patient presents with bilateral neuralgia-like symptoms; diagnosis of MS should be excluded.

Neuroma: A traumatic neuroma, also known as amputation neuroma, is a proliferative mass of disorganized neural tissue at the site of a traumatically or surgically transected nerve. Symptoms are typical arising some time after the initiating event; when the neural tissue on the proximal stump has had time to proliferate, typically around 10 days (6). This phenomenon could explain pain in extraction sites after healing has appeared to occur.

Neuritis: This is a condition caused by inflammation of a nerve or nerves secondary to injury or viral or bacterial infection. Since neuritis is caused by a reactivation of a virus that has been dormant in the trigeminal ganglion, it is considered to project pain within the innervations area affected by the peripheral nerves. Neuritis pain is typically a persistent burning sensation, often associated with sensory aberrations as paresthesia, dysesthesia or anesthesia. Medication: Prednisolone and/or acyclovir administration.

Neuropathy: Other common used term; atypical facial pain. Peripheral sensitization, central sensitization and sympathetic enhancement all can potentially impact the clinical presentation of a neuropathy. When the pain does not resolve with NSRCT, it might be followed by apical surgery and maybe extraction. After each treatment, pain tends to be reduced for a short time and then return to its original, or even increased intensity level. This was the case concerning this patient, which was more or less free of symptoms a couple of weeks after extraction of 36, before an even higher degree of pain was experienced. If topical, peripheral neuropathy, a peripheral neural blockade could be considered. Systemic medications can also

be used for cutaneous, peripheral neuropathies. A central neuropathy may be very similar to a peripheral, but the most telling sign that a neuropathy has taken a more central component is that local anesthetics are no longer effective. The treatment is directed toward the central processing of pain, with medications such as NMDA receptor agnoists, gabapentin, tricyclic antidepressants and opioids.

Turner Syndrome (TS) is a chromosomal condition that affects girls and women. TS occurs when one of the two X chromosomes normally found in females is missing or incomplete. TS affects 1/ 2,500 live female births. Patients with TS are more prone to have medical problems as congenital heart defects, renal abnormalies, hypertension, speech problems, dental abnormalies (narrow, high arched palate). They also often have learning disabilities.

TS patients express significantly higher levels of shyness and social anxiety and reduced self-esteem compared with normal female controls (9), but no literature confirms that these patients should be more prone to neuropathic disorders. However, the actual patient has a diagnosis of diabetes. Patients with diabetes are reported with a higher prevalence of diabetic neuropathy. Diabetic peripheral neuropathy is defined as "the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after exclusion of other causes." (10)

The occurrence of increased from 5% in age group 20-29 years up to 44% in the age group of 70-79 years of age, with no difference between diabetes type I or II. In type I diabetes mellitus, polyneuropathy typically becomes symptomatic after many years of chronic prolonged hyperglycemia. Patients with type 2 diabetes mellitus may present with distal polyneuropathy after only a few years of known poor glycemic control and these patients may already have neuropathy at the time of diagnosis. Sensory symptoms may be negative or positive, diffuse or focal, often localized to the legs. Negative sensory symptoms include feelings of numbness or deadness. Positive symptoms may be described as burning, prickling pain, tingling, electric shock–like feelings, aching, tightness, or hypersensitivity to touch (11).

Treatment of neuropathic pain generally include the use of medicaments, as shown in table 3. Sometimes, nerve block injection techniques are used, as infra orbital block, mental block or mandibular division block.

Brand name	**Generic name**
Neurontin	gabapentin
Tegretol	carbamazepine
Lyrica	pregablin
Trileptal	oxcarbazepine
Lamictal	lamotragine
Epilim	valproic acid

Table 3. Some medications commonly used to manage neuropathic pain (12)

Drugs aimed at relieving nociception, such as NSAIDs and COX-2s will work for inflammatory, acute pain but has no significant benefit in neuropathic pain conditions (6). Anticonvulsives and tricyclic antidepressants are found to be effectful, maybe because the same receptors are involved in neuropathic pain and epilepsy. Drugs such as gabapentin, lamotrigine (Lamictal), and pregabalin (Lyrica) have studies that support their use in treatment of neuropathic pain (7). Of non-pharmacological options, biofeedback, relaxation therapy, cognitive/behavioral strategies, acupuncture or transcutaneous electrical nerve stimulation are proposed (7).

Controlling diet and nutrition are paramount to improving the secondary complications of diabetes, including neuropathy. This involves avoiding large fluctuations in blood glucose.

In this patient, which already was diagnosed with a neuropathic pain condition, all the diagnostic tests were not applied. It was attempted to make the patient as safe and confident as possible. The focus for this patient would be cooperation with the patients MD, thorough examinations in addition to radiographic follow-up, ensuring that the patient feels safe and cared for, as well as detecting possible treatment needs

at an early point. This will minimize the risk of extraction and invasive treatment, which could possibly aggravate this patients symptoms.

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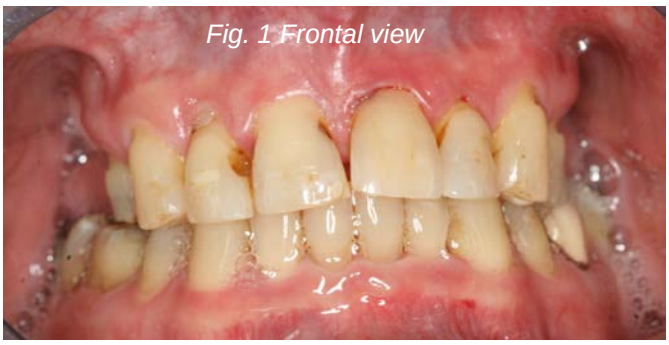
Case no 14 - External cervical root resorption and internal root resorption

Introduction

49 year old white, Northern American male



Chief complaint

Some discomfort concerning mobile teeth.

Medical history

Hepatitis group C, genotype unknown. Monitoring hepatic values at Ullevaal hospital including several liver biopsies. Interferon treatment while hospitalized. Removed gallbladder Shoulder operated Quit smoking 2006 (20 cig/day from age 15). ASA group II

Dental history

The patient was referred to the Department of Endodontics, University of Oslo, by the post graduate student at the Department of Periodontics. 3 years since last dental screening.

Clinical findings

Fig. 2 Occlusal view, maxilla

Fig. 3 Occlusal view, mandibula

Fig. 4, 5. During clinical examination, carious and subgingival defects could be probed; easiest detectable and visualized at the distopalatal aspect of the maxillary canines.

	13	12	11	21	22	23
El test (0-80)	14	21	19	28	22	19
Cold/ Endo-Ice®	Yes	Yes	Yes	Yes	Yes	Yes
Percussion	No	No	No	No	No	No
Palpation	No	No	No	No	No	No
Mobility	-	-	II	-	I	-
PPD	4mm	3mm	4mm	3mm	3mm	3mm
Carious lesions	-	d	m	-	-	-

Table 1 Summary of clinical findings 2010-04-20

Radiographic findings 2010-01-26 and 2010-04-20

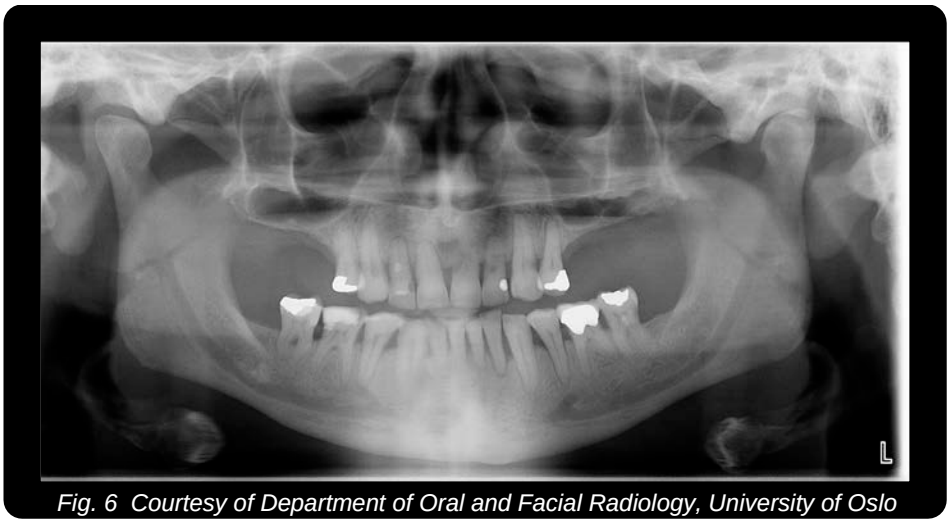


Fig. 6 Courtesy of Department of Oral and Facial Radiology, University of Oslo

Fig. 7

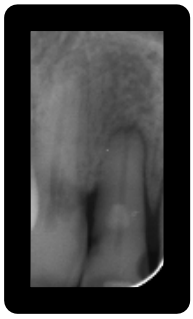


Fig. 8

Fig. 9

Fig. 10

Fig. 11

General marginal bone loss was evident at the radiographs. Lamina dura was judged to be normal in all teeth, with a question about the 12, which had a tentative diagnosis of AP from the Department of Periodontics. However, as shown in the clinical examinations-summary form, no sign of necrosis of infection was found; all teeth responded normal to all clinical tests and additional radiographical views gave no indication of periapical pathology. 14 had filling material resembling OD am. No filling materials teeth *13,12, 11, 21. 13:* intact with diffuse radiolucency at coronal 1/3 of the root *22:* Radiolucent area centrally in the middle part of the root as well as radiopaque filling material at distal aspect. *23*: intact with diffuse radiolucency at coronal 1/3 of the root. *24:* Filling material consistent with am.

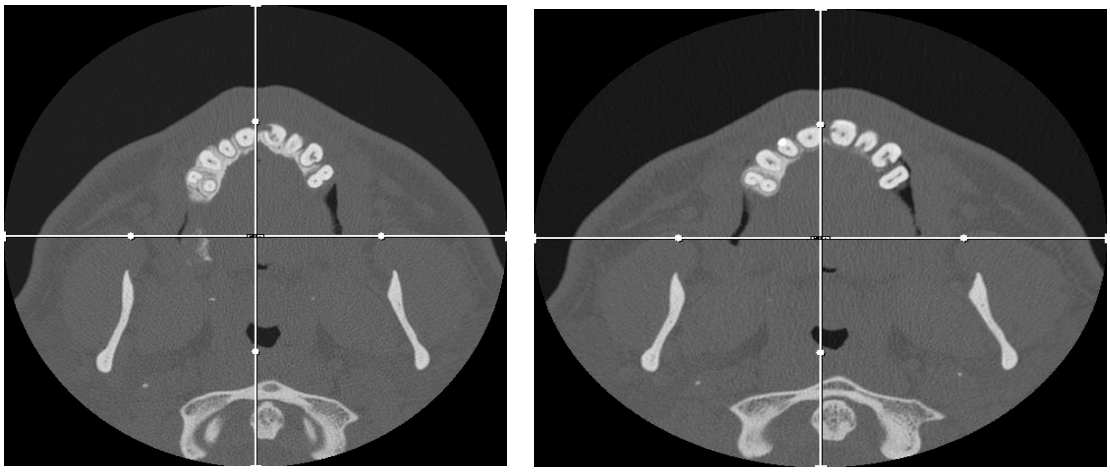
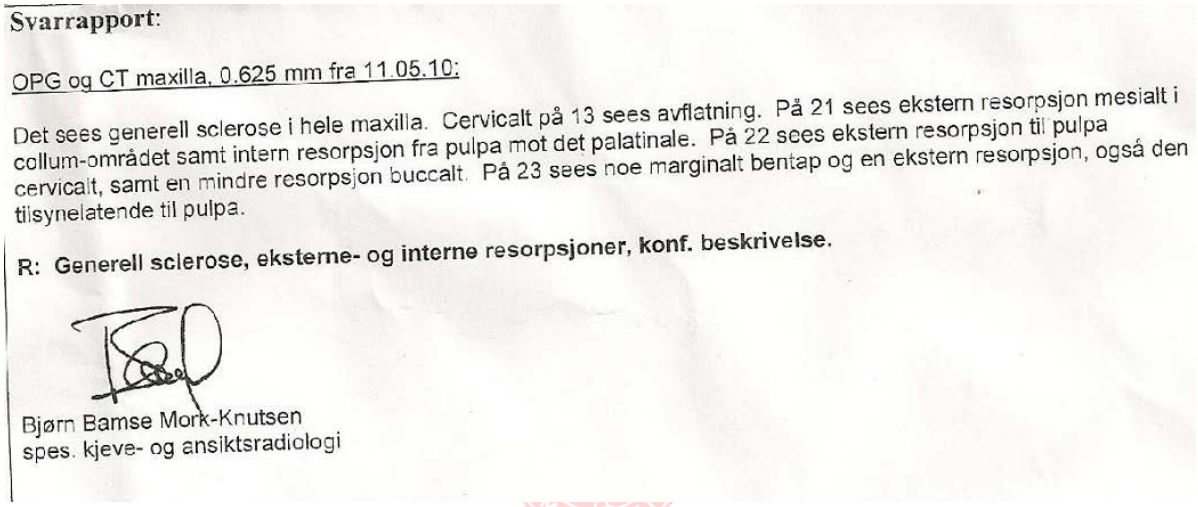


Fig 12, 13 Axial CT-view showing defects of external and internal origin. Courtesy of dr. Mork-Knutsen



Svarrapport:

OPG og CT maxilla, 0.625 mm fra 11.05.10:

Det sees generell sclerose i hele maxilla. Cervicalt på 13 sees avflatning. På 21 sees ekstern resorpsjon mesialt i collum-området samt intern resorpsjon fra pulpa mot det palatinale. På 22 sees ekstern resorpsjon til pulpa cervicalt, samt en mindre resorpsjon buccalt. På 23 sees noe marginalt bentap og en ekstern resorpsjon, også den tilsynelatende til pulpa.

R: Generell sclerose, eksterne- og interne resorpsjoner, konf. beskrivelse.

Bjørn Bamse Mork-Knutsen
spes. kjeve- og ansiktsradiologi

Fig. 14 Copy of the radiologists interpretation and report

Diagnosis

Marginal: Chronic marginal periodontits K04.5

13

- Extern cervical root resorption K03.3, Class 2
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

12

- K02.1 Dentinal caries
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

11

- K02.1 Dentinal caries
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

21

- Internal resorption combined with external cervical root resorption, K03.3, Class 4
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

22

- External cervical root resorption, K03.3, Class 4
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

23

- Extern cervical root resorption K03.3, Class 3
- *Pulpal:* Within normal limits
- *Apical:* Within normal limits

Problem list

- Possibility of weakening of tooth structure because of assumption that considerable tooth substance may be lost in conjunction with treatment attempt.
- Iaterogenic damage of periodontal structure in addition to existing periodontal disease
- Possibility of further progression of resorption process.
- Aesthetic considerations.

Treatment plan

- Orthograde endodontic treatment; pulpectomy of vital pulp tooth 13
- Observation and later extraction and implant regio 21, 22
- Orthograde endodontic treatment; pulpectomy of vital pulp tooth 23
- Surgical repair of the resorptive defects 13/ 23 from the palatal aspect
- Treatment of dentinal carious lesions 12, 11

Treatment 13

2010-05-19: 1.8 ml mepivacaine. Access preparation w/ diamond bur and later on LN-bur and Gates Glidden. One canal orifice revealed. Rubber dam applied w/ CHX disinfection of operation field. Working length determined by apex locator (Root ZX®) and a radiograph. Chemical root canal disinfection w/ 1% NaOCl and 17% EDTA.

Fig. 15 2010-05-19 Working length radiograph

Mechanical instrumentation w/ K- and NiTi hand files in conjunction with PreRace to size 55/21,5mm. $Ca(OH)_2$ as an intra-canal dressing. Cavit and IRM applied as a temporary filling.

2010-06-08: Asymptomatic patient. Rubber dam w/ disinfection applied. 1% NaOCl and 17% EDTA. Canal dried with paper points and filled with AH Plus and gutta-percha after master cone X-ray. IRM plug

Fig. 16 Master cone radiograph

Fig. 17, 18 Final radiographs

Treatment 23

2010-06-01: Articaine with epinephrine 1:100,000 x 1 cartridge. Preparation of access cavity until revealing pulp chamber. Vital pulp. Rubber dam w/ disinfection. Root canal disinfection was done mechanically with BioRace® rotary and NiTi hand files to size; R055/21 mm/incisal edge. Ultra sound preparation of resorption defect. Irrisafe® used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA used for chemical root canal disinfection.

Fig. 19 2010-06-01 Working length radiograph

$Ca(OH)_2$ was placed as an intra-canal dressing. Cavit in combination with IRM was applied as a temporary filling.

2010-06-15: Master cone X-ray. Filled w/ gutta percha and AHplus until 2 mm apically of the resorption site. White MTA® (Angelus, Brazil) used as root filling material more coronally. A cotton pellet with saline water was placed over the MTA. IRM temporary filling.

Fig.20. Master cone radiograph

Fig.21. Before cotton pellet with sterile saline removed

Prognosis

Tooth 13

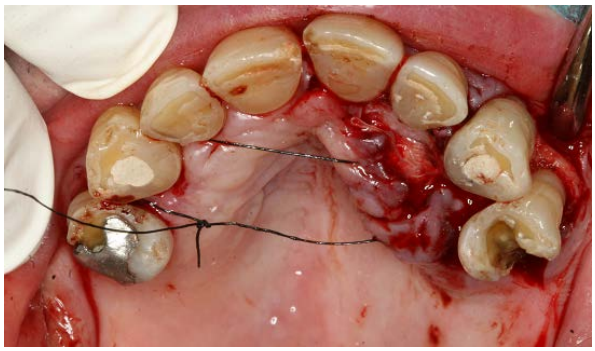
- Endodontic: Good
- Total: Assumed favourable

Tooth 23

- Endodontic: Good.
- Total: Questionable. Heithersay class 3 resorption defect with more substantial loss and some degree of poorer outcome to be expected

Surgical treatment

Pre-operative procedure with patient information and rinsing with chlorhexidine gluconate. 3 x 1,8 ml Xylocaine Adrenaline®. Marginal incision from the mesial aspect of tooth 21 to the distal aspect of tooth 24 on proc alveolaris. Elevation of mucoperiostal flap and securing flap at contralateral side. Osteotomy. Removal of cervical lesion on the root surface of tooth 23 with bur. Trichloracetic acid was not used in this patient. Stryphnon gauze and ferric sulphate for control of haemorrhage. Composite filling applied with pre-treatment 35% phosphoric acid, Scotchbond® and Tetric Ceram®/A3. Polishing of the composite filling. Operation site thoroughly inspected and irrigated with sterile saline solution. Suturing with seven 4-0 Supramid sutures. Post-operative instructions and patient information concerning treatment and prognosis. Analgetic regimen Ibuprofen 600 mg 4 times a day the first days after surgery. The same procedure was performed for treatment of tooth 13 in another treatment session.



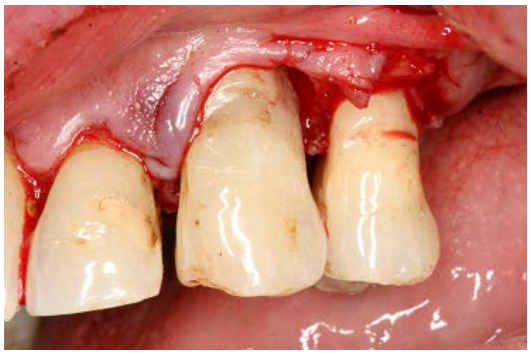


Fig. 22, 23. Flap elevation for external treatment of resorptive defect.

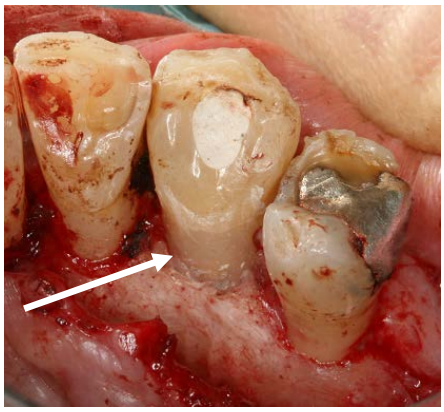


Fig. 24 Composite restoration finshed and polished.

Fig. 25 Suturing with 4-0 Supramid sutures.

Fig. 26, 27 One week control, suture removal

The patient had adequate analgetic effect and was free of symptoms at day of control seven days post surgery. Sutur removal. Soft tissue healing is evident, some inflammation distal aspect of 23. Recommendation of continued rinsing with chlorhexidine digluconate 2mg twice a day for five days.

1,5 year follow-up

Fig. 28- 32 2011-11-29

The patient was free of symptoms and had gone through periodontal treatment at Department of Periodontics, UiO. He had a satisfactory hygiene regimen. There was no evidence of further progression of resorptive lesions.

Fig. 33

Fig. 34

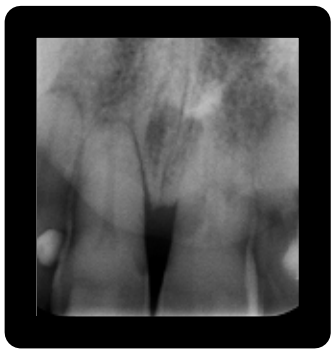


Fig. 35

Fig. 36

Discussion

For morphological description of the teeth treated in this case, see previous cases.

The bone undergoes resorption and apposition as a part of a continous remodeling process. This is in contrast to permanent teeth, where resorption of the mineralized tooth tissues is normally not seen. The mineralized tooth structure is protected by the predentin and the odontoblasts in the root canal, and the precementum and the cementoblasts at the root surface (1). ***External cervical root resorption (ECR)*** is –

as the name indicate – characterized by its cervical location initiated just below/apically of the epithelial attachment. The odontoclastic action results in progressive and destructive loss of tooth structure (2). It is a dental complication that may lead to tooth extraction. The nomenclature has for the past years been varying and inconsistent. We now differentiates between internal resorption, external cervical resorption, external inflammatory root resorption and ankylotic/ replacement resorption. The *classification* of external resorption most commonly used, is developed by Heithersay(3), (figure 37).

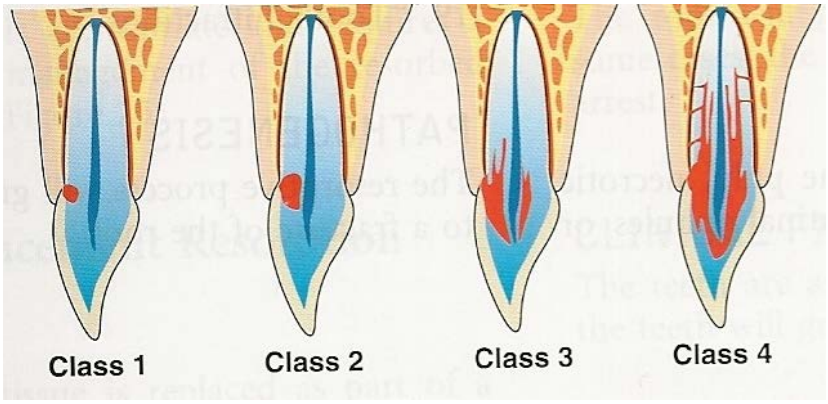


Figure 37. Clinical classification of invasive external cervical root resorption according to Heithersay (3).

Class 1 – Denotes a small invasive resorptive lesion near the cervical area with shallow penetration into dentine.

Class 2 - Denotes a well-defined invasive resorptive lesion that has penetrated close to the coronal pulp chamber but shows little or no extension into the radicular dentine

Class 3 – Denotes a deeper invasion of dentine by resorbing tissue, not only involving the coronal dentine but also extending into the coronal third of the root.

Class 4 – Denotes a large invasive resorptive process that has extended beyond the coronal third of the root.

Predisposing factors are, according to Heithersay, (3) earlier orthodontic treatment, trauma, intracoronal bleaching, orthognatic or other dentoalveolar surgery or periodontal treatment in the affected area. These factors were found either as a sole potential predisposing factor or in a combinations of factors, in a study of a group of 222 patients with 257 teeth displaying cervical resorption (3). Orthodontics was the most common sole factor (in 24,1% of the teeth), followed by trauma (15,1%) and surgery (5,9%). Although systemic disorders causing root resorption are rare, as hyperparathyroidism and renal dystrophy (4), it could be relevant to know. Special tests as blood chemistry tests, urine analysis, endocrine/hormone tests, biopsies, and genetic testing has been mentioned in the literature, but are supposed to seldom be of relevance in these cases because of scientific lack of correlation to clinical findings in general . This patient was diagnosed with hepatitis group C. Patients affected with chronic hepatitis are prone to alterations in bone metabolism and osteoporosis being the most common manifestation. Crosslaps are a parameter of osteoclastic activity: their measurement showed in a study of otherwise healthy males alterations in all the age groups of the hepatitis patients studied (5). The intense bone remodelling in these individuals is due mainly to osteoclastic resorption. Hepatitis C may be a risk factor for bone depletion but this has so far not yet been directly associated with dental resorptions.

The clinical picture of cervical resorption may vary depending on the extent. The patient usually is free of symptoms, and the resorptive defects are often discovered by routine radiographic examination. The pulp is expected to be vital and the tooth responds within normal limits on palpation, percussion and sensibility tests as electric and thermal testing (6). A pink discoloration of the crown may be seen, as well as some degree of irregularity of the gingival contour. If this “pink spot” is present, this is due to undermining of the enamel products because of the resorbing tissue which is fibro-vascular with odontoclastic cells adjacent to the dentine surface. Small channels are present initially which enlarges gradually and fibro-ossous tissue is formed. Inflammatory response when secondary invasion of microorganisms occurs.

Radiographic findings usually includes an irregular, mottled image in the main lesion area. A characteristic is that the outline of the root canal is seen as a radiopaque line demarcating the root canal from the

adjacent radiolucency, representing the resorptive lesion (6). Fig. 38 represents an external cervical resorption. Fig. 39 represents an internal resorptive lesion. The X-ray image of the crestal bone seems to be normal. When taking radiographs of different angulation, the radiolucent area will either move in the same (lingual/palatal) or in the opposite (labial/buccal) direction of the x-ray tube. This is in contrast to internal resorption, where the defect is located centrally of the root regardless of the angle of the X-rays. Heithersay has stated that selection was important to achieve a good prognosis; recommending only to treat defects categorized as classes 1–3. If it is difficult to classify the resorptions, for example at the labial or palatal aspects of a tooth by using conventional radiographic techniques. CBCT examination could be indicated.

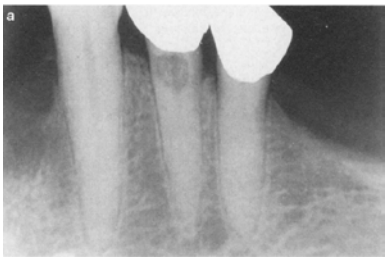


Figure 38, from (7)

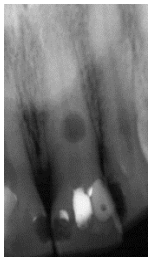


Figure 39, from (8)

Figure 40 from (2)

Histopathologically, the resorptive lesion or cavity is filled with a mass of fibrous tissue, numerous blood vessels and clastic resorbing cells adjacent to the dentin surface. The invading tissue arises from the periodontal ligament (PDL) but differs in both structure and behavior. For invasion to occur, it is likely that a defect in the cementum is present. The defect may be of developmental origin or as a result of physical or chemical trauma. If such a defect in the cement exsists, a direct contact between dentin and the potentially resorptive cells of PDL is possible. Both mononucleated and multinucleated clastic cells are seen (2). A distinct feature of the condition is the layer of intact predentin which is present, see figure 40. This zone of predentin separates the inflammation free pulp from the actively resorbing tissue. The assumed protective predentin is postulated to be the reason why the condition is asymptomatic of nature (9). There is a hypothesis that osteoclasts will not adhere to unmineralized matrix (4). Theories proposed to explain the resistance of the tooth tissue to clastic, cellular activity has been that the tooth may be protected by the remnants of Hertwigs epithelial root sheath. The non-mineralized covering of the dentin by the pre-dentin may provide protection and that the pre-dentin and cementoid layer contain an intrinsic factor, osteoprotegrin (OPG) that inhibits osteoclastic activity (10). Osteoclasts will bind to extracellular proteins containing the aginine-glycine-aspartic-acid (RGD) sequence of amino acids. These RGD peptides are bound to calcium salt crystals on mineralized surfaces and serve as osteoclast binding sites. Both predentin and cementum lack these RGD proteins. Ectopic calcific tissue is often present within the fibrovascular tissue. Infiltrating channels of soft tissue is seen in Class 3 stage, these channels often have communications with the PDL and arises from the PDL even if the tissue differs in structure and behaviour. The precursor cells of the PDL (ectomesenchymal of origin), have the potential to differentiate into cells capable of produce both fibrous and calcified tissue. In early stages there are ingrowth of fibrovascular tissue and later; fibrosseous tissue. No or only a few inflammatory cells are found.

Figure 41 from(2)

Differential diagnostic aspects are reviewed (11), and a summary of the radiographic appearances of various lesions are:

Lesion	**Radiographic appearance**
Caries	Usually closer to crown of tooth
	Progresses from outward to inward
	Margin of lesion not abrupt
External resorption	Margins of lesion are ragged and irregular
	Lesion may be superimposed over canal
	Canal can be followed all the way to apex, unaltered
Internal resorption	Canal or chamber shows enlarged area
	Lesion can be symmetrical
	Canal not present in area of lesion
	Margins of lesion are sharp, well defined

Table 2, from (11)

The *pathogenesis* is not exactly known but the process originates in the periodontium or PDL in contrast to apical inflammatory resorption, which originates in a necrotic pulp. In recent years, there have been advances in understanding how the osteoclasts differentiate and activate in response to a number of factors in a signaling network. A defect in the cementoblast layer in its system of RANK-RANKL-OPG may be of relevance concerning the etiology (12). There may under normal morphology conditions exist gaps in the cementum in the cervical part of the root, leaving the underlying dentin vulnerable to possible attacks. Cervical root resorption is a destructive process capable of resorbing bone and tooth, but seldom an aggressive pathologic process. This in contrast to periapical replacement resorption (PARR) where the resorbing root is replaced by with normal-appearing trabeculated bone and aggressive disease processes, such as osteosarcoma and chondrosarcoma.

Concerning *treatment,* this depends on the severity of the lesion, its location and whether is has perforated the root canal system, and the restorability of the tooth. The treatment objectives is to eliminiate the entire pathological process, restore damaged root surface, prevent further resorption and improve esthetics of tooth (as in cases where resorption has led to a pink spot). Endodontic treatment might be necessary with some class 2 and usually class 3 lesions when pulpal involvement has occurred or is very close to occurring. Heithersay has reported a 100% success rate in the treatment of class I and II ECR lesions treated in this way. The success rate in class 3 lesions was 77.8% and only 12.5% of teeth in class 4

cases. Heithersay concluded that classes 1–3 were treatable, but class 4 lesions were not recommended to treat, and these cases would have benefited from alternative treatment such as extraction and replacement with an implant retained crown restoration (13).

Internal root resorption has been reported as early as 1830. Compared with external root resorption, internal root resorption is a relatively rare occurrence, and its etiology and pathogenesis have not been completely elucidated. Epidemiological data is scarse, but a prevalence of 0,01%- 1% patients affected is suggested(8). Typically, only one tooth per patient is affected by internal root resorption. (Note: apical internal resorption is a fairly common occurrence in teeth with periapical lesions, and not the feature described here.) Even though distinct differences, internal resorption is often confused with external cervical resorption. Intraradicular internal resorption is an inflammatory condition that results in progressive destruction of intraradicular dentin and dentinal tubules along the middle and apical thirds of the canal walls. The resorptive spaces might be filled by granulation tissue only or in combination with bone-like or cementum-like mineralized tissues. The condition is more frequently observed in male than female subjects. A higher prevalence of the condition has been associated with teeth that had undergone autotransplantation(14). Other predisposing factors are trauma, pulpitis, pulpotomy, cracked tooth, restorative procedures, invagination, orthodontic treatment and Herpes zoster viral infection(8). For internal root resorption to occur, the outermost protective odontoblast layer and the predentin of the canal wall must be damaged, resulting in exposure of the underlying mineralized dentin to odontoclasts. The coronal part of the pulp is usually necrotic, whereas the apical part of the pulp must remain vital for the resorptive lesion to progress and enlarge. One hypothesis suggests that the necrotic coronal part of the infected pulp provides a stimulus for inflammation in the apical part of the pulp. Unlike cervical resorption and external inflammatory root resorption, internal inflammatory will stop ‘by itself’ if the whole root canal becomes necrotic(8).

Osteoclasts are motile, multinucleated giant cells that are responsible for bone resorption. They are formed by the fusion of mononuclear precursor cells of the monocyte-macrophage lineage derived from the spleen or bone marrow, as opposed to osteoblasts and osteocytes that are derived from skeletal precursor cells. Odontoclasts differ from osteoclasts by being smaller in size and having fewer nuclei. Osteoclasts and odontoclasts resorb their target tissues in a similar manner. Both cells possess similar enzymatic properties and create resorption depressions termed Howship’s lacunae on the surface of the mineralized tissues. Although mononuclear, dendritic cells share a common hematopoietic lineage with the multinucleated osteoclasts, they have previously been regarded solely as immunologic defense cells. Studies have indicated that immature DCs function also as osteoclast precursors that have the potential to transdifferentiate into osteoclasts(14). Because DCs are present in the dental pulp, it is possible they might function also as precursors of odontoclasts.

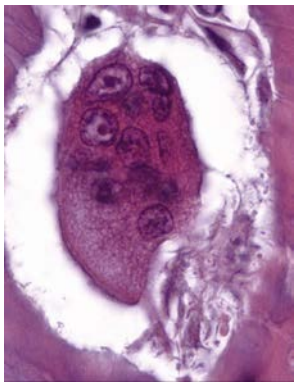


Fig.42 Odontoclast showing multiple nuclei. The empty space is a shrinkage artifact

Studies have shown that both Gr+ and Gr- bacteria have the potential to stimulate RANKL expression and osteoclast activation. The pulp next to the resorption are shown to be hypereemic and with varying degrees of inflammation and infiltration of lymphocytes, macrophages and neutrophilic leucocytes.

Treatment includes instrumentation and cleaning of the root canal. There are no standardized treatment protocols, but inter-appointment dressing to maximize the disinfection is recommended. MTA or warm gutta percha could be beneficial. The prognosis is assumed to be good in cases where there are no perforation to PDL or too much weakened because of loss of tooth structure.

In this case, attempts were done to remove the active tissue from the resorption cavity with bur, ultrasound and curette, and restore the defect with a suitable restorative material, in this case a composite. An

alternative method, which utilizes the topical application of 90% aqueous trichloracetic acid (TCA), curettage and restoration, has been outlined and clinically assessed (15). The effect of TCA is coagulation necrosis, which will render the resorptive tissue avascular. As there is a tendency of recurrence of these lesions, the inactivation of adjacent and potentially resorbing cells by TCA has been recommended. This will in addition give haemorrhage control which sometimes may represent a problem with conventional treatment. Coagulation necrosis is defined as necrosis of a portion of some organ or tissue, with formation of fibrous infarcts, the protoplasm of the cells becoming fixed and opaque by coagulation of the protein elements, the cellular outline persisting for a long time. Calcium hydroxide (CH), used as an interappointment-dressing, will have positive effect on arresting the resorptive process. The strong antibacterial effect and low solubility create a long-term effect in the root canal. The pH increases in the dentin and thereby inhibits the activity of osteoclastic acid hydrolases in the periodontal tissues and activates alkaline phosphatases (16).

Unless there is a minimal entrance opening at root surface, the resorption lacuna(e) can be exposed surgically, granulation tissue removed and the resorptive defect inspected under magnification and illumination. Usually it is necessary to reflect a full-thickness periosteal flap to allow complete access and removal of the ECR lesion from the root, curetting away the granulomatous tissue from the adjacent periodontium to sever the blood supply to the resorbing cells, thereby decreasing the chances of recurrence (13). Vascular channels may be removed with trichloroacetic acid and curettage, as recommended by Heithersay (2). The coagulation necrosis of the ECR resorptive tissue mentioned, will not give rise to damage to the periodontal tissues, according to the literature. It also infiltrates the small channels and recesses of ECR that would otherwise be unreachable by mechanical instrumentation.

Tooth 21 was diagnosed by the radiologist with both internal and cervical resorption. This tooth was going to be, according to the treatment plan, extracted at a later time. The tooth was free of symptoms and no periapical pathology could be diagnosed. The patient had a wish to keep it as long as possible.

Successful *outcome* is expected when the defects are reached early through the occlusal access cavity preparation. Smaller lesions offer the most favorable long-term outcome. These defects would fall into Heithersay class 1 and 2 ECR categories. Here, the pulp is, as mentioned, usually not involved. However, if the resorptive defect is in close proximity to the pulp and there is high risk of pulpal exposure, endodontic treatment should be carried out before external repair of the ECR defect (13). Favorable results depend on complete debridement and closure of the portal of entry (6).

Concerning follow-up; a second CBCT investigation was not undertaken during follow-up examination on this patient. As recommended by the American Association of Endodontists (AAE) and The American Academy of Oral and Maxillofacial Radiology (AAOMR) 2010 Joint Position Statement on the Use of Cone-Beam-Computed Tomography in Endodontics, CBCT should be limited to particular conditions, over-exposure to radiation should be avoided, and in no case may the technique be considered ‘routine’ or utilized for screening purposes. Therefore, clinical and radiological follow-up with traditional intra-oral examination were considered appropriate.

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Case 15 – Removal of separated instrument in mandibular left first molar with later apical surgery

Patient

52 year old Northern European male

Figure 1. Frontal view

Chief complaint

2010-09-15: Tenderness on chewing left side when attending student clinic

2010-10-28: Free of symptoms when appointment in post graduate clinic

Medical history

- ✓ Reiters disease at age 20
- ✓ Smoking 15-20 sigarettes/day for 30 year
- ✓ Partial paralysis left hand since 2005

Medications:

- ✓ Remeron
- ✓ Cipralex
- ✓ Titralac

Reiter's disease – reactive arthritis

Disorder characterized by the symptom triad of nongonococcal *urethritis*, *conjuncitivitis* and *arthritis*. It follows closely a lower urogenital or enteric infection, particularly in young men carrying the HLA B27 antigen (1)

Dental history

Carious lesion 36 autumn 2009. Diagnosis irreversible pulpitis. Patient travelled a lot in work and private, did not meet to scheduled appointments at the undergraduate student clinic. Attending oral hygiene educational programs at Dental faculty. Great need for dental treatment generally. Separation of hand file occurred during treatment session in Student clinic.

Clinical examination, findings

	34	35	36	37
EPT (0-80)	24	21	-	-
Thermal test	Yes	Yes	No	No
Percussion	No	No	No	No
Palpation	No	No	No	No
PPD	WNL	WNL	WNL	WNL
Soft tissue	WNL	WNL	WNL	WNL
Restoration	Comp OD	Comp MOD	IRM	IRM
Lymphadenopathy	Negative			
Mobility	No			

Table 1. Clinical examination form

Fig 2. Occlusal view lower jaw

Fig. 3. Occlusal view, lower jaw

Fig.4 . close-up occlusal aspect tooth 19.

Fig. 5 . Lingual view.

Fig. 6. Intraoral, dorsum tongue.

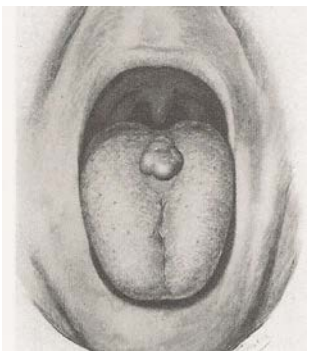

Fig. 7. Illustration from (2)

Embryonal origin, derived from the tuberculum impar (2). No treatment is indicated, the condition is found more often in males

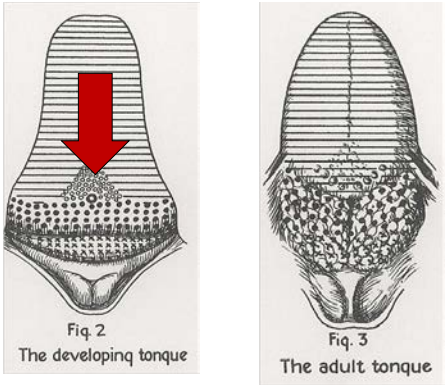

Fig. 8. Illustration from (2)

Differential diagnosis (1): tongue carcinoma, fibroma linguae, hemangioma, Melkersson-Rosenthal syndrome, thyroglossal duct cyst.

Radiographic history

Radiographic examination, findings

	35	36	37
Dental	Radiopaque filling	Temporary filling	Temporary fillin
Periodontal	WNL	WNL	WNL
Apical lucency		Yes, PAI 3	
Prior RCT			Yes
Separated instrument		Yes	

Table 2. Radiological examinations form

Figure 11 X-ray from post graduate clinic, arrow denotes a separated file.

Diagnosis

Pulpal: Infected, necrotic pulp K04.11

Periapical: Chronic apical periodontitis K04.50

Periodontal: Normal

Treatment plan

Removal of separated instrument with ultrasound and iRS-system. Root canal disinfection and sealing of the root canal permanently with non-surgical, orthograde treatment

Problem list

- Iaterogenic damage to the tooth or PDL during attempting removal of separated instrument (perforation, ledge formation, over-enlargement or transportation of the prepared root canal)
- Weakening of tooth
- Possibility of reduced prognosis if retained instrument and non-optimal disinfection (however, the tooth had been treated with intra-canal dressing prior to fracture)

Treatment

2010-10-28

Anaesthesia 1,8 ml Carbocain “Dentsply” (mepivacaine). Rubber dam applied, disinfection with solution of 0,5% chlorhexidine in 70% ethanol. Localizing separated instrument, ML canal (fig. 14), in the SOM. Trying to bypass the instrument without success. A staging platform was created with modified Gates Glidden (Sybron Endo corp, Orange, CA 92867) bur (fig. 28). Ultrasonic K 25/21 file used to loosen fractured instrument

Radiological verification of removed separated instrument

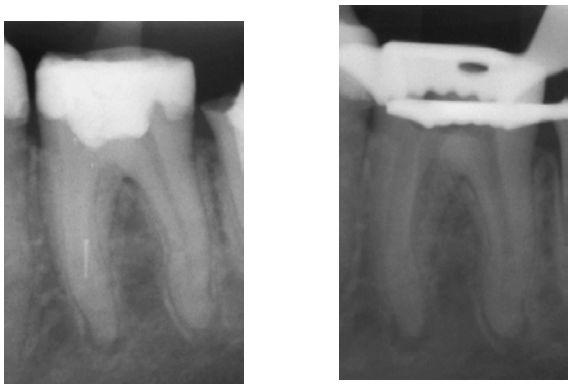

Figure 12, 13. Radiographs before (left) and after removal of separated instrument (right).

After removal of the separated file, The BioRace® (FKG Dentaire, La Chaux-de-Fonds, Switzerland) basic set with the 6 instruments BR0-25/0.08, BR1-15/0.05, BR2- 25/0.04, BR3-25/0.06, BR4-35/0.04 and BR5-40/0.04 was used. The tooth was earlier treated at the student clinic, by hand files. Intracanal dressing had earlier been applied. Opening coronally was done as explained above as well as using the BioRace® equipment. #10 was inserted and apex locator RootZX® was used to determine WL but due to ledging and step-formation, normal signals and confirmation of optimal length were not able to be performed in this case. Apart from BR0, all instruments were used to the WL, determined despite the limitations due to the iatrogenic changes from previous treatment attempt at the student clinic. Irrigation with 17% EDTA, 1 % NaOCl, Irrisafe® ultrasonic activation of 30 sec /canal. Master cone radiograph R 60/20,5, R45/21, R45/18,5 (fig 16). Sealer AHplus® (Dentsply International) was used in the terminal obturation phase and 2 mm of the orifices sealed with IRM® (Dentsply International/L.D. Caulk Division, Milford, DE) plugs.

Figure 14, 15. Photographs shoving localization of the ML canal and the removed metallic foreign body.

Fig. 16. Master cone radiograph

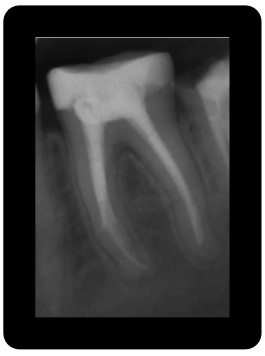

Fig. 17. Final radiograph

Evaluation

Positive concerning long term outcome:

- Separated instrument was possible to remove without excessive amount of dentin removal
- Tooth was free of symptoms and had been disinfected before the instrument fractured in canal

Negative concerning long term outcome:

- From the treatment in undergraduate clinic, ledging and transportation was evident
- Another intra-canal dressing could have been applied. Due to the history from the student clinic, that the patient multiple times did not meet to scheduled appointment and for long periods of time was living in Spain, it was decided to finish the RCT.

Prognosis

- *Endodontic:* Good
- *Total:* Good

Follow-up examination 2012-02-08

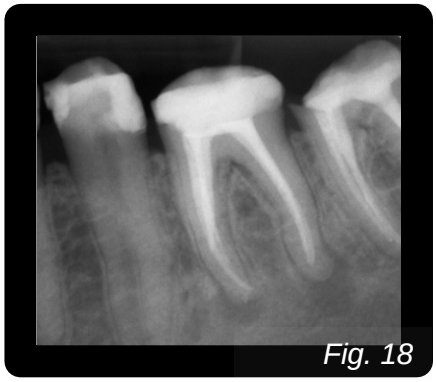

Fig. 18

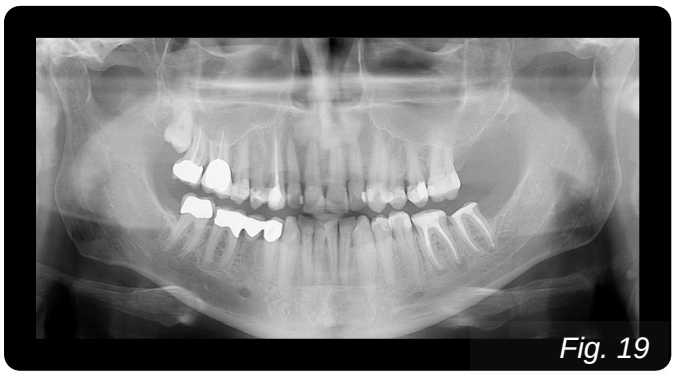

Fig. 19

The patient met for recall examination approximately one year after treatment. He was free of symptoms and intraoral examination unchanged, but radiographically, pathology was evident. An OPG was taken and appointment scheduled for surgical intervention; apicectomy tooth 36. The patient was informed about the procedure, pre-treatment and post-treatment considerations, including aspects concerning smoking and surgery.

Appointment 2012- 04-12: 5.8 ml xylocain with adrenalin (20 mg/ml + 12.5 µg/ml) used to establish anaesthesia. An intrasulcular incision was made with a micro scalpel blade starting from the mesial aspect of mandibular left canine, extending posteriorly to the distal aspect of the second molar. Elevation of full mucoperiosteal flap.No pathological bone fenestration detected. Osteotomy with round bur, localizing the mesial and distal roots, under irrigation with sterile saline to adequately expose the root ends. Anatomical considerations of structures as adjacent roots and the n. alv inf. were taken into account. 3 mm of the root apex was resected with a long fissure bur.

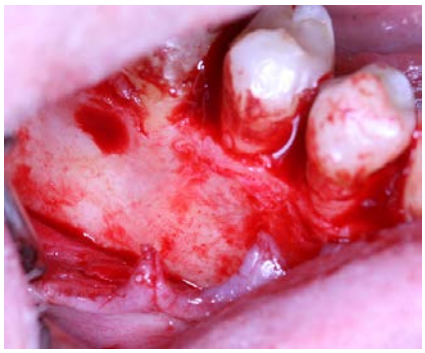

Fig.20 No fenestration evident

Fig. 21 Osseous entry

Fig.22 Before filling retrograde

Retrograde preparation was carried out with the P5 Newtron ultrasound device using ultrasonic tip under constant cooling with rinsing sterile saline. The retrograde preparations were extended 3 mm in the root canals, parallel to the long axis of the roots. Haemostasis with epinephrine and FeS. MTA plugs applied with MTA block and micro pluggers. Counting and removal of sterile cotton gauze, wound cleansing. The flap was repositioned and was hold tight in place with finger pressure in one minute in order to reduce the post operative haematoma and pain. The vertical realising flap was sutured in place with two 5-0 Supramid. The five other interrupted sutures was placed interproximaly in the papillae. A final radiograph was taken. An antibiotic phenoxymethyl penicillin; Apocillin 660 mg, 1+1+2 for 7 days, analgetic Ibuprofen, 600 mg and antiseptic mouth wash Corsodyl were prescribed. Post operative instructions were given and the patient received an ice pack.

Appointment 2012- 04-19: The patient returned 6 days later for control and suture removal. He had decided not to use the antibiotics or the analgetics. He had experienced a low level of discomfort and was

satisfied with the treatment and the post operative conditions. He had reduced his tobacco consumption to less than half.



Fig. 23, 24, 25 One week post treatment; adequate soft tissue healing

Discussion

For morphological description of the mandibular, first molar, see case 1.

The prevalence of retained separated endodontic hand instruments has been reported to range from 0,5%-7,4%(3). When an endodontic instrument fractures, one should evaluate the potential procedural choices (4). Possible approaches include removal of the instrument, bypassing it, leaving it in situ or surgery. Ideally, the root canals should be optimal cleaned and shaped, a prerequisite for healing and regaining of a physiological situation. Otherwise, the outcome of root canal treatment could be compromised (5, 6). Factors of influence on outcome will be absence or presence of infection, the time of instrument fracture during treatment, fragment position in the root canal (apical, middle, coronal) and anatomical/morphological aspects(7). Some authors have found a reduced success rate only if a periapical lesion is present (8, 9) or if the diagnosis is necrosis (10). In certain conditions, as with vital pulp diagnosis, it could be the first choice of treatment to leave the instrument, not weakening the tooth and still be able to perform a treatment with a good prognosis, provided that no bacterial contamination is present. This in contrast to an infected, non-vital tooth, with necrotic debris left apically of the instrument.

NiTi alloys can be called shape memory alloys, and have important practical applications in dentistry because of their super-elasticity, shape memory effect, and corrosion resistance. The alloy has an inherent ability to alter its type of atomic bonding. A disadvantage of NiTi alloy is its low ultimate tensile and yield strength compared with stainless steel, making it more susceptible to fracture at lower loads. The types of failure for rotary instruments are torsional failure or flexural failure. The *torsional failure* occurs due to binding of the instrument in the root canal, or excessive apical force during instrumentation. It is the result of an applied shear moment exceeding the elastic limit of the material. *Flexural fatigue* occurs due to metal fatigue at point of maximum flexure; overuse of the instrument may be a cause. In the case of fatigue, microcracks are first formed on the surface of a material.(11) For hand instruments, torsional failure due to excessive force, or the tip binding in the canal, is the cause of “unwinding” and separation. In general, fracture of metals can be classified as either brittle or ductile. Ductility refers to the ability of a material to undergo plastic deformation before it breaks, whereas brittle fractures are associated with little or no plastic deformation. Hence, brittle fractures usually occur in metals with poor ductility. Typically there is an initiation of cracks at the surface of the metal, and stress concentration at the base of the crack results in its propagation either along grain boundaries (intergranular) or between specific crystallographic planes (cleavage fracture). The modulus of elasticity (Young’s modulus) is a measure of the relative stiffness or rigidity of a material. Modulus of Elasticity = Stress/Strain (this only applies to the elastic portion of the stress-strain diagram). On the stress-strain diagram, the modulus is indicated by the slope of the linear part of the line. Therefore, a material with a steep line will have a higher modulus and be more rigid than a material with a flatter line (12).

Relevant to our use; the term ‘fatigue’ refers to the fact that under cyclic loading, a material will undergo failure at a lower applied stress than it normally would if it were not under cyclic loading. The name ‘fatigue’ is derived from the fact that the materials seem to tire under this type of repetitive loading. Surface

conditions, roughness and sharp angles promote fatigue failure.
50% of all instrument fractures occured in mesial roots of mandibular molars, as in this case (13). There are some conflicting findings concerning if rotary instruments are more prone to fracture than hand instruments. Authors mention that NiTi-rotary systems have reduced the incidence of problems as ledging and transportation, but that rotary instruments tends to fracture more easily than hand instruments (14, 15). On the contrary, Simon *et al* stated that there have been no increase in rate of fractured instruments since the implementation of rotary NiTi instrumentation (7).

Generally, it is legally necessary to inform the patient about

- difficulties during treatment
- complications which may occur
- further treatment that may be required

Therefore, separation of instrument in the root canal is an event that it is important to inform the patient about.

With todays methods, most of the separated instruments can be expected to be removed (13). 87% of the fractured instruments were removed successfully in the study by Suter *et al*. There were no significant differences in the position of the fractured instruments, - in other words, a retained instrument in the apical part of the root was as often able to be removed as a middle or coronal positioned instrument (13). This is in contrast to earlier findings, where the chances for removal was dependent of the localization in the root canal (16). The high degree of probability to remove a separated instrument now, is mostly due to the surgical operation microscope (SOM) with the high degree of magnification and illumination, as well as the availability of ultra-sound devices. However, it is shown that if the fractured instrument was located beyond the apical foramen; 0% was able to be removed by conservative means (13).

If the decision is made to attempt removal of the separated instrument, there are several methods available. After gaining access, the use of ultrasonic techniques and/or microtube removal methods like “lasso&anchor”, “tube & glue”,”Masserann kit”, “spinal tap needle”, “Endo extractor” and “instrument removal system (iRS)”. However, it should be remembered that many of these microtube removal methods require excessive removal of dentin(17).

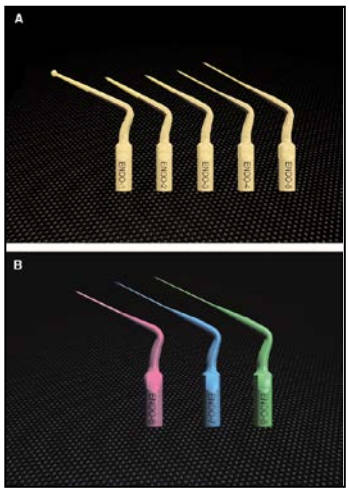

Figure 26 showing different ultrasonic tips, for different use depending on the available space and anatomical considerations (15)

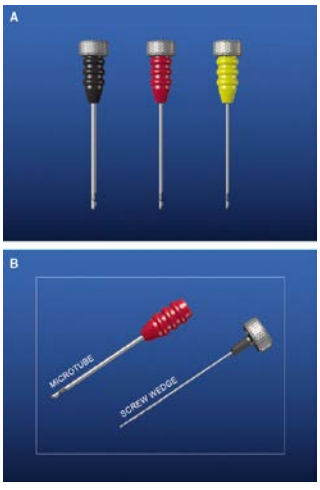

Figure 27. The iRS set of devices for removing broken instruments. A microtube and an internal screw wedge is designed to mechanically remove the intracanal fragment (15)

Before removal attempt, it is important to prevent that the separated fragment gets entry into one of the other canals, if multi-rooted tooth. For any of the mentioned techniques, it is important with straight-line access and visualization of the metallic foreign body. The goal is to expose 2-3 mm, or about one-third of

the instrument(15), it can then usually be removed. The type of material the obstruction is composed of, is a factor of relevance. Stainless steel (SS) instruments are considered to be easier and safer to remove than NiTi instruments. NiTi instruments are more prone to break again during the removal process(18).

Of relevance prior to removal attempt is also anatomical considerations, including the diameter, length, and curvature of the canal. Root morphology may be a limiting factor, so aspects as the thickness of dentin and the depth of external concavities must be carefully considered. Radiographs of different angulations will be of help in revealing these anatomical variations.

When the fractured instrument is localized and visualized, enough space must be created to be able to remove it. After opening sufficient coronally, Gates Glidden® (GG) drills *(Dentsply Maillefer; Tulsa, Oklahoma)* are used to create radicular access. These drills are in sizes 1 to 6 and they have maximum diameters of 0.5, 0.7, 0.9, 1.1, 1.3 and 1.5 mm, respectively. If greater access is required lateral to the most coronal aspect of the obstruction, the bud of a GG can be “modified” and then used to create a circumferential “staging platform.

Figure 28. Modification of GG-drills to make a staging platform is made by selecting a GG drill whose maximum cross-sectional diameter is slightly larger than the visualized instrument (18)

This staging platform will facilitate the introduction of the ultrasound instrument. With aid of the SOM, one may be able to create a groove around the separated instrument using for example 25 K-file tip, until movement is registered. Loosened instrument is removed by flushing with irrigation, Hedström file, plier, micro-tweezer or a microtube removal method, as the iRS-system (see above).

Influence on the success rate reviewed in the literature

	Success rate	Influence of fractured files on outcome of endodontic treatment
Strindberg[6]	73%	Reduction of 19%
Engström *et al*[9]	67%	No effect
Engström and Lundberg[10]	100%	No effect
Grossman[11]	77%	Reduction in the success rate if periapical lesion
Crump and Natkin[12]	91%	No effect
Fox *et al*[13]	93%	Reduction in the success rate if periapical lesion
Kerekes and Tronstad[14]	82%	Reduction in the success rate on tooth necrosed
Molyvdas *et al*[15]	87%	Reduction in the success rate if periapical lesion

Table 1. Influence on the success rate reviewed in the literature.

Table 3. From Simon et al showing influence of fractured files on outcome of endodontic treatment (7)

Even if the prognosis of removing a separated instrument is good, prophylactic measures is of most importance. Factors that contribute to separation of instruments are the root canal anatomy and the frequency of use of the instruments(19). Possible measures for prevention of instrument fracture could therefor be:

- operator training with gentle technique and recognition of challenging anatomy, as S-shaped curves or sclerosis
- monitoring instruments for signs of deformation (difficult with NiTi instruments)
- assuring straight-line access and being aware of the material properties of the metallic alloy, .04 tapered NiTi files were shown to be less likely to separate in preflared canals.

- creating of guide paths (for rotary instruments)
- torque/speed control for rotary instruments
- lubrication during instrumentation
- using the instruments only once

There are some different opinions of how many times the NiTi files can be used, but up to 10 canals (2-3 cases) and 10 cycles of sterilization are shown not to increase the chance of fracture.

At the Department of Endodontics, University of Oslo, all patients are included in a recall program. Prognostic aspects are explained prior and post treatment, so that the patient is prepared and know that an appointment for follow-up will come later on. This preparation and explanation of the healing course as a dynamic process is of importance for understanding, cooperation and possibly the recall-rate. In communication with patients, it is recommended to use neutral expressions, such as 'chance of healing' and 'risk of inflammation' instead of 'success' and 'failure' (20). Patients have also mentioned that they appreciate these routines and that they feel safe and well taken care of by this recall program.

The patient eventually returned for follow-up examination one year after treatment after rescheduling appointments. The radiolucency periapically was larger and more evident in all roots. An appointment for extended radiographical examination with OPG and surgical intervention was scheduled. The patient rescheduled and did not meet at the Section of Maxillofacial Radiology or the Department of Endodonics for surgery. Eventually, in April, the apicectomy of 36 was performed, as described above.

'Prognosis' is defined as the forecast of the course of disease (as the time course and chances of healing after treatment(21)). In spite of all the information available, there have still been many unsolved answers to the questions related to the outcome of apical surgery. This may be explained by the poorly standardized materials and methods of many studies, some studies only use single-rooted teeth, different sample sizes, inclusion or exclusion of teeth with poor prognosis such as deep periodontal defects of lack of buccal bone plate, initial treatment or retreatment, treatment providers (oral surgeons or endodontits) and variability concerning root end management procedures Clinical procedures in apical surgery have considerably evolved, implying that specific studies are of less relevance today.

Success is generally defined as 'the accomplishment of an aim or purpose'. The outcome, therefore, is best defined in direct relation to the specific aim. The aim of endodontic treatment is to eliminate the cause of AP and in apical surgery, the aim is to eradicate the disease and allow healing of the site.

A huge difference in recall rate may influence the results. Some studies have a follow-up from under one year. The classification of outcome has been inconsistent among follow-up studies. This patient was recalled for follow-up after one year was gone. When assessing healing after apical surgery; complete healing, incomplete healing (scar), uncertain healing and failure are terms used in the literature(22, 23). The periapical index (PAI) has not been validated for teeth followed after apical surgery but this index has been used in study on follow-up apical surgery.

Healing progress quickly after apical surgery, peaking within the first year after treatment. Studies with comparable techniques, report a favorable outcome in 91% (24), 92% (25, 26) and 97% (27). When the authors of last citation, recalled the same patients after a longer time period, 5-7 years (97% = one year), the percent of sustained healing was 91% (28).

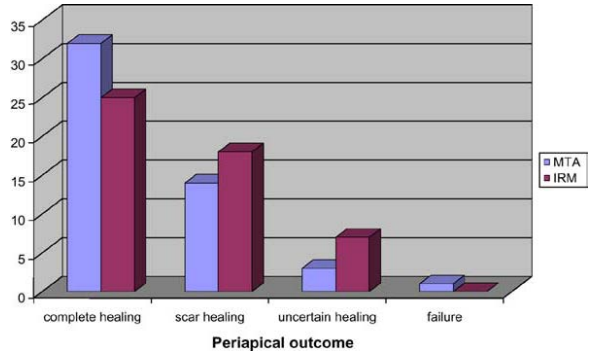

Fig. 29 MTA scored 92% success at the 1-year assessment compared to 86% for IRM% (26)

Approximately 60% of the teeth that heal eventually, and almost all those that heal by scar, are already healed by 1 year. The majority of teeth that appear either healed or diseased at 1 year demonstrate the same outcome also after 3–5 years(29-31). The 1-year follow-up may be considered conclusive for the majority of cases, while a longer follow-up is required for those cases that appear as still healing. Recurrence of disease in the long-term has been reported in 5% to over 40% of healed cases (21).

The patient will be recalled in the follow-up program.

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Case 16 - Persistant pathosis after retreatment, surgical intervention

Patient

58 year old white, Northern European male.

Fig.1. Frontal view

Chief complaint

The patient complainted of a bad taste and secretion from his lower jaw, right side.

Medical history

Allergy grass, pollen, unspecific. Asthma. Inhalation steroids. Nasonex spray. ASA I.

Dental history

The patient received a RCT 44 several years ago, and was re-treated orthograde at the postgraduate clinic, Department of Endodontics, University of Oslo in 2008. At a recall in the follow-up program, a sinus tract was discovered (fig. 3/arrow), as well as a non-healing situation diagnosed radiographically. The patient scheduled to me for explorative operation and assumed indication for extraction because of tentative diagnosis vertical root fracture (VRF).

Clinical findings

Fig.2. Occlusal view, maxilla

Fig.3. Occlusal view, mandibula

Fig. 4. Close-up sinus tract

Fig.5. Sinus tract with gutta-percha cone

	45	44	43	42
EPT	34	-	31	33
Cold	Yes	-	Yes	Yes
Percussion	No	No	No	No
Palpation	No	Yes	No	No
Mobility	-	-	-	-
PPT	3	3	3	2
Restoration	MOD am	ODB comp	-	MI comp

Table 1. Summary of clinical findings

Extraoral examination within normal limits

Intraoral examination reveals sinus tract mesiolabially of tooth 44.

Radiographic history

Fig.6.February 2008 before re-treatment

Fig. 7. May 2008 after re-treatment

Fig. 8 August 2009

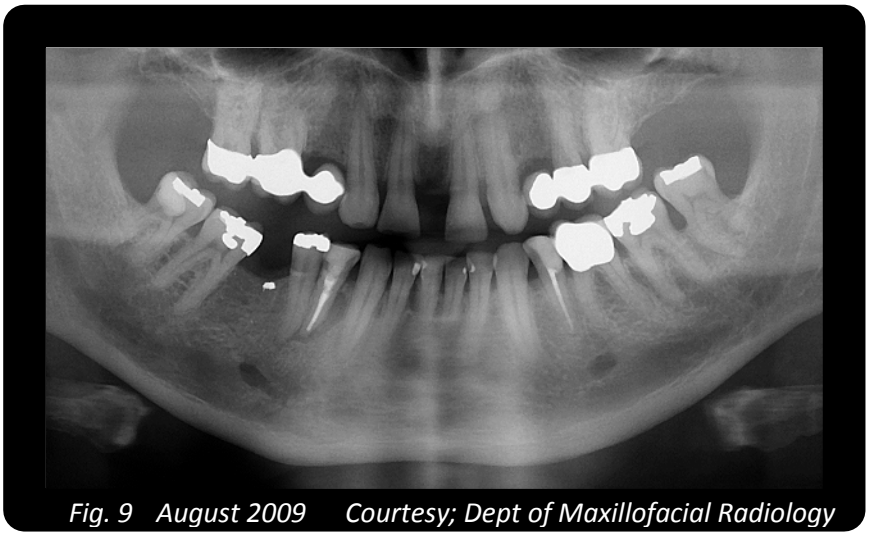


Fig. 9 August 2009 Courtesy; Dept of Maxillofacial Radiology

Fig. 10 June 2011

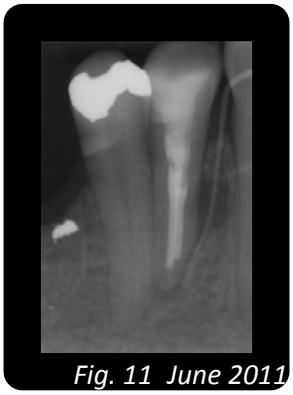


Fig. 11 June 2011

Radiographical findings

Fig.12. 2011-11-11

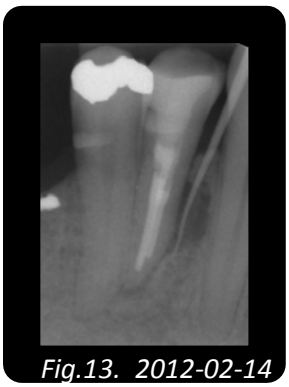


Fig.13. 2012-02-14

Tentative diagnosis

VRF, infected lateral canals or persistent apical infection, extraradicular infection. The presence of a third, untreated canal was not so likely because the prevalence of a third canal in mandibular first premolar is reported to be present in only 0,5 % (Vertucci) – 5,7 % (Caliskan et al) (2) in a Caucasian population.

Treatment plan

Exploratory surgical procedure/reflect flap and transilluminate to verify or disprove presence of a VRF. If present; extraction of tooth was planned. Otherwise, surgical intervention with elimination of persistant infectious focus, possibly in lateral canal(s). The patient had a strong wish for retaining the tooth and resisted extraction at the moment whatever diagnosis found.

Treatment 2012-02-14

Fig.14. Fenestration of bone (arrow)

Fig. 15. During operation procedure

Fig. 16. Close-up after haemostasis

After LA with 3,6 ml 2% lidocaine with 1:100,000 epinephrine for the right mandibular nerve block and 1,8 ml buccal infiltration, a mucoperiosteal flap was elevated. Pathological fenestration of the cortical bone was observed in the area between the teeth 43 and 44 (fig. 14). Osteotomy and access was made by removal of bone buccaly with a round hard-metal bur under constant cooling and rinsing with sterile saline solution. Granulation tissues were removed with a sterile curette, and a microbial sample obtained by rubbing sterile paper points against the root. The paper points were pooled in a sterile tube containing 1 mL of pre-reduced VMGA III transport medium for microbial cultivation. In this medium, cysteine is added to inhibit oxidation. During inspection through the SOM, no fracture line was observed. Exposed lateral canals as etiological factor for post-treatment disease were not verified. The granulation tissue was in communication with the apical area. Therefore, 3-4 millimeters of the root apex was resected with a long fissure bur under sterile saline irrigation, with as little bevel as possible. Adequate distance to the adjacent roots to avoid damage was ensured during the procedure. A retrograde preparation was carried out with the P5 Newtron ultrasound device using ultrasonic retrotips. The cavity was extended 3 mm in the root canal with removal of gutta-percha in the apical part. Care was taken to prepare as parallel to the long axis of the root as possible. A sterile epinephrine gauze pad was placed in the cavity in order to achieve haemostasis. FeS was used at single points with bleeding. The apical preparation was rinsed with sterile saline and dried with sterile pre-curved paper points. The root surface and preparation was carefully inspected with an explorer under high magnification with the SOM and micro-mirror. A retrograde MTA ProRoot® filling was placed into the cavity using plastic instrument MTA- carrier/ MTA block and condensed with micro pluggers. The material was examined under magnification with an explorer to check marginal adaptation and integrity. The gauze pads used were removed, and the number of pads counted. The surgical site was irrigated carefully with sterile saline, and the area below the flap checked and irrigated. The flap was then repositioned and hold tight in place with finger pressure in some minutes in order to reduce the post operative haematoma and pain. Flap closure was obtained by suturing the vertical releasing flap with three 5-0 Supramid single sutures and the intrasulcular incision with five 4-0 sutures. Postoperative radiograph was taken. The patient received postoperative instructions. Antibiotics and analgesics were provided to the patient , phenoxymethylpenicillin (penicillin V) 1+1+2, for five days, and ibuprofen 600 mg combined with 1 g paracetamol against pain, 1x3 times a day. The patient returned 1 week later for suture removal and reported slight postoperative pain. The first phase of healing after surgery was uneventful.

Result

Fig. 17. After suturing

Fig. 18. After retrograde filling

The tooth has a shortened root but the marginal bone level in physiological conditions. The surgical procedures and retrograde management were considered adequate. The patient was provided with phenoxymethylpenicillin, which later, after receiving results from the microbiological analysis, showed not to be the antibiotics of choice (fig. 20). Because of the favorable clinical course, additional antibiotics were not prescribed. Concerning microbiological sampling and results; possibility of contamination of the indigenous oral microflora is present.

Tester / funn

DNA-DNA Hybridisering:

Fusobacterium nucleatum subsp vincentii	(G- anaerob stav)
Campylobacter rectus	(G- mikroaerofil stav)
Treponema socranskii subsp socranskii	(G- anaerob skrue)
Actinomyces viscosus	(G+ anaerob stav)
Actinomyces israelii	(G+ anaerob stav)

Fig. 19. Results from the microbiological analysis

	c	C		R/I/S	c C mg/l
PEN			Penicillin G	R	0,5-2
AMC			Amoksicillin + klavulansyre	S	4/2-8/4
PIC			Piperacillin	R	32-64
TZP			Piper. + Tazobactam	S	32/4-64/4
TCC			Ticarcillin + klavulansyre	S	32/2-64/2
CXT			Cefoksitin	S	16-32
CTT			Cefotetan	S	16-32
IMI			Imipenem	S	4-8
CLI			Klindamycin	S	2-4
CMP			Kloramfenikol	S	8-16
MTR			Metronidazol*	*	8-16
AMO			Amoksicillin	R	2-4
AMI16			Amoksicillin	R	16
AMC16			Amoksicillin + klavulansyre	S	16/2
TIC64			Ticarcillin	R	64
MTR4			Metronidazol*	*	4

Fig. 20. Testing for antibiotics resistance

Mottatt en grålig vevsbit på 5 x 6 mm. Kapsel A. KV/iv

DIAGNOSE :
Resektat fra kjeve med granulasjonsvev.

Rune Waalen 17.02.2012

Fig. 21. Diagnosis from the histology analysis

Evaluation & prognosis

Endodontic: The microbiological analysis showed presence of bacteria capable of extraradicular existence. When source of infection removed, it is reason to believe healing will occur. Since the lesion was not found to contain epithelial lining and the likelyhood of additional problems existing, as undiagnosed VRF, the prognosis is considered hopeful. Possible overgrowth of *Candida* because of inhalation steroids. *Candida* species are known to be a possible contributoral factor in persistant endodontic infections.

Total: Questionable

2,5 months follow-up examination

The patient was examined clinically and radiographically after two months.

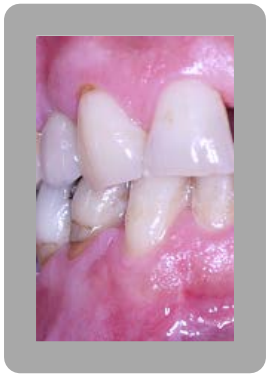


Fig. 22. 2012-04-25

Fig. 23. 2012-04-25

Fig. 24. 2012-04-25

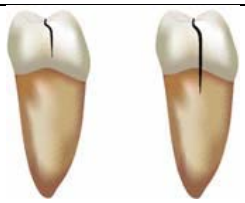
The patient presented without symptoms and adequate soft tissue healing. The sinus tract had closed with scar tissue present. He had since the operation never noticed exudation, bad taste or smell, as previously experienced. The radiograph showed sign of bone regrowth in the operational area, but it was too early to give definitive evaluation concerning the osseous healing situation. The patient will be re-examined in February 2013.

Discussion

The mandibular premolars may be difficult to treat, they have a high flare-up and failure-rate(2). A possible explanation may be the large degree of variations in root canal anatomy in these teeth, especially the first premolar, as in this case. If two canals are present (25 %) (2), they tend to be round to the pulp chamber to the foramen or a broad root canal with bifurcation into two separate root canals. Direct access to the buccal canal is usually possible, whereas the lingual may be more difficult to find. The lingual canal tends to diverge from the main canal at a sharp angle. The lingual inclination of the crown tends to direct files bucally, which could make the localization of the lingual orifice more difficult. To extend the lingual wall of the access cavity more lingual makes this canal easier locatable. Access preparation may have to be modified to allow access to the complex root canal anatomy frequently seen in the apical half of the root in these teeth. According to Vertucci; One canal is present in 74% of cases, two canals are present in 25,5%, three canals in 0,5%. Caliskan *et al*: One canal: 75%, two canals 19%, three canals: 6. Note: Racial/ethnic background may give differences in frequency and a higher prevalence of more than two canals than the information mentioned above. Average time of eruption: 10-12 years. Average age of calcification: 12-13 years. Average length: 21,6 mm.

The aim of endodontic treatment is elimination of infection in the root canal system and prevention of re-infection. Some clinical cases do not respond to the traditional protocol used in endodontic therapy. Even when treatment is attempted; residual bacteria and apical pathology may persist, or secondary infection may be evident (1). Inadequate aseptic control, poor access cavity design, missed canals, inadequate instrumentation and leaky restorations may lead to post-endodontic disease. Factors found to contribute to persistence of a periapical radiolucency after treatment are intraradicular infection, extraradicular infection, foreign body reaction, cysts (possibly with cholesterol crystals) and fibrous scar tissue healing. By periradicular surgery, we want to remove diseased periapical tissue, seal the apical root canal system and make conditions for healing of hard and soft tissues.

Periapical lesions are infectious disorders that exhibit a variety of clinical and radiographic manifestations. The radiographic appearance in this case could mimic the picture of a VRF and the case was referred with this as tentative diagnosis. Historically, VRF and longitudinal fracture were considered synonymous. VRF is now considered to be a sub-type of longitudinal fractures (table 2).

Diagnosis	**Image**	**Direction**
Craze lines		***Occlusogingival direction***
Fractured cusps		***Mesiodistal and faciolingual***
Cracked tooth		***Mesiodistal***

Split tooth		***Mesiodistal***
Vertical root fracture		***Faciolingual***

Table 2. Suggested classification of longitudinal root fractures (3). Illustrations from (4)

VRF has several features which separate it from the other longitudinal root fractures; it is almost always affects a RCT tooth, fracture lies in bucco-lingual direction and originates on the root surface. It is often caused by excessive obturation force, post preparation or excessive dentine removal during instrumentation. When the fracture line reaches the gingival crevice, a deep isolated, narrow pocket is formed, usually all the way to the apex of the tooth. This pocket harbor much of the same species of microorganisms as in the root canal, even if the root canal flora is not that complex, and the ratio between anaerobic and facultative anaerobic bacteria is shown to be about 100 times higher in the root canal (5). Studies have indicated that differences in the treatment outcome may be related to differences in the composition of the microbial flora in AP (6). Root canals of infected teeth have a complex microbial flora consisting of cocci, rods, spirochetes, filaments, and sometimes fungi. The microorganisms are after a period of time able to form biofilm, in contrast to the planctonic bacteria. By this biofilm-formation, they are able to resist phagocytic cells, as well as locally delivered irrigation and systemic drugs.

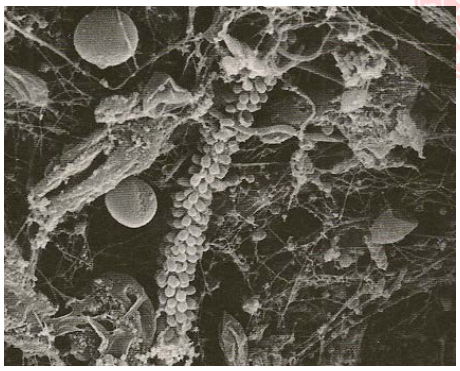


Fig. 22. A scanning electron micrograph showing extensive bacterial colonization near the apical foramen. Note the "corn cob"- like structure, seldom seen in primary infections and might indicate an extra-radicular infection.(1)

Specific microbes are often found in cases post-treatment disease. In addition to a high prevalence of enterococci and streptococci, *Actinomyces* species, peptostreptococci and *P. alactilyticus*, *P. propionicum*, *D. pneumosintes* and *F. alocis* are more often found. *A. israelii* is known to be able to establish in the periapical tissues, and was present in this case. It is known to be involved in periapical actinomycosis. If this microorganism is found to be present, is may indicate a communication between the periapical tissues and the root canal (5). For microbes to maintain AP and post-treatment disease, they must have ability to perpetuate inflammation external to the root canal system. This could be achieved by sequestration – creating a physical barrier between the microbe and the host, by cellular evasion/avoiding leukocyte-dependent anti-bacterial mechanisms and humoral evasion – avoiding the host's antibodies and complement(5). *A. israelii* has been shown to be able to avoid phagocytosis by PMN leukocytes primarly through collective cohesion. It is known that *Actinomyces* species may survive in the granulation tissue outside the root canal (7). Other anaerobic and facultative anaerobic bacteria are also able to survive in periapical, inflammatory lesions of asymptomatic teeth; *Prevotella* and *Porphyromonas* species as well as enteric bacteria (7). *T. socranskii* was also found in this case; this is one of the most predominant

spirochetes in infected root canals (in addition to *T. denticola*). From PCR-analysis, we know that spirochetes are present in infected root canals in a much higher prevalence than previously thought.

In addition to this, the presence and prevalence of fungi associated with endodontic infections are well documented (8, 9). Yeast colonization associated with periradicular pathosis has been demonstrated in untreated root caries, dentinal tubules, failing root canal treatments, apices of teeth with asymptomatic apical periodontitis, and in periapical tissues and the occurrence has been reported by culture, molecular methods and electron microscopy in situ (10) , Fungi has especially been detected in retreatment cases like this case. According to Grossman (1952), as many as 17% of infected root canals may contain *Candida* species.

The genus *Candida* contains a numerous of species, *C. albicans* being the most important, because of its ability to form biofilm and the most prevalent recovered from the human mouth. It is estimated that this species accounts for over 80% of all oral yeast isolates (11). Candida belongs to the normal flora of man – in mouth in 20-40% of healthy individuals. They rarely cause infection in this population. These endogenous fungi are opportunistic pathogens, infection by Candida usually arise from an imbalance of normal microbiota and some predisposition present in the host. Virulence factors associated with fungi is concerning adherence, evasion of host defences (as by phenotypic switching/ antigenic modification through frequent cell surface changes). Fungal adhesion is required for host colonization; adhesins are often glycoproteins (mannan, chitin). Mycelium formation promotes penetration and invasion. Endotoxin-like glycoproteins in the cell wall can have pathogenetic importance.

Natural, nonspecific defence mechanisms are in general very effective in preventing oral fungal infections, as barrier function of intact mucosae, saliva flow and antimicrobial components of saliva, as histatins. Following fungal colonization or invasion of tissues, a nonspecific inflammatory response is often elicited. Most fungi activate complement by the alternative pathway, become coated with C3 fragments and attach to PMNs, monocytes and macrophages. The main leucocyte contributing to the destruction of fungi is the neutrophile. Other components of the non-specific response include eosionophils, basophils, platelets and NK-cells. Macrophages may persist at sites of infection. The specific immune response to fungal infections involves humoral and cell-mediated immunity. Antibodies are produced in response to fungi, especially IgA – preventing microorganisms to adhere to oral surfaces and IgG with opsonizing antibodies. T-lymphocytes are involved in the cell-mediated immune response and are important against mucocutaneous candidonsis. Patients with T-cell defects are particulary prone to candidosis.

Organisms able to penetrate and colonize dentin tubuli have more chance of surviving and multiply. The microbial cells are also more protected from intracanal medicaments and procedures. On the basis of cell dimension, fungi should be able to penetrate tubuli, since dentin tubuli are of dimension up to 2 µm (1). The size and the density of the tubules varies, depending on the location in the tooth. The numbers of tubules is low peripherally and increases towards the pulp – favorable in terms of protective aspects against possible intruding microorganisms.

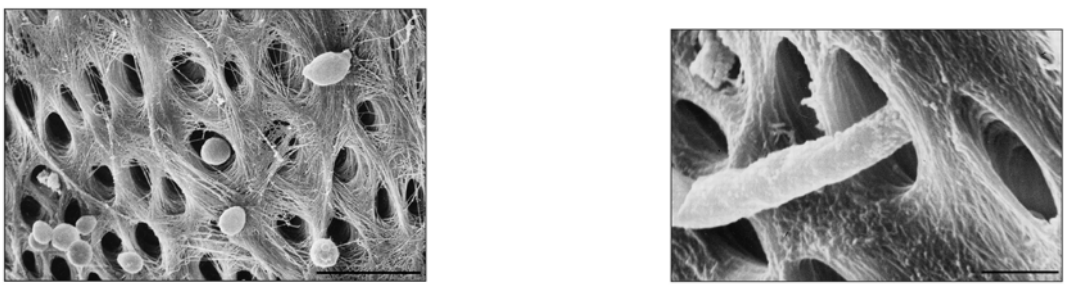


Fig. 23, 24. Left: Scanning electron micrograph (SEM) of C. albicans blastospores on root canal surface in vitro. (The bar indicates 10 µm). Right: SEM of C. albicans hyphae penetrating a dentinal tubule. The bar indicates 2 µm (9)

Investigators have found growth of fungi into dentin tubules. Sen *et al* investigated the growth patterns of *C. albicans* in relation to human radicular dentin. They observed pseudohyphae penetrating into dentinal

tubuli. They also found that presence of smear layer increased the adhesion of *C. albicans* to dentin. Waltimo *et al* found, in an in vitro study, the penetration depth of yeast cells and hyphae up to 60 µm.

C. albicans may leave its normal habitat in the oral cavity and establish in the root canal where the organism take advantage of the ecological changes and that their microbial competitors have been eliminated by treatment (12). Reports exist that fungi is present more often in root canals of obturated teeth in which the treatment has failed. Waltimo *et al* in 1997 studied the occurrence of yeasts in cases of apical periodontitis persistent to convential therapy. *C. albicans* was the most commonly isolated yeast species and represented 80% of the identified yeasts (13). A total of 48 strains of fungi were isolated from 47 of the 692 positive samples (7%). Of the 48 yeast isolates 20 were identified to the species level. The fungi were endomyceteous yeasts and they were isolated either in pure culture (six cases, 13%) or together with bacteria (41 cases, 87%), mostly Gr+ facultative bacteria. The frequent coexistence of yeasts and streptococci in the same canal may be due to ecological conditions that favor the growth of both of the organisms, or because of synergism between yeasts and streptococci. The findings of yeasts in pure culture strengthened the theory that yeasts are pathogenic in apical periodontitis.

Study	Method	Prevalence
Möller 1966	Culture	3%
Nair et al 1990	LM and TEM	22%
Waltimo et al 1997	Culture	7%
Sundqvist et al 1998	Culture	8%
Molander et al 1998	Culture	4%
Peciuliene et al 2001	Culture	18%
Hancock et al 2001	Culture	3%
Cheung and Ho 2001	Culture	17%
Pinheiro et al 2003	Culture	4%
Siqueira and Rôchas 2004	PCR	9%

Table 3. Studies reporting the occurrence of fungi in persistent endodontic infections (8)

A difference in the composition of the microflora are reported between poorly treated and well-treated teeth, when the teeth are sampled at re-treatment. In poorly root-filled teeth, the flora is more similar to the polymicrobial infection seen in untreated root canals. One can assume that reason for the unsatisfactory treatment is inadequate aseptic methods and/or poor coronal restoration — that together allow an influx of carbohydrates and possibly new bacteria from the oral cavity (12).

Endodontists have for a long time been aware of the need for use of antimicrobial strategies that include fungi elimination from infected root canals. Already in 1967 Grossman stated: *"One of the problems in endodontic treatment is the presence of Candida organisms in infected root canals; it is necessary to eliminate these organisms to maintain the periapical tissue in a normal state or to restore it to a state of health."*

The treatment of root canals is unique in the way that it is possible to isolate the root canal from the rest of the oral cavity by means of barrier techniques. The regimen of asepsis during treatment is of outmost importance, with disinfection of operating field, tooth and rubber dam. Elimination of bacteria from root canal may be difficult because of irregularities and branches of the root canal system and possible penetration into the dentinal tubules. The microorganisms within the root canal must be actively eliminated by a combination of physical debridement and antimicrobial chemical treatment procedure. For cases of resistance to antimicrobial agents, the use of alternative medications, or the combination of antimicrobial agents, is suggested to increase the spectrum of action.

C. albicans are showed to be highly resistant to CH (14) and even more resistant in vitro than *E. faecalis*. *C. albicans* is able to survive a wide range of pH values, so the alkalinity of saturated calcium hydroxide

solution may not have effect. In addition, CH solution may display the Ca^{2+} ions necessary for growth of Candida.

EDTA is shown to have antifungal activity in two ways, anticolonization – reducing the adhesive properties and antigrowth – decreasing the metabolic activity and pathogenicity by extracting Ca^{+} ions. Studies have shown that sodium hypochlorite, EDTA, iodine, potassium iodide and CHX are more effective against *C. albicans* than calcium hydroxide in vitro. The use of these disinfectants may provide an alternative local medication in endodontic yeast infections. Several studies have shown that *C. albicans* was resistant to the antibacterial effect of CH medication, but were sensitive to chlorhexidine (15).

In the study of Waltimo *et al* (16), all tested isolates were susceptible to Amphotericin B. Site of action for this medicament is the sterols of the plasma membrane, induction of leakage of intracellular constituents. They also showed that 14% of periodontal strains had resistance to fluconazole, in comparison to those from endodontic origin, where no resistant strain was found.

The National Asthma Education and Prevention Program (NAEPP) guidelines for the diagnosis and management of asthma, list oral candidiasis as one of the local side effects with inhaled corticosteroids (ICS). The amount of Candida spp. has been shown significantly greater in asthmatic patients taking inhaled steroids compared with those who were not. It could be speculated whether this patient had elevated levels of Candida spp in the oral cavity. There are no scientific background information to be found concerning if patients with elevated levels represent a higher risk of Candida-infected endodontic infections. The patient had no subjective or objective findings of Candida infection in his oral cavity.

There is a need for controlled clinical trials to evaluate the efficacy of treatment strategies and long term outcome concerning yeasts in persistant AP.

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Case 17 – Ostemyelitis

Patient

52 year old white, Northern European male

Fig. 1 Frontal view

Medical history

Use of antihypertensiva, no known allergies. Patient is a tobacco smoker. ASA group II.

Dental history

The patient had no subjective symptoms, but presented with swelling from molar area buccally of tooth 37 in 2008 (fig 2 & 3). Anamnestic factors incl. trauma was negative. The retreatment of 35 was initiated at specialist clinic first time 2009, at that time referred from the student clinic because they were not able to get dry canal. Long-term $Ca(OH)_2$- inlay performed. Thereafter long-term Tri-antibiotic paste (Hoshino mixture). The patient was referred to me after the period of Hoshino mixture. Teeth 36 and 37 were retreated at Department Endodontics in 2009 and 2010. The patient had no further subjective symptoms after the episode with swelling in 2008.

Fig. 2. Frontal view 2008, buccal swelling molar area

Fig. 3.Close-up buccal abscess 2008

Clinical findings 2010-10-06

	34	35	36	37
El test (0-80)	24	80	-	-
Thermal test	Yes	No	-	-
Percussion	No	No	No	No
Palpation	No	No	No	No
Mobility	-	-	-	-
PPD	3	3	4	3
Restoration	-	OD comp / IRM	Porcelain crown	Porcelain crown
Extraoral exam	Normal			

Table 1. Summary of clinical findings

Fig.4 Occlusal view, maxilla

Fig.5. Occlusal view, mandibula

Fig. 6, lingual view

Fig. 7 Close-up occlusally

Fig. 8. Buccal view

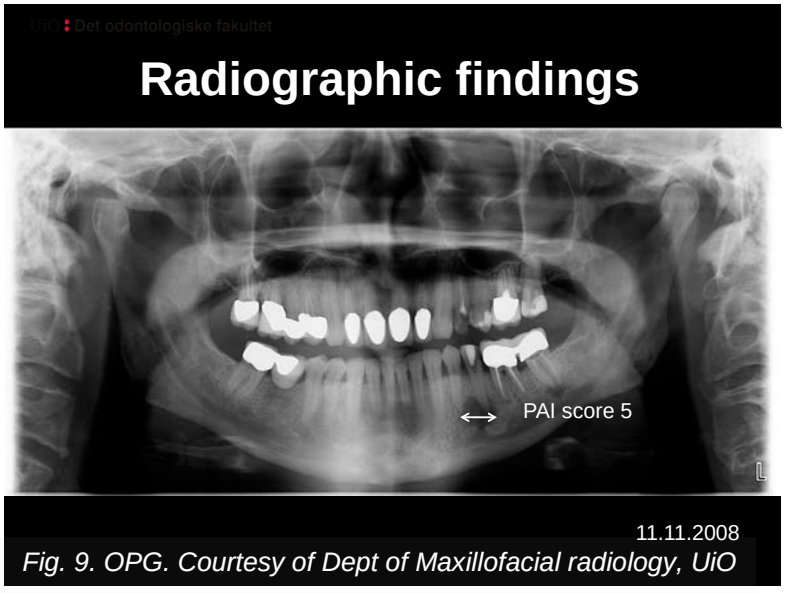


Fig. 9. OPG. Courtesy of Dept of Maxillofacial radiology, UiO

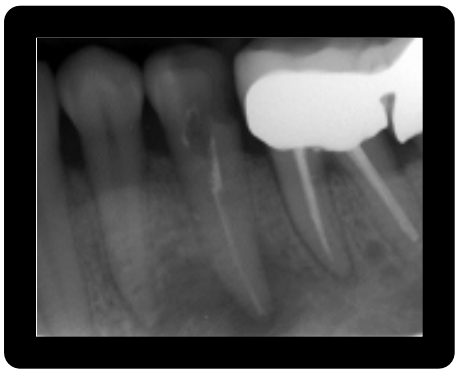


Fig.10. 2008-03-26

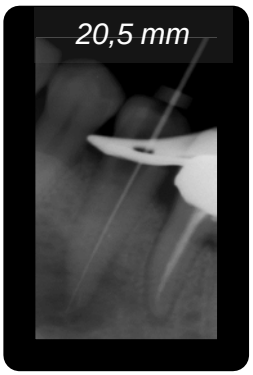


Fig.11. 2008-05-13

Fig. 12. 2010-10-06

Diffuse radiolucent area still can be observed apically and laterally of the root of 34, to the adjacent root of 35. Some further raduolucents zones are evident, 36, 37 considered ‘healing’ after NSRCT.

Fig. 13. OPG. Courtesy of Dept of Maxillofacial radiology, UiO

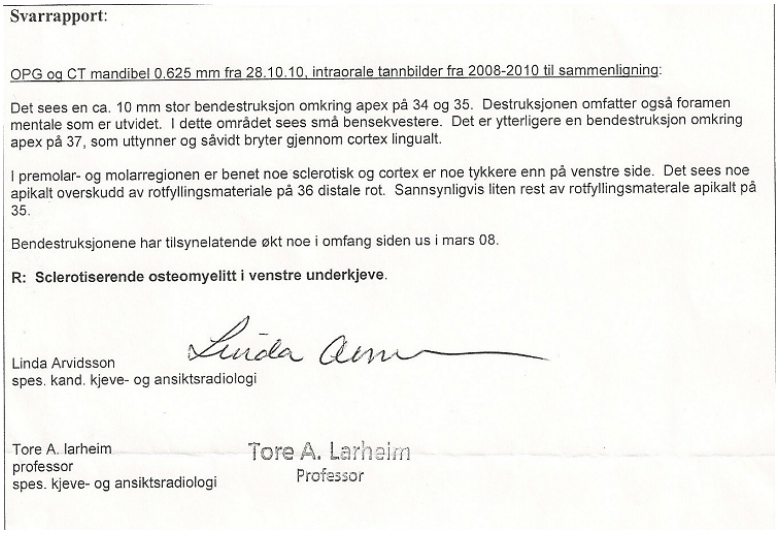
Because of no healing response evident radiographically after treatment and additional treatment attempts, the patient was referred for at CT scan.

Differential diagnosis

In this situation, besides apical periodontitis, conditions as radicular cyst, lateral periodontal cyst, granulomae conditions (as eosinophilic gr.), odontogenic/ non-odontogenic tumors, actinomycosis, osteomyelitis and Paget's disease are to be considered. The malignant entities should not be ruled out, as Ewing's sarcoma, osteosarcoma, chondrosarcoma, non-Hodgkin's lymphoma and metastatic disease.

Referral to the patients MD for general investigations may be relevant; with full blood count (FBC), erythrocyte sedimentation rate (ESR) for judging if malignancy or leukemia. Liver function tests (LFTs) with possibility of alcoholism. Blood glucose (possible diabetes). Serology (EBV – Burkitts lymphoma. Blood culture if osteomyelitis.

Diagnosis



Svarrapport:

OPG og CT mandibel 0.625 mm fra 28.10.10, intraorale tannbilder fra 2008-2010 til sammenligning:

Det sees en ca. 10 mm stor bendestruksjon omkring apex på 34 og 35. Destruksjonen omfatter også foramen mentale som er utvidet. I dette området sees små bensekvestere. Det er ytterligere en bendestruksjon omkring apex på 37, som uttynner og såvidt bryter gjennom cortex lingualt.

I premolar- og molarregionen er benet noe sclerotisk og cortex er noe tykkere enn på venstre side. Det sees noe apikalt overskudd av rotfyllingsmateriale på 36 distale rot. Sannsynligvis liten rest av rotfyllingsmaterale apikalt på 35.

Bendestruksjonene har tilsynelatende økt noe i omfang siden us i mars 08.

R: Sclerotiserende osteomyelitt i venstre underkjeve.

Linda Arvidsson
spes. kand. kjeve- og ansiktsradiologi

Tore A. larheim
professor
spes. kjeve- og ansiktsradiologi

Tore A. Larheim
Professor

Fig. 14 Diagnostic report from Dept of Maxillofacial Radiology, UiO, dr. Arvidsson/dr. Larheim

Pulpal : K04.19 Previous endodontic treated

Periodontal: Generally normal, localized marginal defects related to crown restorations

Periapical: K10.2 Sclerotizing osteomyelitis left lower jaw

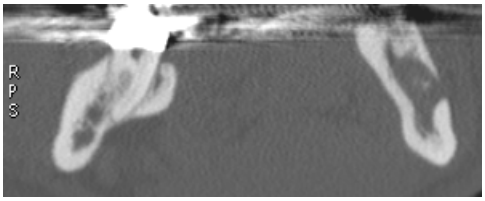


Fig. 15. Coronal view showing destruction of cortical bone in region 35

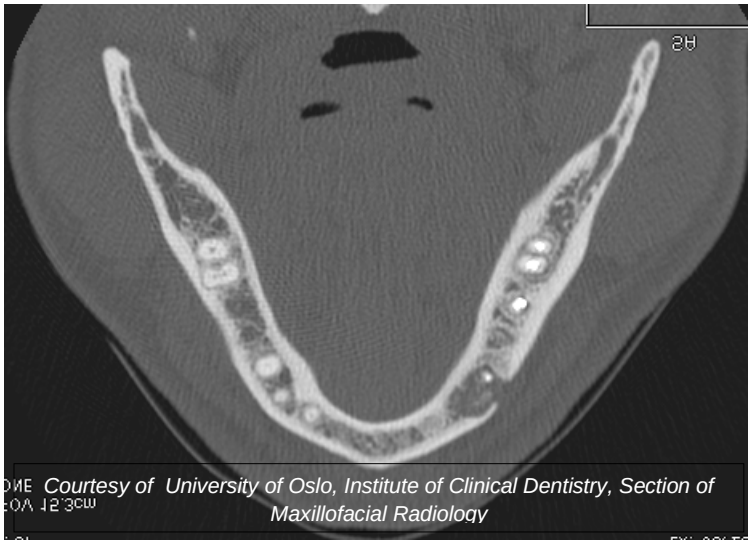


Fig. 16. Axial view showing bone destruction in premolar area

Fig. 17. 3D-reformatted image showing extended/ resorbed foramen mentale.

Courtesy of University of Oslo, Institute of Clinical Dentistry, Section of Maxillofacial Radiology, dr.Linda Arvidsson.

Problem list

Uncertain response to osteomyelitis treatment. Possibility of microorganisms resistant to the antibiotics of choice. Sigarette smoking.

Treatment plan/treatment options

- Endodontic re-treatment of mandibular, left second premolar

and:

- Surgical debridement and sequestrectomy. Biopsy (benign vs malignant lesion). Microbiologic sampling. Antibiotic therapy

or, if further progress

- Extraction and surgical decortication, osteosynthesis, fixation/reconstruction and/or graft treatment
- (Hyperbaric oxygen)

Therapy in collaboration with Department of Oral Surgery and Oral Medicin, UiO

Treatment

2010-10-06: Asymptomatic patient. Aseptic procedure/ rubber dam with disinfection of working field. Chemical root canal disinfection with 1% NaOCl, 2% CHX, 17% EDTA. R070/20,5mm. No exudation observed in the SOM. Canal dried with paper points, interappointment dressing $Ca(OH)_2$. Planning next visit after further diagnostic radiological investigations because of lack of healing response and atypical radiolucency.

2010-12-16: Osteomyelitis diagnosis confirmed by CT. No change in clinical findings; no swelling extra-or intraorally. Normal sensibility in region of innervations of n. mentalis. Asymptomatic patient. Per oral 300 mg Dalacin (clindamycin hydrochloride) x 3. Therapy in collaboration with Department of Oral Surgery and Oral Medicin, UiO.

2011-01-13: Control at Dept of Oral Surgery. Unchanged conditions. Endodontic treatment recommended finished followed by surgery with removal of sequestra and granuation tissue. Continued Clindamycin medication, dosage 150 mg x 3 for the next months.

2011-02-09: Aseptic procedure/ rubber dam with disinfection of working field. Master cone radiograph. Gutta percha, sealer AHplus, IRM plug.

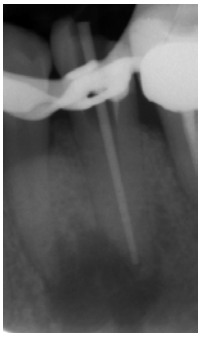
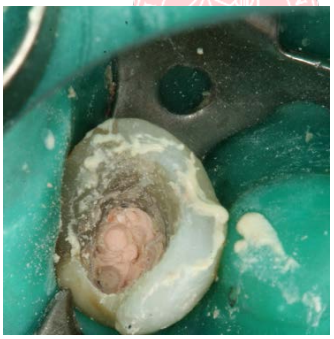




Fig.18, 19, 20. Photos showing (from the left): Master cone radiograph, IRM plug applied and Fuji II LC occlusal temporary restoration.

Result


Fig. 21. 2010-10-06 with Hoshino mixture intracanally

Fig. 22. 2011-02-09 after obturation

Continued medication 300 mg Dalacin (clindamycin hydrochloride) x 3

2011-04-14: Treatment at Dept of Oral Surgery: 2,5 carp conduction anesthesia, 1,5 carp infiltration anesthesia, flap elevation. Removal of bone buccally of tooth 35. Capping of root, excavation of granuloma UL preparation retrograde, MTA apically. 7 sutures Vicryl 3.0 Rp Pinex Forte no XX. Continued Dalacin medication.

Prognosis

Endodontic: Uncertain

Total: Uncertain

Evaluation

Tooth 37; concerning the radiographic appearance and the known diagnosis of osteomyelitis in the jaw, one could have considered apical surgery performed also in this area. Radiopaque area consistent with a root tip and root canal material should have been removed.

Follow-up examination

2011-05-19: Control at Dept of Oral surgery. Adequate soft tissue healing. No pain, swelling or decreased sensibility. Discontinuation of antibiotics. Persistence of part of root and/or gutta percha evident.

2011-10-03: Control at Dept of Oral surgery. Some degree of healing evident radiographic. The patient had no swelling or other signs of clinical changes related to the diagnosis osteomyelitis. No changed sensibility in the area of innervation of n. mentalis after surgery.

Fig. 23. Courtesy of Dept of Maxillofacial Radiology, UiO. 2011-07-12.

Fig. 24. Courtesy of Dept of Maxillofaacial Radiology, UiO. 2011-10-03

Fig. 25. Courtesy of Dept of Maxillofaacial Radiology, UiO 2012-03-07

Fig.26. Oct 2010

Fig. 27. Nov 2011

Fig. 28. March 2012

2012-03-28: The patient was free of symptoms. No changed sensibility in the area of innervation of n. mentalis after surgery. Healing can be seen at the apical aspect of the premolar 35 but the persistant root apex and filling material must be expected to be an infectious focus. The operator at the Department of Oral Surgery and Oral Surgery was informed about this finding.

Discussion

For description of tooth morphology of the mandibular, second premolar; se case 4.

The ultimate goal in surgical endodontics is not only the eradication of periapical pathosis but also preservation of periodontal conditions using suitable surgical techniques(1). Treatment involves removal of necrotic material, tissue break-down products, elimination of infection from the root canal system, followed by a fluid-tight seal of the apical portion of the root canal with a biocompatible material. Before surgical procedures, planning of treatment including soft tissue management is of importance. Example of flap design fig. 29-33 from (2). All radiographs and CT-images should be evaluated and be on screen close to the operator. Pre-operative instructions is always given prior to the treatment, including information of

possible adverse effects, information concerning the correlation of smoking and healing/ post-infection issues.

The flap should offer optimal access and have an adequate blood supply, the flap must be of adequate size and fully reflected. The edges must lie on the sound bone. Important factors to consider is the number of teeth involved in the surgery, the length and shape of the roots involved, the dimensions of the lesion, the amount of attached gingiva, the existence and depth of periodontal pockets, the locations of muscle attachments and frenulums, the height or depth of the vestibule, the location of anatomic structures, such as the neurovascular bundles and the maxillary sinus. The type of incision and choice of flap design should be adapted to local conditions and depending on factors as the type of treatment in the particular case. Different flaps are used in different situations; as cervical resorptive defects, cervical area perforations, periodontal procedures , intra-sulcular flap (marginal), triangular used during periapical surgery in postrerior areas or rectangular used when multiple teeth, large lesions or long roots. Semilunar flap could be used if special aesthetic indications but have several disadvantages, as well as the submarginal flap, Ochsentein-Luebkeflap.

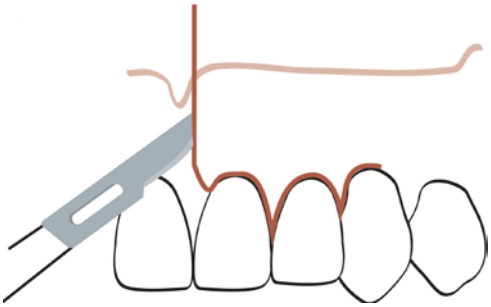


Fig. 29. A triangular flap is formed by a mesial vertical and sulcular incision extending to at least two teeth distal from the releasing incision.

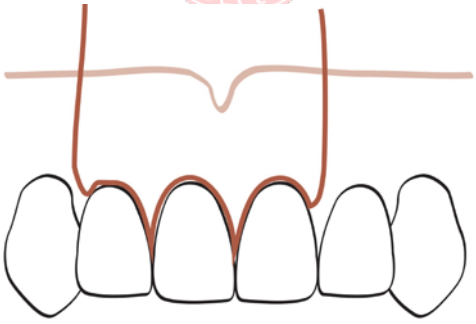


Fig. 30. A rectangular flap comprising two releasing incisions connected by a sulcular horizontal incision.

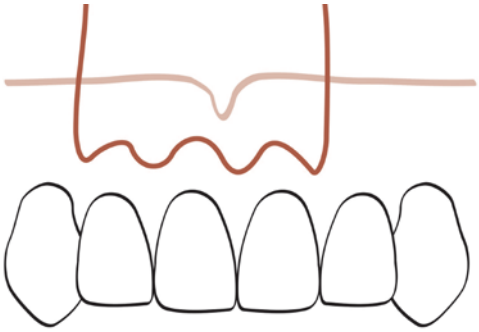


Fig. 31. A submarginal incision formed by a scalloped horizontal incision within the attached gingiva and two releasing vertical incisions.

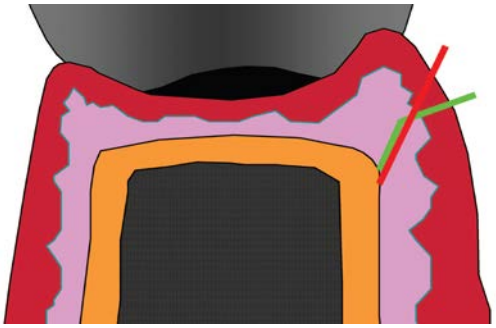


Fig. 32. Left: Schematic drawing with a red line representing a single straight incision directed to the crestal bone. The green line represents the papilla base incision with a shallow incision placed at the level of the lower third of the papilla in a slight curved line connecting one side of the papilla to the other. In a second step, the scalpel is placed to the base of the previously created incision inclined apically, almost parallel to the long axis of the tooth and directed towards the crestal bone margin.

Fig. 33. Right: The line of incision horizontally connects one side of the papilla to the other in a curved line (2).

The incision is made clearly defined, for maximum tissue thickness reflection and with optimal possibility of reapproximation and reattachment. Elevation of the flap gives access to the bone by separating a full mucoperiostal flap of tissue and raising it from its underlying hard tissue attachment. The periosteum is retracted as an integral part of the flap. The flap is hold away from the surgical site, but handled carefully.

Most endodontic surgery problems can be avoided by using the following incision rules (3)

- Firm continuous incision
- An incision should not cross an underlying bony defect
- The vertical incision should be in the concavities between bone eminences
- The vertical incision should not extend into the muccobuccal fold
- The termination of the vertical incision at the gingival crest must be at the mesial or distal line angle of the tooth
- The base of the flap must be at least equal to the width of its free end

The word “osteomyelitis” originates from the Greek words “osteon” = bone and “muelinos” = marrow (4). In modern literature, the term often implies infection in the entire bone, including the cortex and the periosteum. The inflammatory process begins with an infection of the medullary portion of the bone and eventually extends to include the haversian systems and the periosteum. The infection becomes established when pus and edema compromises or obstructs the local blood supply. Following ischemia, the infected bone becomes necrotic and leads to sequester formation, a classical sign of osteomyelitis. The disease may be a continuation of an apical periodontitis with spreading of the infection into the bone marrow, but it is not dependent on an infected tooth as a reservoir of the causative organisms (5).

Osteomyelitis is not so common anymore with our societies improved nutrition status, widespread availability of health services and the integration of antibiotics into the treatment modalities. The majority of the cases is found to be in men; a 3:1 male to female ratio. Lower jaw is more often affected because the maxillary blood supply is far more extensive than in mandibula.(5, 6).

Etiology is found to be mostly odontogenic; dental-infection related or traumatic (fracture related). There may be a history of fractures, irradiation/ medicamentaton with bisphosphonates (osteoradionecrosis), leukemia and other immunodefiency diseases as AIDS, diabetes, malnutrition, alcoholism, drug abuse or immunosuppresion (steroids and cytostatic drugs). Possible neoplasia should be taken into consideration.

Status of the dentition is not found to be of prognostic importance in the assessment of either occurence or outcome of disease (7). Generally, conditions altering the vascularity of bone predispose the patient to the onset of osteomyelitis.

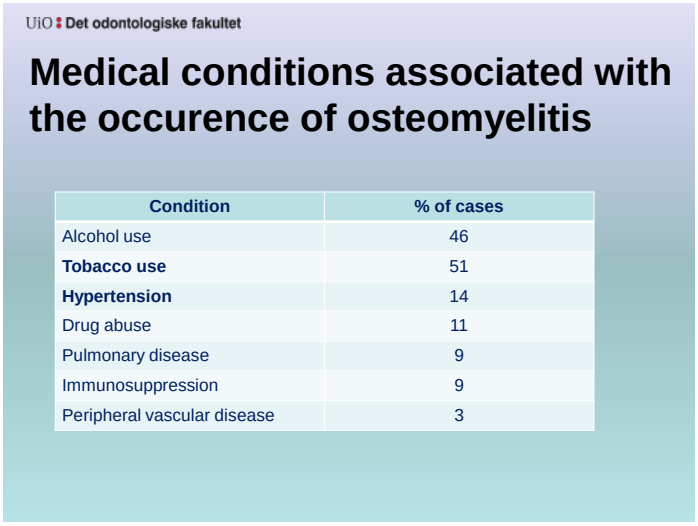


Table 2. Numbers are from a descriptive paper of 35 cases, The term ”association” is used, and ”predisposing factors”, but no statistic is used in the study.(8)

Radiologically, in addition to osteolytic areas, osteosclerotic areas may also occur, but a significant degree of variation between different cases and subclasses exist. The purpose of imaging is to confirm the clinical diagnosis or distinguish osteomyelitis from other lesions that may mimic inflammation in the same regio. Imaging studies aim to delineate the location and extent of the lesion, define the stage, and depict the course of the disease and its response to treatment. Conventional radiographs include the panoramic radiograph and posteroanterior (PA) mandibular, lateral oblique mandibular, and occlusal views. Cross-sectional imaging modalities consist of computed tomography (CT) and magnetic resonance imaging (MRI) of the mandible (5).

Different terminology and classification systems are used based on features as clinical picture, pathological-anatomical or radiological aspects, etiology and pathogenesis. The Zurich classification system, mainly based on the clinical course and imaging, seems to be one classification system of value for the clinician. It consists of three classes: Acute osteomyelitis, primary chronic osteomyelitis and secondary chronic osteomyelitis. Acute osteomyelitis may last up to one month, if it lasts longer it is called chronic osteomyelitis. Primary chronic osteomyelitis, however, has never undergone an appreciable acute phase. Primary chronic osteomyelitis has been called diffuse sclerosing osteomyelitis, chronic osteomyelitis with proliferative periostitis, Garré osteomyelitis and nonsuppurative osteomyelitis or osteomyelitis sicca (9). Primary chronic osteomyelitis may manifest in childhood and early adolescence, but has a second peak after the age of 50 years. The symptomatology is nonspecific. Absence of fever and leukocytosis and a lack of deficiences in cellular or humoral immunity are usually noted. Suppuration or sequestration is almost never observed, as in this patient. Mandibular swelling may or may not be found intra- and extraorally, the overlying mucosa and skin frequently are normal. In the past, evaluation of treatment results was performed primarily based on the clinical presence or absence of pain, swelling, or occasionally, purulent discharge.

The histologic findings of acute osteomyelitis show an inflammatory exudate, decreased osteoblasts, and increased osteoclasts. Necrotic bone may present with an acellular histologic picture.

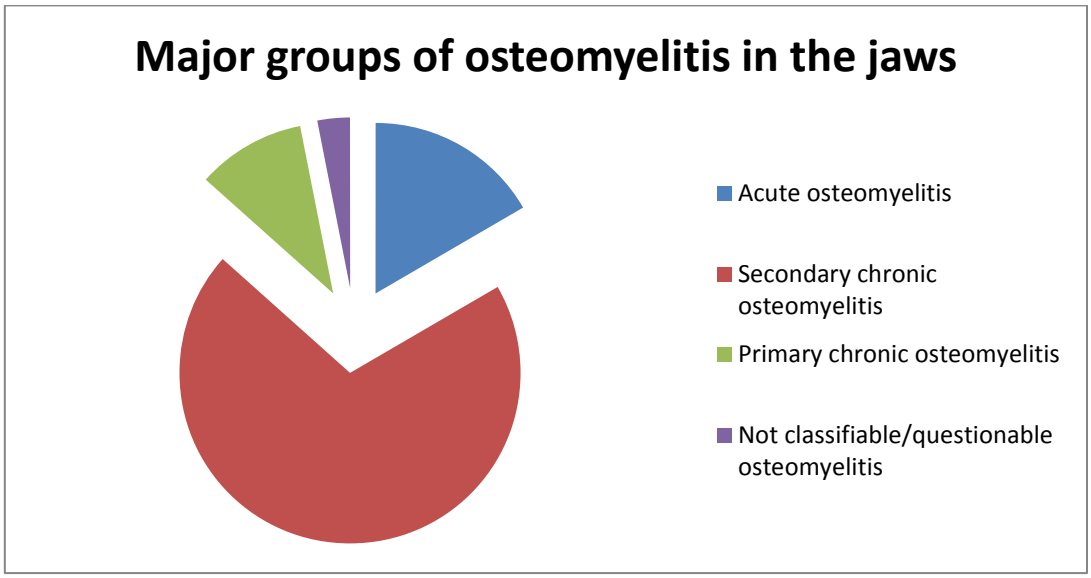


Fig. 34. Distribution of osteomyelitis cases treated at the Department of Cranio-Maxillofacial Surgery in Zurich 1970-2000. n= 290

Swelling, pain, tenderness and draining fistula are generally the most common symptoms of osteomyelitis (8), symptoms not unlike other and more common infectious diseases of the jaw. Trismus is frequently observed because of inflammatory involvement of the muscles of mastication. Hypesthesia or anesthesia along the chin may be present and reflect extension of inflammation to the mandibular canal and compression of the inferior alveolar nerve. Pain and swelling are a common symptom (70-90%), but purulent discharge and fistulae are less common (around 30%).

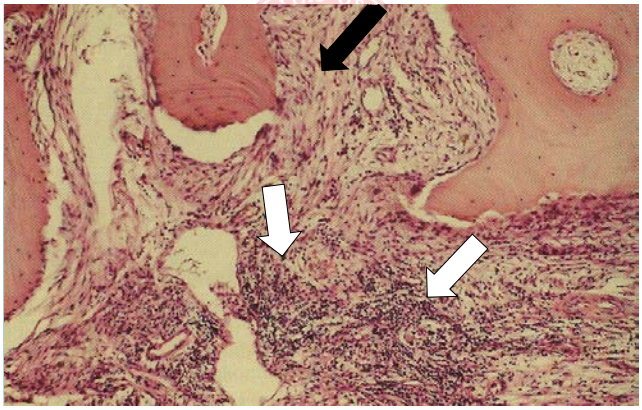


Figure 35. Lamellar bone with preserved osteocyte nuclei is present beside signs of inflammation fibrosis of marrow spaces (black arrow). Extensive infiltration by inflammatory cells (white arrows)(4)

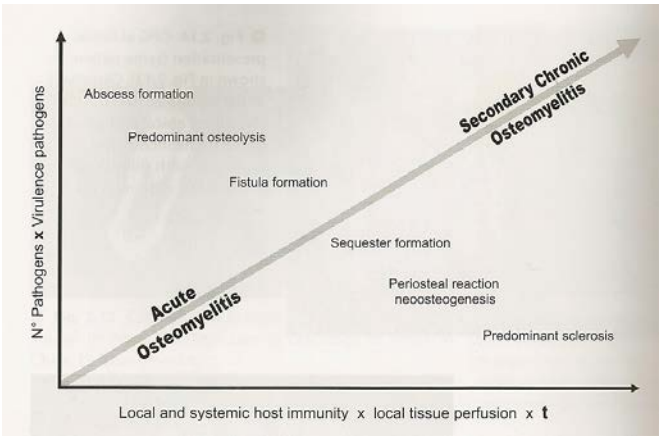


Fig. 36. The formation of certain clinical and radiographic findings is dependent on the intensity of the disease and the magnitude of imbalance between the host and the microbes, as well as the time frame

Concerning the microbiology, osteomyelitis is a polymicrobic infection with several responsible pathogens. Earlier, *S. aureus*, *S. epidermidis* and *Actinomyces* were discussed as the major pathogens, but newer techniques reveal a more complex microbiologic composition. Prolonged antibiotic treatment prior to harvesting and possible contamination of the sample may complicate the interpretation of each result.

In general, treatment involves through surgical debridement and prolonged antimicrobial therapy. An underlying alteration of host defenses is often present in many patients with osteomyelitis. This is important to identify for correction of factors that may delay recovery. A combination of conservative and surgical treatment was also performed in this case. First, several attempts of conservative treatment were conducted, probably because the symptoms was diffuse and included few of the classical signs of an osteomyelitis situation. Tri-antibiotic paste had been used as an intracanal dressing for several months. It has been shown that a mixture of ciprofloxacin, metronidazole and minocycline (Tri-mix/ Hoshinos mixture) is useful for sterilization of infected root dentine, and that the drug mixture can be applied to root canals (10) . In endodontic diseases, bacteria may invade not only dentine but also cementum (11). These bacteria are reported to be mainly obligate anaerobes and are sensitive to this tri-antibiotic paste. It appears to be difficult to eliminate these microbes using conventional root canal medications. It has been shown that the drug combination could be delivered to the dentine-cementum junction and, it is probable that such bacteria are killed with local application of the drug combination to root canals. When the diagnosis osteomyelitis was confirmed, use of systemic antibiotic therapy was indicated. Whenever possible, specimens should be obtained for Gram staining, aerobic and anaerobic cultures and sensitivity testing.

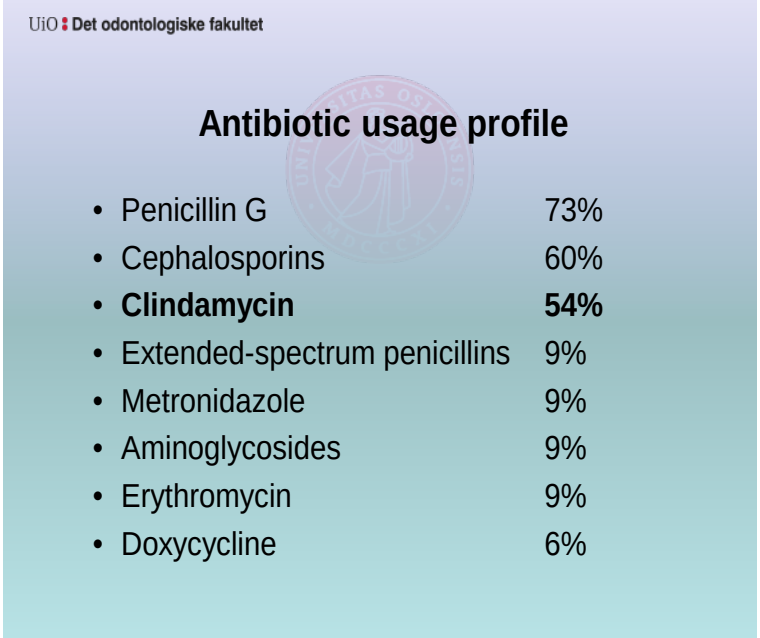


Table 3. Concerning systemic antibiotic treatment: often patients receive combination of antibiotics to treat their osteomyelitis (8)

The occurrence of osteomyelitis cases are as mentioned reduced dramatically. We can reduce the incidence further by using a rubber dam and apex locator during root canal therapy (12). Without a rubber dam, saliva will contaminate the tooth and our gloves, which in turn transfer bacteria onto the endodontic instruments. Without an apex locator, we can over-instrument the canal and introduce bacteria deep into the medullary portion of the jaw bone. This continuous introduction of bacteria into the jaw may possibly cause osteomyelitis in an immune-compromised patient (12).

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UNIVERSITAS OSLOENSIS MDCCCXI

Case 18 Apical surgery of lower, left second molar

Patient

56 year old Northern European female

Fig.1. Frontal view

Medical history

Medications: Acid. acetylsalicylic 75 mg Albyl-E “Nycomed Pharma” , Simvastatin 40mg Zocor “MSD”. The patient was a tobacco smoker. ASA group II.

Dental history

The patient presented with multiple restorations; fillings and crowns, as well as earlier endodontically treated teeth. Most of the treatment was due to teeth with large amalgam restorations followed by treatment with metal-fused crowns made by the patients general practitioning dentist (GPD). She described not having any new cavities/carious lesions in the last several years.

Clinical findings

The intraoral mucosa was normal, extraoral examination revealed physiological conditions. The patient was free of subjective symptoms.

Fig. 2 occlusal view maxilla

Fig. 3. Occlusal view mandibula

	33	34	35	36	37
Cold	Yes	-	-	-	Yes
Percussion	No	No	Yes, vertically	No	No
Palpation	No	No	No	No	No
Mobility	No	No	No	No	No
PPD, mm	2	2	2	2	3
Restoration	Crown	Crown	Crown	Crown	Crown
Soft tissue	WNL				
Extraoral examination	WNL				

Table 1. Summary of clinical findings

Radiographic findings

Fig. 4. Intraoral radiograph

Mandibular left canine: Radiopaque restoration coronally, consistent with metal-ceramic crown. Lamina dura can be followed around the root without any disruption.

Mandibular left first premolar: Metal-ceramic crown with radiopaque post. Root filling material in the canal, intact lamina dura.

Mandibular left second premolar: Metal-ceramic crown and post. Partial root filled with thin radiopaque material in the canal consistent with gutta percha. Lamina dura widens into a radiolucent area apically approximately 4-5 mm in diameter.

Diagnosis 35

Pulpal: K04.19 Previous endodontically treated tooth

Periapical: K04.50 Chronic apical periodontitis

Marginal: Normal

Problem list

Anatomical aspects concerning the mental foramen.

The use of platelets inhibitors concerning bleedning during the procedure.

Treatment options

Orthograde retreatment and new porcelain crown, apicoectomy with retrograde filling, extraction and leave, extraction and implant.

Treatment plan

The patient had gone through a lot of expensive dental treatment, was satisfied with the crown on the actual tooth and had a wish for keeping it. No carious lesion or coronal leakage was suspected, but a composite restoration was present beneath the crown margin. An orthograde re-treatment was decided not to be performed in this case. The treatment decision was apicoectomy with retrograde filling. The patient's medical doctor(MD) was consulted for the seponation of the platelet inhibition medication, Albyl-E. The patient discontinued the medicin 5 days before surgery. Possibility of prescription of a short course of antibiotic therapy post operative. Planning of the treatment included an extended X-ray examination including an orthopantogram, revealing the position of the foramen mentalis and awaiting the procedure until the patients smoking habit had changed.

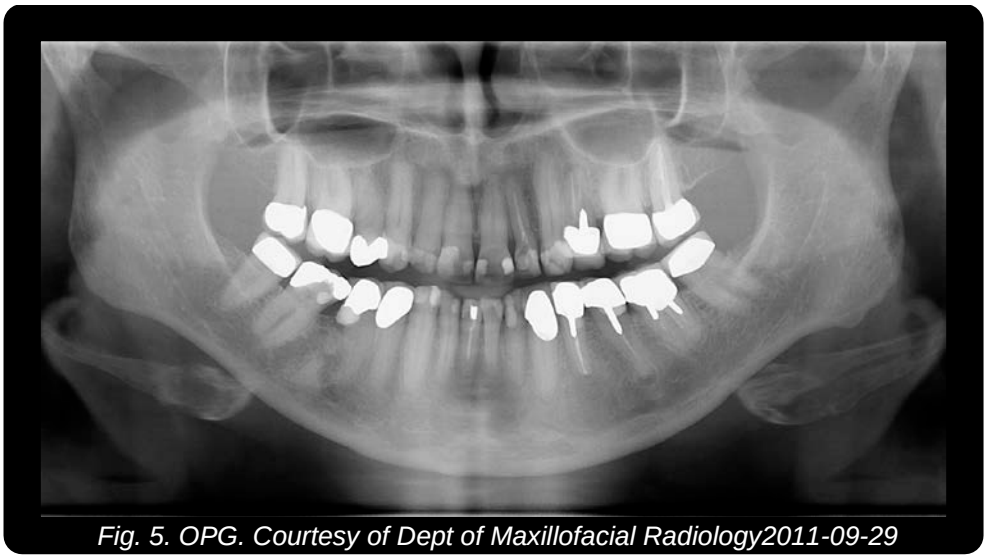


Fig. 5. OPG. Courtesy of Dept of Maxillofacial Radiology2011-09-29

The patient was informed of the precautions, procedures, treatment, prognosis and possible adverse effects as well as negative effects when it comes to smoking and healing after surgery. She was requested and encouraged to reduce her consumption of tobacco some weeks prior to surgery.

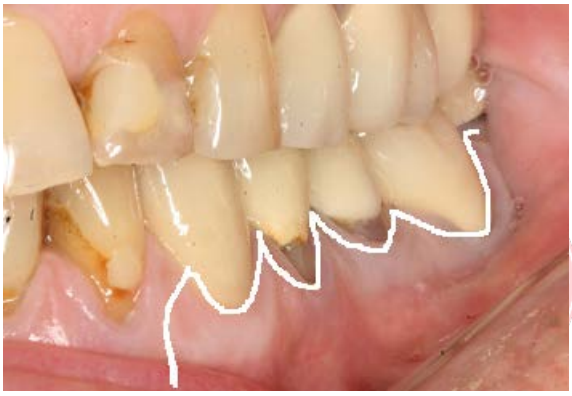


Fig.6,7. Treatment planning including choice and placement of incision

Treatment

The cortical topography was viewed and palpated, and the radiographs including radiograph OPG was interpreted.

5.4 ml xylocain with adrenalin (20 mg/ml + 12.5 µg/ml) was used as conduction and infiltration anaesthesia. An intrasulcular incision was made with a micro-scalpel blade at the distal aspect of mandibular left second molar extending anteriorly to the mesiobuccal gingival line angle of the mandibular right canine with an angulated vertical releasing incision.

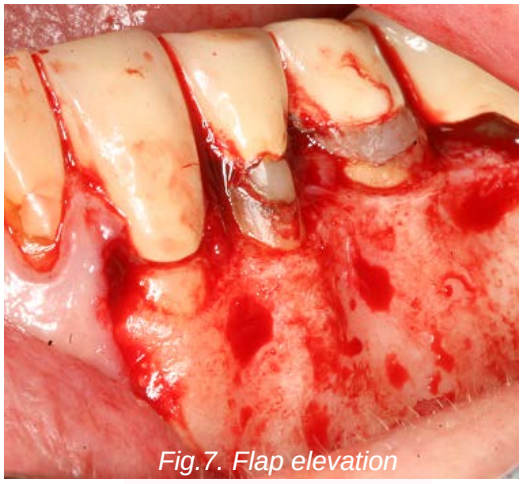


Fig.7. Flap elevation

Elevation of the full mucoperiosteal flap with a periosteal elevator. The flap was elevated at the junction between the vertical releasing incision and horizontal incision extending apically, laterally. A retractor was used facilitating the reflection of the flap, all the time carefully used and lying on a sterile cotton gauze pad for avoiding pressure on the n. mentalis. A small pathological fenestration was seen apically for the root in mesial aspect. The surgical burs used was # 8 round bur for osseous access. To think about in this process, is that the root tissue is more yellow and darker than adjacent bone and not possible to indent with a probe. It does not bleed from root dentin and it is surrounded by PDL which can be located by placing 1% methylene blue stain in the bony crypt so that the root outline will be displayed more clearly. Radiopaque marker could have been used if necessary.

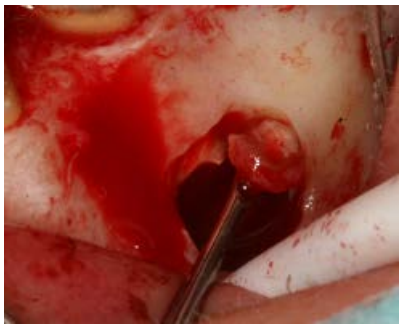


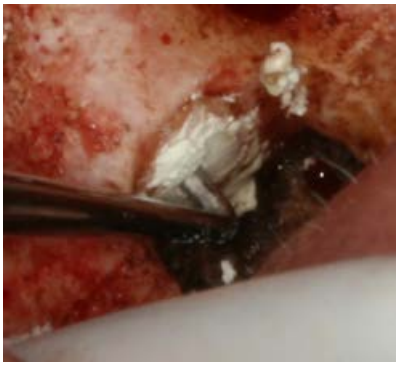
Fig. 8,9. Removal of the root apex

3-4 mm of the root apex was resected with a long fissure bur in hand piece. The soft tissue lesion was removed using periodontal curettes. Retrograde preparation of 3 mm was performed with diamond-coated ultrasonic tips in P5 Newtron ultrasonic device. Continuously rinsing with sterile saline was done throughout the procedure. Hemostasis was accomplished with stryphnon gauze recemic adrenaline and ferric sulfate, followed by drying of the retroprep with sterile paper points.

Fig.10,11. Drying of the retrograd preparation with sterile, angulated paper points after hemostasis acheived

Fig.12,13. Inspection of the preparation and filling with white ProRoot MTA®

A retrograde MTA filling was placed into the cavity using plastic instrument as a carrier, condensed with micro condensing pluggers.



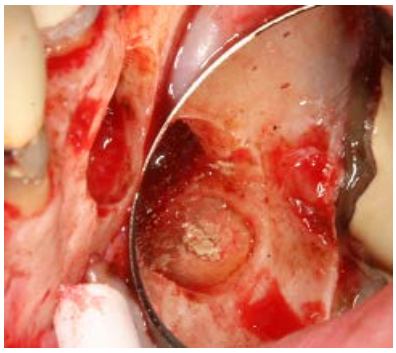


Fig.14,15. Filling retrograde

The retro-filling was examined under high magnification in the SOM (Global Surgical™ Corporation, St. Louis, MO, U.S.A) to check the adaptation and surface structure. The Stryphnon gauze was removed and the surgical field was irrigated with sterile saline and carefully inspected. The number of sterile gauze tupfers used was counted. The flap was repositioned and was hold in place with finger pressure for some minutes in order to reduce the post operative haematoma and ensure an optimal adaptation of the flap before suturing.

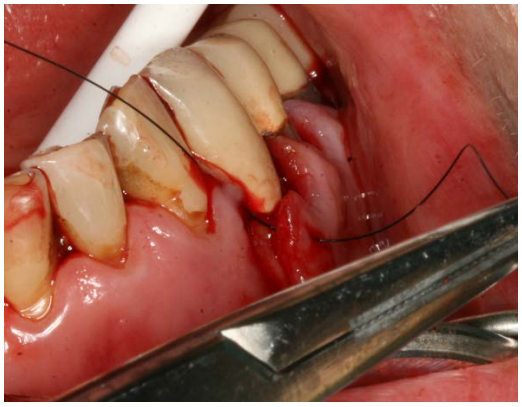


Fig. 16,17. Suturing with Supramide 5-0

The vertical releasing flap was sutured in place with four 5-0 Supramide sutures. The other four interrupted sutures were placed inter-approximaly in the papilla and the patient received an ice pack to reduce post operative haematoma and pain. The patient was recommended analgetics; 500 mg Paracetamol in combination with 400 mg Ibuprofen 3-4 times a day, as well as instructed to rinse with chlorhexidinedigluconate 2mg twice a day**.** No antibiotic was prescribed.

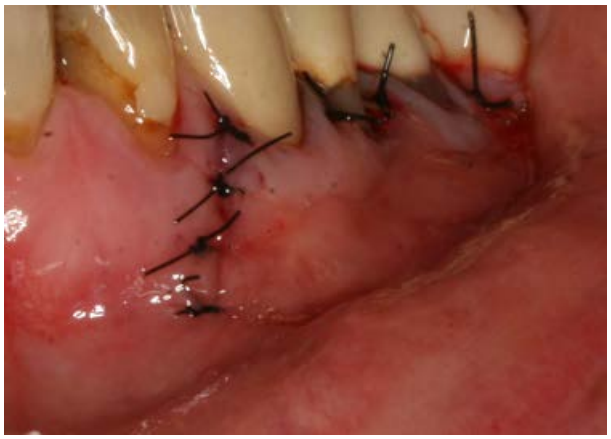


Fig.17, 18. Post treatment

Evaluation

The root is shortened because of the procedure but marginal bone level is > 2/3. The apical preparation is of an adequate length and the filling seems dense.

Prognosis

Endodontic: Good, even if no orthograde retreatment was performed prior to surgery.

Total: Short root, but marginal bone level is judged to be physiological and pathological marginal breakdown is not to be expected.

Two days after treatment

The patient took contact with the Department of Endodontics because of swelling and enlarging discomfort in the surgical field. A firm swelling without fluctuation was palpated. The dentist who was on duty that day prescribed antibiotics; Phenoxymethylpenicillin. kalic 660 mg (1 mill. IE) Apocillin “Actavis” nr 28. Simvastatin taken concurrently with clarithromycin, macrolid antibiotics as erythromycin or fungal agents may give interactions and should be avoided. The chosen antibiotic has no known interactions with the patients other medications.

One week after treatment

Sutur removal was performed. The soft-tissue healing was satisfying, swelling was absent and the patient had little discomfort. The patient now was used of a reduced smoking level. She considered stop smoking completely.

Four months recall

The patient met for follow-up examination almost four months post operative.

Fig. 19.Clinical situation at follow-up, lateral view

Fig. 20. Occlusal view

Intraoral conditions were healthy, the patient was free of symptoms. X-ray showed signs of healing in the periapical area as well as in the bone cavity, with a less trabecular bone structure, as to be expected considering the time aspect.

Fig.21. Radiograph 4 months after apicecoectomy.

Discussion

For morphological description of the mandibular, second premolar, see case 4.

AP lesions may be free of bacteria periapically, or with the inflamed periapical tissues invaded by virulent bacteria from the root canal, resulting in extraradicular infection. AP developes as a response to infection, and in the chronic form, a granuloma is formed. In addition to the inflammatory cells, it may contain fibrous tissue and sometimes cholesterol crystals, as well as proliferating strands of epithelium derived from the cells of Malassez. It may or may not develop a cyst cavity, which is lined in part or in full by epithelium (2).

Fig.22. Host defence against endodontic infection. A dense wall composed of defence cells is observed at the apical foramen of this rat tooth associated with apical periodontits.(1)

Histologically, periapical lesions are classified into granuloma (epithelialized and non-epithelialized), abscess (epithelialized and non-epithelialized) or cyst (true or pocket), fig. 24.

Fig. 23. Bacterial colony attacked by phagocytes within the lumen of a pocket cyst (1).

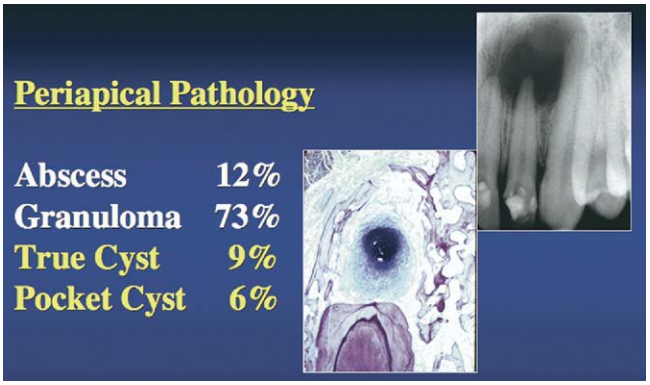


Fig 24. According to Nair (3, 4), 15% of all periapical radiolucencies are some type of cyst. From (5)

The changes in mineralization and structure of the bone adjacent to the site of inflammation form the basis of radiographic diagnostic procedures for the detection and monitoring of CAP. When a patient returns for a follow-up consultation, judging periapical radiographs is one important aspect. Because CAP often develops without subjective symptoms, the radiological diagnosis is particularly important. A widened periodontal space is associated with initial or residual inflammation, and is a sign of chronic inflammation.

Andreasen & Rud found that if the periodontal membrane is more than doubled in width, moderate or severe inflammation is likely present (6)

Also to consider when judging radiographs is that the PDL may vary in width from patient to patient, from tooth to tooth in the same individual, as well as from location to location around one tooth. Some patients have a prominent well-defined lamina duras, whereas in other patients, the lamina dura may be generally faint (2).

When an earlier endodontic treated tooth is clinically and radiographically diagnosed as non-healed, several treatment options should be discussed with the patient. Non-surgically endodontic retreatment is generally the first choice of intervention in cases where the initial treatment has failed and the patient has a wish for maintaining the tooth. The main cause of endodontic treatment failure is the persistence of microorganisms within the root canal system (7-9). Apart from persistent intraradicular infection, extraradicular infection may be present (10, 11), radicular pocket cysts, immune reactions to foreign bodies (giant cell) or immune reactions to endogenous substances as cholersterol clefts, as mentioned above. The effect of microorganisms can be both direct and indirect tissue damage. Enzymes, exotoxins and metabolic end products cause the direct damage, while structural components of the bacterial cell (as LPS, peptidoglycane, lipoproteins, lipoteichoic acid and membrane proteins) are more related to indirect damage by stimulating host defences. These bacterial products acts as modulins and stimulate the host immune reactions, not only defending the host against infection, but also causing tissue destruction. The host cells, stimulated by these bacterial components, release chemical mediators such as cytokine and prostaglandin, involved in induction of bone resorption. Toll-like-receptor4 (TLR-4) on osteoblasts may stimulate osteoclast differentiation and RANKL expression in osteoblasts and stimulation of these cells to secrete IL-1, IL-6, prostaglandin E_2 and TNF-α will give enhanced osteoclast differentiation (9). Binding of receptor activator of NF-κB ligand (RANKL) to receptor activator of NF-κB (RANK) activates a signal transduction cascade that leads to osteoclastogenesis in the presence of macrophage colony-stimulating factor (M-CSF). Osteoprotegrin (OPG) is also produced by osteoblasts and stromal cells. It competes with RANK for RANKL to inhibit osteoclastogenesis and osteoclast activation. The balance between expression of RANK (stimulator) and OPG (inhibitor) will affect the amount of bone to be resorbed.

Prior to the surgical treatment, the inner layer of dentine in the necrotic root canal is aimed removed. However, in many cases the bacteria have penetrated into the tubules and is not possible to remove mechanically (12), fig. 25.

Fig. 25. Bacteria located deep within dentinal tubules, apical ramifications or lateral canals, protected from instrumentation. From (9)

In apical surgery, our goal is to remove the apical 3 mm of the root. The background for this is the knowledge that 98% of apical canal anomalies and 93% of lateral canals system ramifications occur in the apical 33 mm (13, 14). We want the bevel to be short, closer to 0 degrees, and as perpendicular to the long axis of the tooth as possible. This is to conserve root length, maintain crown/root ratio, increase the ability to visualize important lingual anatomy, have less chance of incomplete resection, easier detect multiple or

aberrant canals, easier to maintain root end preparation (REP) and maybe most important: less exposed dentinal tubules (less micro-leakage).

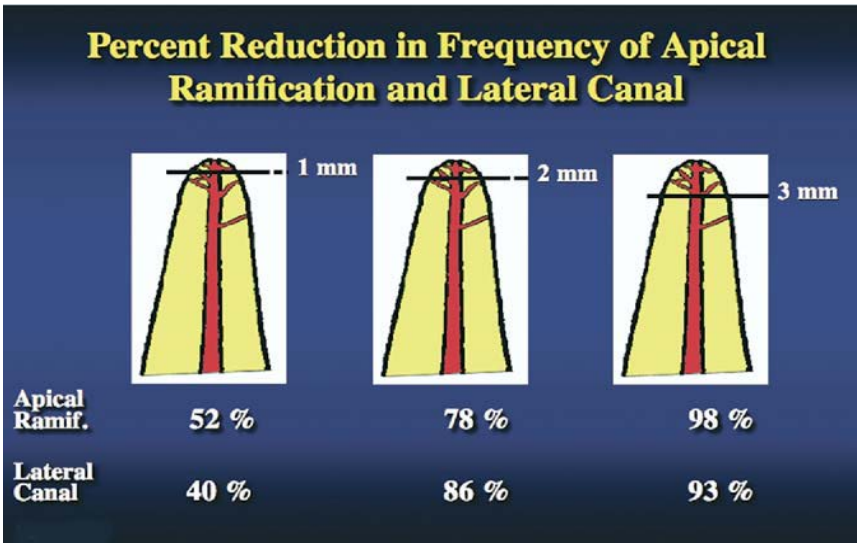


Fig. 26. Frequency of apical ramifications and lateral canals. A 3-mm apical resection was needed to eliminate the majority of apical ramifications and lateral canals (5).

Contemporary surgical endodontics began in the early 1960s, along with the recognition of endodontics as a specialty in the United States in 1964. Dr Robert Baumann, otolaryngologist and dentist, described the use of the otologic microscope in dentistry in 1977. He predicted that the SOM would find a place in the armamentarium of the modern dentist as it did in otorhinolaryngology, neurosurgery, vascular medicine, and gynecology. In July of 1982, the First International Congress in Microsurgical Dentistry was held in Bordeaux, France. Dr. Pecora gave the first presentation on the use of the SOM in surgical endodontics at the 1990 annual session of the American Association of Endodontists in Las Vegas, Nevada. He used the Zeiss OPMI I SOM. When reaching year 1995, there was considerable increase in the use of the SOM. Microscope companies such as Zeiss, Global, and JEDMED were the most sold brands. Microsurgery procedures and equipment have for the last years been widely used in surgical endodontics. A SOM, micro-instruments like micro-mirrors and small US-tips give advantages over conventional techniques. A small osteotomy site, reduced soft tissue damage, ultrasonic tips working in the long axis of root and possibility of visualization of isthmuses in the root end are easier to achieve.

The indications for endodontic microsurgery includes: failure of endodontic re-treatment, teeth with wide, long posts, obstructions in the root canal as fractured instruments or sclerosed canals, root perforations that cannot be treated conservatively, investigative procedures such as biopsies or visualizing suspected longitudinal fractures.

Fig. 27. The Global® SOM used in this case.

	Traditional	Microsurgery
1. Osteotomy size	Approx. 8–10 mm	3–4 mm
2. Bevel angle degree	45–65 degrees	0–10 degrees
3. Inspection of resected root surface	none	always
4. Isthmus identification & treatment	impossible	always
5. Root-end preparation	seldom inside canal	always within canal
6. Root-end preparation instrument	bur	ultrasonic tips
7. Root-end filling material	amalgam	MTA
8. Sutures	4 × 0 silk	5 × 0, 6 × 0 monofilament

Table 2. Summary of some differences between traditional technique and microsurgery in apical surgery.

In this case, the knowledge that the major anatomical implications of surgery in mandibular premolars and molars may be proximity to the mental foramen, the external oblique ridge that thickens in the molar area and *N. lingualis*, was taken into account. The mental foramen may have variations in position. It usually lies between the premolars, but could also be adjacent or distal to the second premolar. The distance from CEJ of the second premolar to the mental foramen is reported to range from 8 to 21 mm. In 20% of a given sample the distance was less than 12mm (15). If the foramen is close, it is suggested to cut a horizontal groove, 1mm deep and 3-4mm long, slightly superior to the foramen. The tip of the retractor may be firmly located in this groove to minimize accidental slippage and damage to the neurovascular bundle. An extended radiographical examination with an OPG was performed prior to treatment to evaluate the mentioned anatomical considerations.

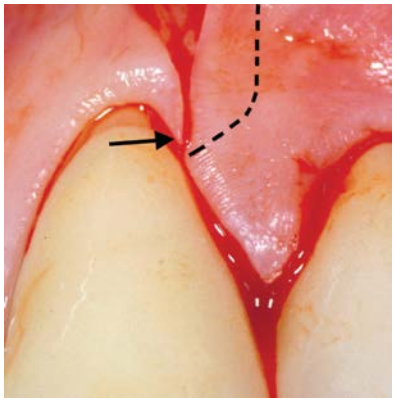


Fig. 28 Flap design in generally is discussed in case 17, but just to be noted, the clinical photos from this patient, fig. 7, and this photo, the vertical releasing incision should be placed with care. As the figure shows, the incision with arrow will create a compromised concerning blood supply. The left, unreflected tissue most likely necrotize. The dashed line indicates the desired course of incision, beginning in a 90-degree angle to the gingival marginal.

From Velvart; showing the background of the chosen incision in this case(16).

Concerning the healing of the soft tissue, the patients smoking could possibly impair the normal flap re-growth. Nicotine is a vasoconstrictor that reduces nutritional blood flow to the skin, resulting in tissue ischemia and impaired healing of injured tissue. Nicotine also increases platelet adhesiveness, raising the risk of thrombotic microvascular occlusion and tissue ischemia. In addition, proliferation of red blood cells, fibroblasts, and macrophages is reduced by nicotine. Slower healing has been observed clinically in smokers with wounds resulting from trauma, disease, or surgical procedures (17). Smokers should be advised to stop smoking prior to elective surgery or when recovering from wounds resulting from trauma, disease, or emergent surgery.

In this case, there was a small fenestration in the cortical plate in relation to the root apex. Alveolar fenestration is defined by the American Association of Endodontists (AAE) (2007) as a window-like opening or defect in the alveolar plate of bone, frequently exposing a portion of the root, usually located on the facial aspect of the alveolar process. No involvement of the marginal bone is present. Concerning prevalence of fenestrations: Studies on human skull collections report a mean prevalence of 9% (18, 19), the mesiobuccal root of the first maxillary molar being the most frequent (37%). These findings have been confirmed by a recent cone beam computed tomography (CBCT) analysis on patients with periradicular defects of endodontic origin (20).

Concerning hard-tissue management, advantages exists using high-speed handpiece, like reduced surgical time and that a light pressure can be applied. Disadvantages are the risk of developing a surgical emphysema and no sterile internal irrigation available with this technique at our clinic. An irrigation system with sterile saline in a low-speed handpiece was used in this case. Eriksson and co-workers demonstrated that there previous had been underestimation of the temperature at which irreversible damage could occur in bone tissue. The threshold for irreversible damage to bone was at the level of 47 ^{o}C and the threshold temperature for impaired bone regeneration was between 44 ^{o}C and 47 ^{o}C at an exposure time of 1 min (21). Continous and copious irrigation is therefore important during hard tissue management. It has been shown that No 6 round bur caused smaller zones of aseptic necrosis than fissure burs (22). Round, steel burs with widely spaced flutes that minimize clogging with bone chips and coagulated debris and reduce vibration is recommended (23). It is important to preserve as much bone as possible buccal aspect to prevent periodontal breakdown.

Fig. 29. For the root tip, Lindemann H151 which has widely spaced flute design, is recommended. If smoother surface is wanted; tungsten carbide finishing can be done. Some recommend single use of burs.The photo show the burs used in this case

During surgical curettage, it is necessary to remove the entire periradicular soft tissue lesion. It is not possible to determine the exact nature of the periradicular soft tissue lesion clinically. If it is a true cyst (as mentioned, incidence 9%), it is unlikely that the lesion will resolve without removing the entire periradicular soft tissue lesion. Foreign material is also possible in the soft tissue lesion.

A root end preparation (REP) should fulfill the following criteria (13):

- ✓ The apical 3 mm of the canal system is thoroughly cleaned and shaped
- ✓ The prep is parallel to, and centered within, the anatomic outline of the pulpal space
- ✓ Adequate retention for the material used
- ✓ All isthmus tissue removed
- ✓ Dentinal walls not weakened

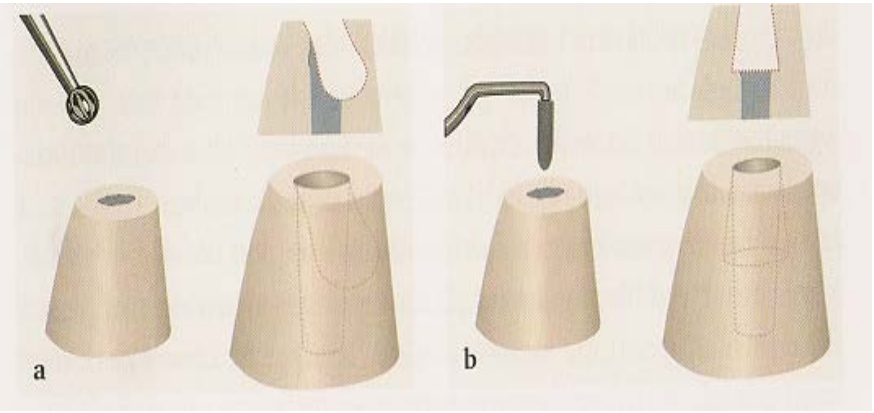


Fig. 30, 31. Comparison of apical preparation with bur a) and ultrasonic tip b). Note the angulation of preparation in a) with risk of perforation lingually, compared to the preparation in the length axis of the tooth in (b). Left illustration from von Arx in (24)

Cutting off root end without bevel with less dentinal tubules exposed is our goal (14, 25). The less access that this non-bevel will lead to is compensated for by use of UL-tips and surgical micro-mirrors.

Some authors have proposed that the use of ultrasonics may cause cracks in the root. Others have not substantiated this. Different tips appear to have some effect. The clinical importance of this remain unknown (1).

The apical preparation is then ready to be filled with a suitable material, that is a material that should be easy to handle and place, have an adequate working time and be dimensional stable. It should give a completely seal and adapt easily to various shapes. Important is the aspect of biocompatibility – it should promote cementogenesis. It should be sterile and non-porous, insoluble in tissue fluids, give no corrosion or oxidation. Non-resorbable properties are also wanted, as well as being bacteriostatic, radiopaque and not discolor surrounding tissues.

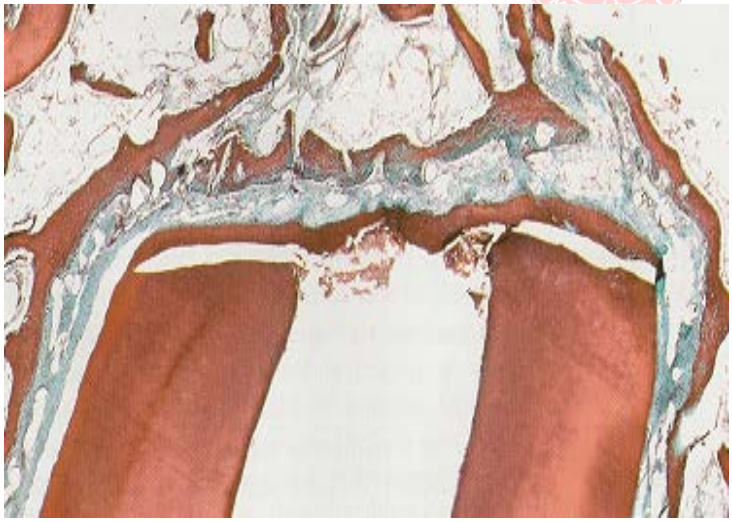


Fig. 32. Tissue respons to MTA root end filling in monkey teeth. New cementum has grown in over the root-end. No inflammation is found in the adjacent tissue. From Torabinejad et al in(1)

Mineral Trioxide Aggregate (MTA)-based cements, Super-EBA or IRM cements are materials of choice for root-end filling material. As figure 33 shows, treatment outcome are very satisfying using both MTA and IRM. Earlier, smoothing of the gutta percha was done, without root-end filling. New technique with apical preparation and root-end filling has shown highly significant better outcome (fig. 37) (9, 26).

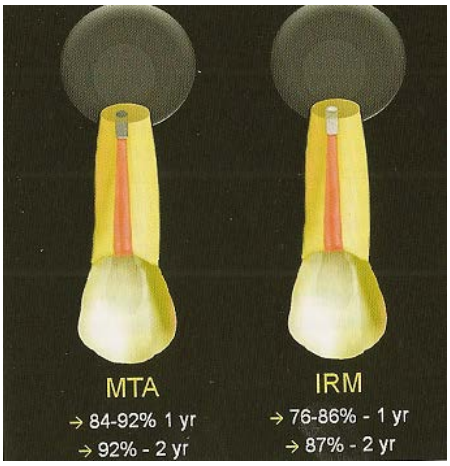


Fig. 33. Comparison of the surgical treatment outcome after root-end filling with MTA vs IRM. Data according to Chong et al and Lindeboom et al. From (9)

MTA seems to be more often preferred over other materials as S-EBA and IRM. MTA has superior sealing qualities, is biocompatible with adjacent cells and promotes tissue regeneration (reformation of bone PDL and cementum) (13). MTA was the material used in this case. Cementum can be expected to reform over the dentin over the resected root end, as shown in fig. 32.

Concerning which technique is most efficient for the placement of MTA in the REP, there are no studies showing one technique more efficacious than the other. The Micro Apical Placement (MAP)-system or, as used in this case, the MTA-block are available at the Department of Endodontics, UiO.

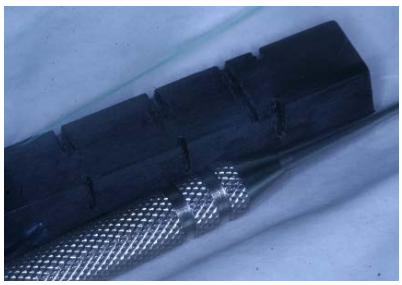


Fig. 34, 35, 36. MAP-system and block with grooves and a # 3 Hollenback instrument for delivery of MTA retrograde

Rud *et al* (27) reviewed studies on outcome reported up to 1970 and Friedman (28) reviewed studies reported from 1966 to 1997. These reviews demonstrate that the reported outcomes of apical surgery have been contradictory. In spite of the large amount of information available, answers to questions related to the outcome of apical surgery have remained obscure owing to the poorly standardized materials and methods of many studies (28). Also, the clinical procedures in apical surgery have considerably evolved, particularly in the past decade, as mentioned in other parts of this case book. More recent studies indicate that endodontists may have better outcome with new, microsurgical techniques compared to operators without microsurgical equipment (29, 30)

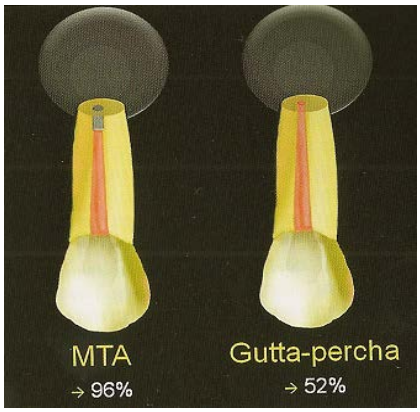


Fig. 37. Comparison of the surgical treatment-outcome after root-end resection followed by either MTA root-end filling as is done in endodontic surgery today or just smoothing of the gutta-percha. From (9, 26)

Presence or absence of clinical sign and symptoms should not be considered to influence the outcome of surgical endodontics. One study reported a poorer outcome in teeth with sinus tract present, as Forssell 1988 a follow-up study on apicectomized teeth (31). Others have reported comparable treatment outcome for asymptomatic teeth and for teeth present with preoperative symptoms (32, 33).

Several outcome studies have investigated both implant and endodontic therapy. An endodontically treated tooth that has incomplete radiographic healing at the time of re-evaluation would not be considered a success by definitions most often used, even if it was asymptomatic and fully functional. Outcome criteria for implants have been primarily judged by the implants' survival and functionality in the mouth. An implant with a sinus tract would be considered surviving. It is therefore difficult to compare endodontic and implant success rates. However, in comparable, retrospective, meta-analysis, and systematic review studies have shown comparable, high, success rates. (34-36).

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UNIVERSITAS OSLOENSIS MDCCCXI

Case 19 Apicectomy in maxilla, right first premolar

Patient

31 year old Northern European male.

Fig.1. Frontal view

Chief complaint

Discomfort upper, right molar segment during chewing, mostly from the first molar.

Medical history

The patient is healthy, no allergies. ASA group I.

Dental history

The patient had endodontic treatment of tooth 14 several years ago, and orthograde re-treatment at the Department of Endodontics, postgraduate clinic, in 2009. The follow-up control of the patient revealed a non-healing situation. In addition, an iaterogenic damage of tooth 16 had happened at the student clinic – extraction planned performed by the dental student.

Clinical findings

Fig. 2. Occlusal view, maxilla

Fig.3. Occlusal view, mandibula.

Fig.4. Lateral view

Fig.5. Palatal view

Radiographic history & findings

Maxillary, right second molar: Coronal (and possible buccal or palatal) radiopaque material consistent with composite restoration. Intact lamina dura.

Maxillary, right first molar: Filling material in the root canal and at the coronal aspect. Radiolucent zone interradicularly, adjacent to the furcal area.

Maxillary, second premolar: Radiopaque filling material consistent with composite at OD aspect, normal lamina dura.

Maxillary, first premolar: Radiopaque material in root canals and occlusally, consistent with root canal filling and composite. Lamina dura shows droplike widening in apical area about 8 mm Ø.

Normal marginal bone level.

Diagnosis 14

Pulpal: Endodontically treated tooth (K04.19)

Apical: Chronic apical periodontitis (K04.5)

Marginal: Within normal limits

Problem list

Anatomic relation of sinus maxillaris

Treatment options

Extraction and implant, extraction and bridge restoration, extraction and leave, surgical intervention/ apical surgery (orthograde retreatment attempt already performed).

Treatment plan

The patient had a wish to retain the tooth. A new appointment was scheduled for apicectomy of upper, first premolar. Before this, an appointment at the Section of Maxillofacial Radiology for a panoramic radiograph for optimal treatment planning.

Treatment

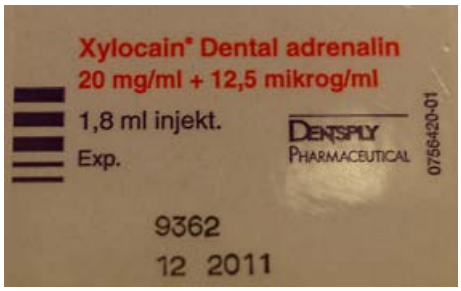

Fig. 8. Xylocain with adrenalin (20 mg/ml + 12.5 µg/ml) was used in this case.

Infiltration of 7,2 ml xylocain with adrenalin was done to establish anaesthesia in the operation field. An intrasulcular incision was made with a microscalpel blade (fig. 9), starting from the mesial aspect of maxillary right canine extending posteriorly to the distal aspect of the second molar with a vertical releasing incision starting from the mesiobuccal gingival line angle of the canine to preserve the papilla (fig.10).

Fig. 9. Micro scalpel blade used in this case

Fig. 10. Planning of incision

Elevation of the full mucoperiosteal flap was initiated with a periosteal elevator. The flap was carefully elevated at the junction between the vertical releasing incision and horizontal incision extending apically, laterally. A retractor was used to facilitate the reflection of the flap. No pathological fenestration could be seen. Osteotomy was accomplished with a round bur on a hand piece, to adequately expose the root end. For resection 3 mm of the root, a long fissure bur was used, with enough distance from the neighboring roots and as low degree in bevel as possible for minimal leakage. The root surface was inspected with an explorer under high magnification. Granulous tissue was curetted and a sample sent to histopathological investigation. Retrograde preparation of about 3-4 mm was accomplished with Satelec ultrasound device with ultrasonic tip, as parallel to the long axis of the root as possible. During the procedure, irrigation with sterile NaCl 9 mg/ml “Fresenius-Kabi” solution was done. The apical preparation was inspected with a microsurgical mirror under magnification and illumination. Sterile gauze with epinephrine Xylocaine® Adrenaline “AstraZeneca” 10mg/ml + 5 mg/ml was placed in the crypt for adequate haemostasis.

Fig.11, 12. Epinephrine for local application during surgery (left) and sterile saline as a coolant (right).

A retrograde ProRoot® MTA filling was placed into the root-end-cavity using MTA block and the specially designed plastic instrument, and condensed with micro pluggers.

Fig. 13. Plastic instrument for MTA delivery

Fig.14. MTA block

The gauze was then removed and the surgical site was irrigated carefully with sterile saline, verifying that the ferric sulfate was completely removed for avoiding delayed healing. The flap was repositioned and was hold tight in place with finger pressure in order to reduce the post operative haemorrhage and pain. The vertical realising flap was secured in place with a thin 5-0 Supramide suture. The other interrupted sutures were placed interproximally in the papilla. A final radiograph was taken. Antibiotic phenoxymethyl penicillin; Apocillin 660mg 1+1+2 for 7 days, analgetics 'Ibuprofen' (ratiopharm) 600 mg against post-op pain, antiseptic mouth wash 'Corsodyl' (GlaxoSmithKline) for intraoral microbial reduction during healing phase, were prescribed. Post operative instructions were given and the patient received an ice pack.

Mottatt to opptil 4 x 3 mm store gulhvite og brune vevsbiter. Kapsel A. ABP/iv

Mikr. ses et granulasjonsvev med tett infiltrasjon av kroniske betennelsesceller. Det ses kun en og annen granulocytt. Sikkert epitel som i en cystevegg er ikke funnet. Det er ikke funnet fremmedlegemer, heller ikke ved undersøkelser i polarisert lys. Mot den ene siden virker vevet noe mer grovfibret.

DIAGNOSE :
GRANULASJONSVEV MED INTENS KRONISK INFLAMMASJON.

Diagnostisert av T. Solheim/sh

Result

Fig. 15. 2010-12-01

The patient was scheduled for post-operative control including suture removal but was not able to meet because of trip to Hungary for assessment of implant treatment in maxillary molar area. The suture removal was done in the clinic in Hungary. The result of the histological examination was granulation tissue with intense infiltration of inflammatory cells, no foreign body or epithelial lining was evident.

Prognosis

Endodontic: Good

Tooth: Good

One year follow-up examination 2012-02-14

Fig. 16. Before treatment (left)

Fig.17. 26 months post treatment (right)

Fig.18. Frontal view at follow-up examination

Fig. 19. Lateral view at follow-up examination

The patient had in 2010 a consultation in a dental clinic in Hungary for planning of implant treatment. In 2011, he underwent treatment with inserting a bone substitute to build up the ridge/ alveolar process because of lack of bone and a short distance to the maxillar sinus. However, the patient now had a wish for further treatment in Norway, at the University of Oslo. The patient was free of symtoms and physiological conditions are evident clinically and radiologically, with an intact lamina dura around the treated tooth 14.

Discussion

The maxillary, first premolar has a buccal pulp horn that usually is larger than the palatal but the palatal orifice is the largest one. Because of the mesial concavity of the root, the palatal orifice is kidney-shaped in cross-section at the CEJ. The access preparation will be oval shaped, wider bucco-lingually. The root canals, most often two, are narrow and curved. The roots are considerably shorter and thinner than the canines. The buccal root may fenestrate through the bone. This tooth is prone to mesiodistal root-fractures and fractures at the base of the cusps, particularly the buccal one. Full occlusal coverage will help to prevent cuspal and crown and root fracture. According to Vertucci; One canal is present in 26% of cases, two canals in 69%, three canals: 5%. Caliskan *et al*: One canal: 10%, two canals: 90%. Average time of eruption: 10-11 years. Average age of calcification: 12-13 years. Average length: 20,6 mm.

Histological analysis of periapical lesions refractory to orthograde endodontic treatment, has revealed that the major cause of root canal treatment failures are microorganisms persisting in the apical part of root canals of root filled teeth (1). Contamination of the periradicular tissues may also give an inflammatory and immune response affecting the surrounding bone, and root filling materials or fibers from paper points may

initiate a foreign body reaction which delays or prevents healing (2). When an endodontic infection is judged as non-healed, non-surgical or surgical re-treatment are approaches to consider. As in this case, re-treatment is indicated prior to surgery. When failed cases are retreated orthograde before periapical surgery, it is shown to be a 24% higher success rate compared to cases in which only periapical surgery was performed (3).

In the pre-op situation, the patient should be informed of the diagnosis, treatment aspects, precautions, prognosis, the expected post operative course and the available management options. An explanation of the procedure should be given, as well as potential outcome and possible risk of adverse effects as regional complications of LA include paresthesia, hematoma formation and bleeding. Systemic effects of LAs involve both the cardiovascular system and the central nervous system (CNS). The treatment provider ought to know the sign and symptoms of these effects, including the toxic effects of LA on the CNS include excitation followed by depression. CNS toxicity may cause symptoms such as lightheadedness, dizziness, and visual and auditory disturbances including tinnitus. These are followed by signs of CNS excitation such as muscular tremors of the face and extremities and convulsions. CNS depression will result in drowsiness, unconsciousness, respiratory depression and eventually a coma. The systemic toxicity of LA can be prevented by avoiding the use of excessive doses and by aspiration technique to detect the intravascular location of the needle. The management of toxic effect includes the use of oxygen when the early signs of toxicity are first detected and administration of anticonvulsants if seizures are present. Maximum doses of anesthetics could be calculated exactly, but an easy and safe rule is that one may safely use 1 cartridge of any LA for every 11 kg of patient weight. It is implied that the treatment provider is able to distinguish the patients symptoms with situations as vasovagal syncope, epileptic seizures, angina pectoris or a heart attack. Device for oxygen delivery and a puls oximeter to monitor HF and measuring the oxygen saturation of arterial blood (SpO_2) are benifical to have in the dental office.

Local anesthetics (LA) form the backbone of pain control in dentistry. They are used to achieve three major goals in endodontic surgical procedures; anesthesia during surgery, haemostasis during surgery; and prolonged post-surgical pain control. Their introduction, by Karl Koller and Sigmund Freud (topically), and William Halsted (injectably) in 1885, revolutionized the dental and medical surgery. Prior to their introduction, general anesthesia was the method of managing surgical pain. The introduction of an injectable LA, cocaine with epinephrine 1:50,000, permitted surgeons to operate painlessly on a conscious human being, without the increased risk of potentially significant adverse drug effects from large doses of inhaled anesthetic gases or larger doses of injected drugs which earlier had been necessary. However, by the early 1900s, reports of adverse reactions to cocaine and epinephrine had appeared; addiction and lethal dysrhythmias/ ventricular fibrillation. Cardiopulmonary resuscitation did not exist until 1960's. In 1904 in Germany, Alfred Einhorn synthesized procaine (Novocaine), like cocaine, an amino-ester.; working by diffusing through the lipid-rich nerve membrane and then blocking Na^+ channels, thus producing a non-depolarizing nerve block. Slow onset, short duration and allergies led to the development lidocaine (Xylocaine), the first amino-amide by Nils Löfgren, Sweden. The duration was longer and more profound and it provided more reliable anesthesia than did the esters. In 1960, the second amide was introduced, mepivacaine (Carbocaine), followed in 1965 by prilocaine (Citanest)(4). In 1969, carticaine was synthesized and, in 1976, introduced in German dentistry. The generic name was changed to articaine. It was Introduced into Canada in 1983, and the United States in 2000. Most clinical trials have shown similar properties of articaine and lidocaine. A trial performed at 29 sites in the United States and United Kingdom in the late 1990s compared articaine to lidocaine in more than 1,400 patients undergoing dental care. The summary of the trials stated there were no clinically significant differences between articaine and lidocaine, they concluded that articaine was a "safe and effective local anesthetic" for dentistry. To find articaine, or any new LA, superior to the exising is difficult, because the already available LAs are so effective. There have been some reports of paresthesia after using articaine in inferior alveolar (mandibular) nerve block anesthesia. Evidence-based research concerning this does not exist.

The effect, as mentioned, of LA diffusing across the plasma membrane and binding to the inner pore region of sodium channels, will prevent inflow of sodium ions; resulting in blockade of neuronal depolarization and

also the transfer of signals from the peripheral tissues to the CNS. Tissue inflammation may reduce the threshold for activation of these sodium channels, possibly contributing to the peripheral mechanisms for reduced pain threshold (allodynia) or increased responsiveness to painful stimuli (hyperalgesia) observed in inflamed tissue. LA also play a role in postoperative pain control, in immediate (min– hrs) pain control via blockade of discharges from peripheral nerves and second, the prolonged blockade of peripheral input acts to decrease the part of post-operative pain that is due to central sensitization. Central sensitization refers to the amplification in responsiveness that occurs in the CNS in response to prolonged nociceptor stimulation. Long-acting LA might produce profound post-operative analgesia even days after a single injection of the drug. Protein binding is responsible for the duration of action. Duration will also be increased with the vasoconstrictor added. Surgical models have been used to evaluate LA and analgesic drugs, mostly in oral surgery procedures as surgical removal of impaired third molars or periodontal surgery. Some differences have been found, related to the onset (the lower pKa, the more rapid onset). The lipid solubility will also influence on the potency, permitting the anesthetic to penetrate the membrane more easily.

There could be a concern of drug interactions and epinephrine; tricyclic antidepressants, MAO inhibitors, nonselective β-blockers, nonselective α-adrenergic blockers, digitalis and thyroid hormones are medicaments to evaluate prior to treatment. It is important to remember that the anesthetized bone at the surgical site is more sensitive to heat because of a temporary decrease in blood supply caused by the LA. See case 18 for more about hard tissue management and the issue of temperature.

Adequate haemostasis is essential to ensure the success of periapical surgery. It will improve visualization of the surgical field, shorten the time of surgery and facilitate the retrograde cavity preparation and filling. The amount of intraoperative haemorrhage during endodontic surgery is reported to range from 1 to 48mL, with the duration of surgery being a major predictor of bleeding (5). Optimal bleeding control can be achieved by a combination of pharmacological and non-pharmacological techniques. Application of local pressure and good tissue approximation and suturing are non-medicamental haemostatic measures. Examples of pharmacological haemostatic agents are Ferric sulphate, Telfa pads, CollaCote, calcium sulfate, bone wax, epinephrine soaked pellet and SurgiPlaster. In this case, Ferric sulphate and racemic epinephrine was used locally.

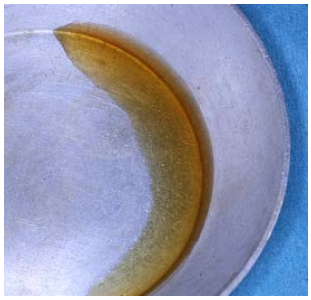

Fig. 20. FeS was used for haemostasis and removed thoroughly with curretage and saline irrigation after termination of the root-end management to prevent delayed healing and foreign body reaction.

A vascular injury gives vasoconstriction, followed by platelet adhesion and clot formation and the release of serotonin and thromboxane A2 (TXA2). Haemostasis involves platelet adhesion and degranulation. Activated thrombin promotes the adherence of platelets. Clot formation trigger the clotting cascade and the development of a fibrin/platelet plug at the site of injury. The intrinsic pathway of the clotting cascade is dependent on factors XII, XI and VIII, the extrinsic pathway is dependent on factor VII and a common factor X turn prothrombin to thrombin, which converts fibrinogen to fibrin and via XIII to fibrin polymer. The fibrinolytic pathway mediates the dissolution of the fibrin/platelet plug in the post-operative period.

Several diseases are well recognized to interfere with the clotting cascade, leading to poor haemostasis. Von Willebrand's disease is perhaps the most known hereditary bleeding disorder. Conditions as acquired or inherited bleeding disorders must be ruled out during patient questionnaire/ pre-treatment examinations.

We want healing after endodontic surgery to be by primary intention, without attachment loss and as little as possible of recession or scarring. (Soft tissue management and flap design are discussed in case 17).

Phases of healing include (6): Clotting, inflammation, epithelial healing, connective tissue healing, proliferation, maturation, remodeling.

Within 24 h: PMN and macrophages migrate into the blood clot. Reparative cells migrate along fibrin strands, capillary buds follow them. Microvascularization in the flap and surrounding tissues is provided from contributions from periosteal, periodontal and bone microvascular networks.

2 days: Epithelial streaming. (Because of epithelial bridging, some authors recommend suture removal after 2-3 days)

4 days: Epithelial barrier formed. Granulation tissue replaces the fibrin clot.

7 days: Epithelium has matured into multiple layers and new stratum corneum is evident

2 weeks: Fibrous connective tissue substitutes granulation tissue, new periosteum forms and new woven bone trabeculae occupy 80%.

4 weeks: The new trabecular bone matures

It may be important to note that small amounts of mechanical stress may result in increased collagen strength and collagen formation. To prevent scar formation and delayed healing, we can think of keeping the surgical field moist (minimize shrinkage of flap), re-approximate tissue edges in their correct position (to promote primary healing), compressing the repositioned tissue with a saline-moistened piece of gauze (reduce the coagulum to a thin fibrin layer), tissue margin should rest passively in the desired place and avoid tissue trauma (stretching, tearing, distortion). Pressure against underlying bone to make the blod clot as thin as possible.

Concerning the choice of suture material, there are absorbable sutures (used in the inner layers if multilayered flap) or non-absorbable sutures. The absorbable sutures are of biological origin (gradually digested by tissue enzymes) or of synthetic materials (hydrolyzed in tissue fluids). The non-absorbable sutures are recommended to minimize the inflammation during the healing process (6). Both monofilament and multifilament sutures are for sale on the market. Monofilament are made of a single strand of material as nylon or gut. This is least traumatic type of suture matieral and less plaque will accumululate. Multifilament variant is twisted together, as silk, teflonized polyester, cotton and linen, which have good handling properties. There may however be more bacterial accumulation and ingrowth of tissue when using the multifilament suture types. The size of the suture material denotes the diameter. As the nuber of 0's increases, the thread diameter decreases. 4-0 (0000) has a smaller diameter than 3-0 (000). The smallest possible size for adequate wound support should be used. Microsurgical techniques tend to increase the number of sutures but reducing the suture size, common used sizes in microsurgery is 5-0 to 8-0).

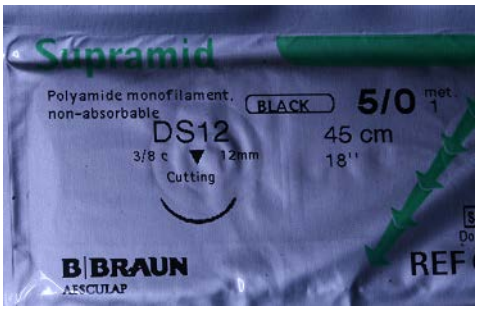

Fig 21. The suture material, Supramid 5-0, used in this case.

Post-operative pain is usually controlled with non-narcotic analgesics. A long-acting anaesthetic is recommended given at the end of the procedure(4) together with NSAIDs.

Fig. 22. (right) The control of pain in the postoperative period may start at the end of the operational procedure with injecting a long-lasting LA as bupivacain (Marcain®, "AstraZeneca"

Concerning prognostic aspects; many studies are difficult to compare. The composition of the study material differs, as well as the tooth material, number of roots used as a unit and the sample size. The size of the sample included in a clinical study is important for the study's internal and external validity. The sample size also determines the power of the statistical analysis of differences between groups. The smaller the difference in the outcome, the larger the sample required in each group to achieve sufficient power for significance to be demonstrable. Case selection criteria are also of importance since the reported outcomes may have been influenced by inclusion of teeth with poor prognosis. Previous endodontic treatment or not included in a given study, is expected to influence the reported outcome. Treatment providers oral surgeons vs endodontists, using microsurgical techniques, are in some studies shown to differ (7). Technical aspects as the root-end management, using burs or UL, the type of REF material as well as the pre- and post restoration may be of importance and affect the outcome (8).

Concerning technique; Tsesis *et al* found a significant difference in healing rate when comparing traditional surgical technique (TRS) (44,2%) with modern surgical endodontic treatment, endodontic microsurgery (EMS) (91,1%) including use of SOM and UL tip. The root-end material of choice was the same, IRM. Endodontic microsurgery can be stated to be effective (7, 8) . This was confirmed by a meta-analysis of the literature performed in 2010 reporting 59% positive outcome for TRS and 94% for EMS (9). In part II, the authours found that the probability of success when using SOM was 1.07 times the probability of success when using no magnification or loupes (10).

Concerning tooth position, the anterior teeth tends to have a higher success rates than the other tooth groups (11), possibly due to the easy access and root anatomy.

In some studies, the patients age as no effect on the outcome (12). Others have found higher success rates in patients in their 20s and a decrease with age (8). This patient was 31 year old.

Most studies show that a perforation of the antral floor during surgery do not adversely affect the long-term prognosis, however no perforation occurred in this case.

In 1999, a randomized controlled trial comparing root canal retreatment using surgical and non-surgical approach was done by Kvist & Reit. Nonsurgical and surgical retreatment was randomly assigned to 95 endodontically failed cases. The outcome of the procedures was clinically and radiographically recorded, and followed for 4 years. At the 12- month recall, a statistically significant ($p < 0.05$) higher healing rate was observed for cases surgically retreated. At the final 48-month examination, no such difference was found. These findings may be explained by a slower healing dynamics in the nonsurgical group and the late failures in the surgical group. The study did not show any systematic difference in the outcome of surgical and nonsurgical endodontic retreatment. In a review from 2009, Torabinejad *et al* (13) compared the clinical and radiographic outcomes of nonsurgical retreatment with those of endodontic surgery to determine which modality offers more favorable outcomes. A significantly higher success rate was found for endodontic surgery at 2–4 years (77.8%) compared with nonsurgical retreatment for the same follow-up period (70.9%; $P < .05$). At 4–6 years, however, this relationship was reversed, with nonsurgical retreatment showing a higher success rate of 83.0% compared with 71.8% for endodontic surgery. The authors concluded that it appeared that endodontic surgery offers more favorable initial success, but nonsurgical retreatment offers a more favorable long-term outcome.

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20 – Three cases of differential diagnostic interest

Iaterogenic lesion of soft tissue

Introduction

64 year old Northern European female was referred from the Department of Periodontology, UiO where she had been a patient for 1,5 years.

Fig.1. Frontal view

Medical history

Non-contributory

Dental history & chief complaint

The patient had gone through a non-surgical periodontal treatment. She had been explained and educated in hygiene/ prophylactic program from the Dept of Periodontology and had cooperated extremely well in her intraoral hygiene regimen. The patient was referred to the Department of Endodontics with request of endodontic revision/ re-treatment procedure because of tentative diagnosis endodontic-periodontal lesion.

Clinical findings

Fig.2. Occlusal view maxilla.

Fig 3. Occlusal view mandibula

	34	35	36	37
Cold	Yes	Yes	-	Yes
EPT	24	31	-	36
Percussion	No	No	No	No
Palpation	No	No	No	No
Mobility	-	-	I	-
PPD	3	3	8	5
Furcation involvement	-	-	Yes, II	Yes, I
Restoration	-	ODL comp	Crown	O Am
Soft tissue intraorally	WNL	WNL	Sinus tract lingually	WNL
Extraorally	WNL			

Table 1. Clinical findings 2011-10-25

Fig.4 Lateral view left side

Fig. 5 Bucco-lateral view

Radiographic history & radiographic findings

The sinus tract was traced with gutta percha points at the Dept of Periodontology and the tooth referred to the Dept of Endodontics, UiO.

Fig. 6: X-ray at the time of referral.

Fig.7, 8: X-rays at examination date in endodontic post graduate clinic

Mandibular, left second premolar: Radiopaque MOD restoration consistent with composite. Lamina dura intact.

Mandibular, left first molar: Radiopaque restoration coronally, consistent with a metal-ceramic crown, previous RCT. Vertical defect in marginal bone level to ½-3/4 of the root length, lamina dura can be followed in normal with apically around the roots.

Mandibular, second molar: Radiopaque filling material consistent with amalgam restoration occlusally. Marginal bone level reduced. Intact lamina dura.

Consultation at the Department of Endodontics 2011-10-25, post graduate clinic

The patient was examined as summarized in table 1. She was free of symptoms and had not noticed the gingival defect lingually of tooth 36. However, at appointment at the Post graduate clinic, Dept. of Endodontics, endodontic pathology could not be detected. I then asked the patient to show me in what way she used the interdental brushes.

Fig. 9, 10. Occlusal and buccal aspect use of interdental brush illustrated.

Fig.11,12. The lingual views show interbrush about 5 mm below the gingival margin – creating a soft tissue tunnel, giving an illusion of an infectious sinus tract.

It was evident that this was no sinus tract of infectious origin but, an iaterogenic defect created during excessive and improper interdental brush technique.

Treatment

None. The patient was informed about the findings and the need for changing technique when using the interproximal brushes.

Trauma with tentative diagnosis internal resorption

Patient
32 year old Scandinavian female.


Figure 1. Frontal view

Medical history& chief complaint

Bipolar disorder. Medications: Lamictal® (lamotrigin) “Glaxco SmithKline” tabl. The patient has noticed a discoloration of her maxillary, right lateral incisor.


Fig.2. Close-up labial aspect


Fig.3. Close-up palatal aspect

Dental history

The patient herself contacted the Dental Faculty, UiO, for routine examination. She was not aware of specific treatment needs. The patient had some years ago been exposed to domestic violence, but refused to specify or talk about this issue, which was respected. Therefore, the information concerning history of trauma is sparse. The patient was referred by the dental student, with a tentative diagnosis of internal resorption of iaterogenic origin.

Clinical findings

The patient had a moderate caries prevalence, a tendency of abrasion and chronic decalcification in the enamel. Intra-oral examination revealed the right lateral incisor is grayish discolorated, especially in the gingival 1/3 of the crown. The coronal segment was not mobile or displaced. The tooth was slightly tender of percussion vertically. Sensibility pulp test was positive on ice and electric stimulation. Extra-oral examination was judged to be within normal limits.

Fig. 4. Occlusal view, maxilla

Fig.5. Occlusal view, mandibula

Radiographic examination at the student clinic and at the post graduate clinic

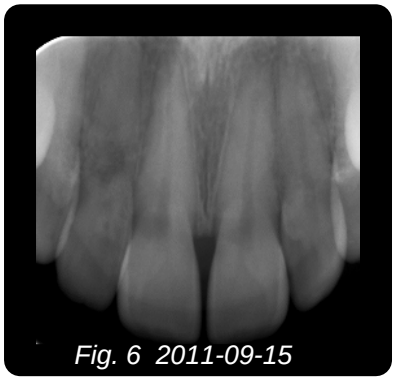


Fig. 6 2011-09-15

Fig. 6 (left). Radiograph showing a radiolucent area, apparently located in the middle aspect of tooth 12.

Fig. 7 (below) Orthopantogram

Fig. 7 2011-11-29 Courtesy of Dept of Maxillofacial Radiology

Fig. 8

Fig. 9

Fig. 10

A radiolucent zone separated the root fragments, with the appearance of ingrowth of bone tissue. A horizontal root fracture was likely tobe the original diagnosis at time of trauma. The root fracture site is no longer a line, since a long time has gone since the time of trauma (3-4 years assumed – the patient is not comfortable telling about the incident). Generally, the angulation of the cone in radiographic detection of a horizontal root fracture is critical. If a horizontal root fracture is suspected, it is recommended to take multiple radiographs.

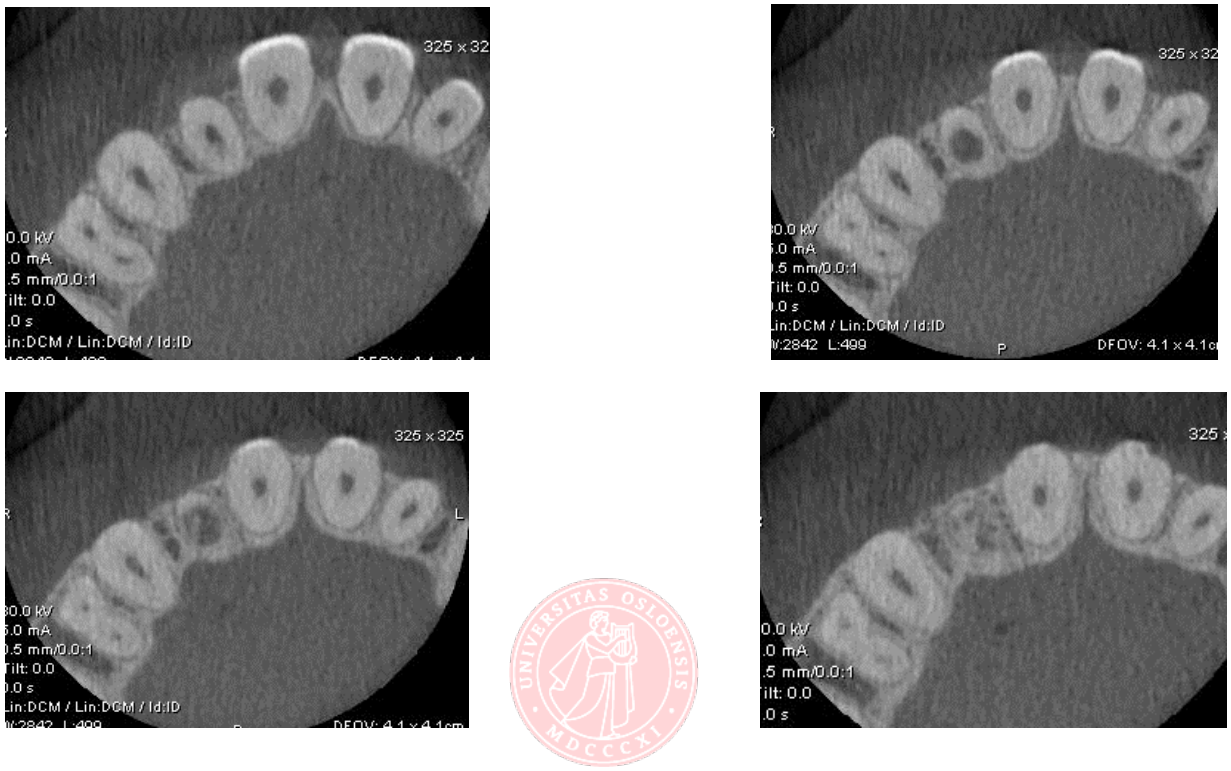
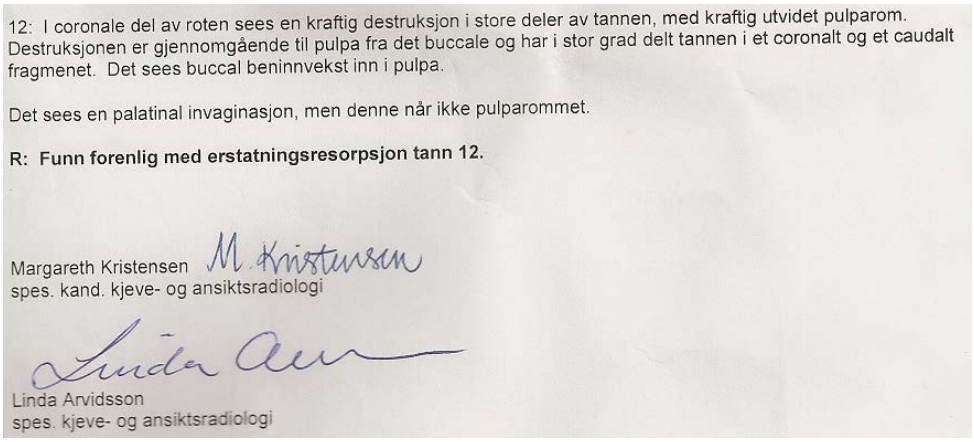


Fig. 11 CBCT investigation. In the coronal part of the root, a destruction is going through most part of the root. Courtesy of Dept of Maxillofacial Radiology, dr. Kristensen

Diagnosis

S02.53 Root fracture, K03.39 Pathologic resorption, trauma induced.



12: I coronale del av roten sees en kraftig destruksjon i store deler av tannen, med kraftig utvidet pulparom. Destruksjonen er gjennomgående til pulpa fra det buccale og har i stor grad delt tannen i et coronalt og et caudalt fragmenet. Det sees buccal beninnvekst inn i pulpa.

Det sees en palatinal invaginasjon, men denne når ikke pulparommet.

R: Funn forenlig med erstatningsresorpsjon tann 12.

Margareth Kristensen
spes. kand. kjeve- og ansiktsradiologi

Linda Arvidsson
spes. kjeve- og ansiktsradiologi

Fig. 12. Decription from the radiologist

Problem list

Weak tooth, with root fragments separated of ingrowth of bone tissue, assumed to proceed further.

Treatment plan

The patient was free of symptoms and she seemed to deny any problem. She was informed about prognostic aspects and to expect the tooth to be lost eventually. It was recommended to recall her for further observation in a year, with implantology as the first choice of intervention, she agreed on this.

Discussion

For morphological description of the maxillary, lateral incisor, see case 6.

Generally, a root fracture is confined to the root of the tooth involving cementum, dentin, and the pulp. Root fractures can be further classified by whether the coronal fragment is displaced (1). Radiographs recommended, are periapical, occlusal and eccentric exposures. An occlusal exposure is optimal for locating root fractures in the apical and middle third. Bisecting angle exposure or 90^{o} degree angulation exposure is needed to locate the fractures in the cervical third of the root. When a trauma with diagnosis root fracture recently has happened, it is advised to rinse exposed root surface with saline before repositioning and if displaced, reposition the coronal segment of the tooth as soon as possible. It need to be verified that the correct position has been reached, radiographically. Stabilizing the tooth with a flexible splint for 4 weeks is recommended(2). It is advisable to monitor healing for at least 1 year to determine the pulpal status. If pulp necrosis develops, then root canal treatment of the coronal tooth segment of the fracture line is indicated. Patient instructions should be: Soft food for 1 week. Good healing following an injury to the teeth and oral tissues depends, in part, on good oral hygiene. Brushing with a soft brush and rinsing with chlorhexidine 0.2 % is beneficial to prevent accumulation of plaque and debris. Follow-up: Splint removal and clinical and radiographic control after 4 weeks in apical third and mid-root fractures. However, if the root fracture is near the cervical area the splint should be kept on for up to 4 months (1). Clinical and radiographic control after 6-8 weeks and after 4 months. Clinical and radiographic control are then recommended after 6 months, 1 year and every year for 5 years. Follow-up may include endodontic treatment of the coronal fragment if pulp necrosis develops.

Different scenarios could be relevant concerning treatment in this case, if diagnosed earlier. Different treatment modalities are shown in fig. 13(3).

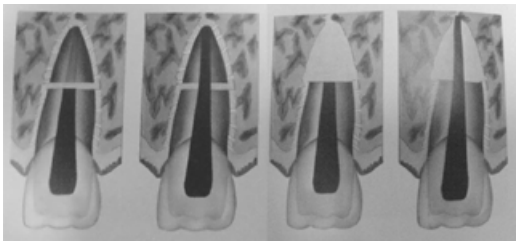


Fig. 13 from (3)

The prognosis may be favorable of horizontal root fractures when fracture is located in the middle third of the root; no mobility and vital pulp. The majority of the teeth with root fractures remain vitality(4). *The prognosis may be questionable* when the fracture is located in the coronal portion of the root and the coronal segment is mobile, no probing defect, necrotic pulp but without radiolucent area at the fracture site. *The prognosis may be unfavorable* when the fracture is located in the coronal portion of the root and the coronal segment is mobile, there is sulcular communication and a probing defect(4).

In most endodontic cases, the periapical radiograph is the image of choice as it provides a high definition image at a low dose. However, conventional radiographic techniques have certain limitations, like compression of 3-dimensional anatomy, geometric distortion and anatomical superimposition. With the CT technology, new possibilities evolve. Use of CT diagnostic has improved the clinician's ability to diagnose and treat endodontically related problems. The technique uses high energetic X-ray beams and measures the differences in electron density in different kind of tissues. These differences are represented by a grayscale, called The Hounsfield scale. It is named after Sir Godfrey Hounsfield, and is a quantitative scale

for describing radiodensity. Air is black and has the unit of -1000 Hu, bone tissue is white with the unit 1000 Hu.

Some advantages are that the method is a painless and non-invasive procedure with good sensitivity to detect pathology of the head. CT scan is far superior to an MRI when evaluating skull fractures, CT scan is much cheaper than an MRI an equally as fast. It has little degree of artifacts, like motion artifacts, and to a little extent operator dependent. CT scan can be performed in patients with implanted medical devices. It may give the opportunity of many kind of examinations.

Disadvantages with the technique are that, unlike MRI, CT scan is associated with a high energetic radiation (this is about the same radiation exposure that a normal individual would get in about 12 months). CT scan should never be done in a pregnant female because of the exposure of radiation risk to the fetus. The dye used in a CT is iodine based and is often a cause of allergy. It cannot be used in patients with kidney failure. CT is not very good at identifying pathology of the soft tissues

Cone beam computed tomography (CBCT) is an extra-oral imaging system which produces 3-dimensional scans of the maxillofacial skeleton and is increasingly used in endodontics. The machine provides a high-quality image that should supply the surgeon with the desired information. The typical image presentations for these machines are views in the axial, coronal, and sagittal planes, with other views possible with secondary reconstruction of the data. The radiation dose for the CBCT is generally lower than conventional CT. Conventional CT will have a radiation dose: Maxilla: 250µSv, mandible: 480µSv. Cone Beam CT Double jaw: 30-100µSv. Artifacts arising from metal restorations are more severe using conventional CT.

Imaging technique	Effective doses (micro Sieverts)
Panoramic radiograph	**13**
Cephalometric radiograph	**1−3**
Periapical radiograph	**1−8**
Occlusal radiograph	**8**
CBCT (6 cm field of view of standard mandible)	**75.3**
CBCT (6 cm field of view of standard maxilla)	**36.5**
Conventional CT scan of head	**2000**

Table 1. Comparison of effective doses of various imaging techniques

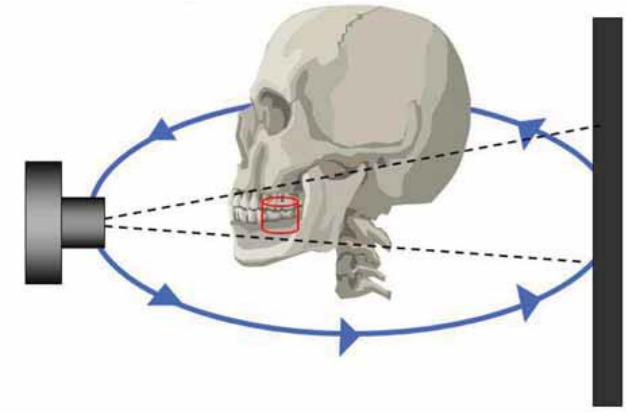


Fig. 14 The X-ray source and detector rotate once around the patient's head. This results in a cylindrical volume of data being captured. Sophisticated software reconstructs the data, which may then be displayed in axial, sagittal and coronal planes. From (5)

CBCT may be useful in complex endodontic cases where conventional radiography has not provided sufficient information. It can provide additional information via 3-dimensional views in order to manage a case predictably(5). CBCT scans offer a significant radiation dose reduction as compared to medical CT (see table 1).

Some indications for CBCT in Endodontics (5, 6):

- Detection of dental periapical pathosis in patients who present with contradictory or nonspecific clinical signs and symptoms, who have poorly localized symptoms associated with an untreated or previously endodontically treated tooth with no evidence of pathosis identified by conventional imaging, and in cases where anatomic superimposition of roots or areas of the maxillofacial skeleton is required to perform task-specific procedures. Lofthag-Hansen et al 27 demonstrated that CBCT scans resulted in 62% more periapical lesions being detected as compared to two angled periapical radiographs (7)

- Pre-surgical case planning to determine the exact location of root apex/apices and to evaluate the proximity of adjacent anatomical structures as the maxillary sinus.

- Diagnosis and management of dento-alveolar trauma, especially root fractures, luxation and/or displacement of teeth, and alveolar fractures.

- Assessment of root canal anatomy Identification of potential accessory canals in teeth with suspected complex morphology based on conventional imaging.

- Identification of root canal system anomalies and determination of root curvature.

- Diagnosis of non-endodontic origin pathosis in order to determine the extent of the lesion and its effect on surrounding structures.

- Intra- or post-operative assessment of endodontic treatment complications, such as overextended root canal obturation material, separated endodontic instruments, calcified canal identification, and localization of perforations.

- Localization and differentiation of external from internal root resorption or invasive cervical resorption from other conditions, and the determination of appropriate treatment and prognosis.

- Dental implant case planning when cross-sectional imaging is deemed essential based on the clinical evaluation of the edentulous ridge.

Nasopalatine duct cyst

Patient

55 year old Northern European male.

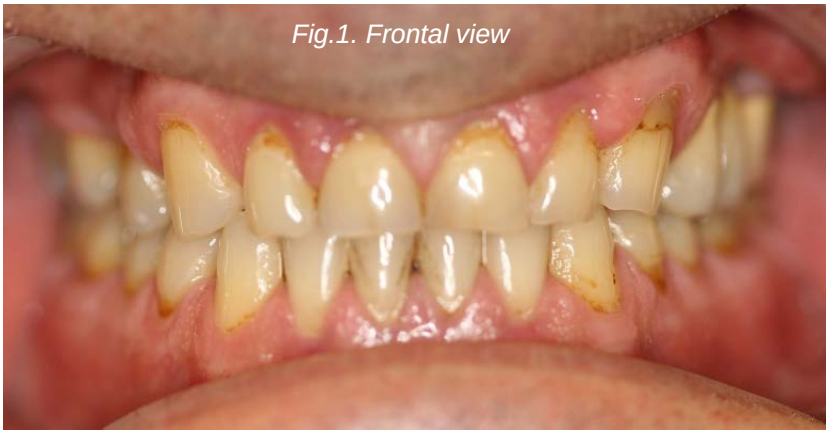


Fig.1. Frontal view

Fig.2 Occlusal view, maxilla

Fig.3 Occlusal view mandibula

Chief complaint

Swelling and exudation palatally in the anterior maxilla.

Medical history

Non-contributory

Clinical and radiographical findings 2011-03-09

All front teeth in maxilla had positive sensibility tests with EndoIce® and EPT. No percussion or palpation tenderness. No pathological PPD. Intact teeth with normal lamina duras. A heart-shaped radiolucent area can be seen in the area at the end of the gutta percha cone.

Fig. 4 Palatal view, gp in sinus tract

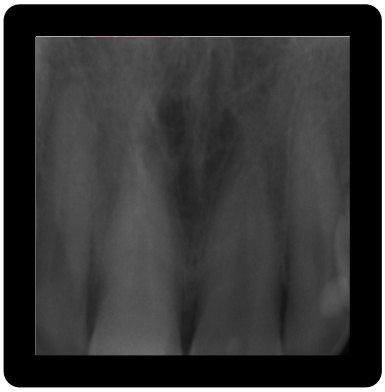


Fig. 5 Mid-line radiolucency

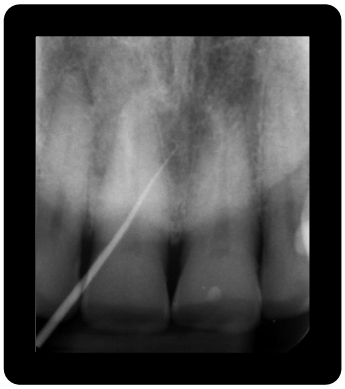


Fig.6 Fistulogram

Fig. 7 OPG Courtesy of Dept of Maxillofacial Radiology

Endodontic treatment needs and diagnosis of dental origin was excluded. The patient was informed about findings and tentative diagnosis and referred to the Department of Oral surgery, UiO.

Fig. 8 Elevation of palatal flap 2011-06-14

Fig. 9 Enucleation of cyst. Cyst lumen

Fig. 10. 2011-06-21

Fig. 11. 2011-07-18

Photos: Courtesy of dr. Wilberg

The patient experienced some pain and swelling during the first healing phase, but no paresthesia. About a month after surgery, the clinical conditions were satisfactory and the patient was free of symptoms.

Prognosis:

Good.

Discussion

The epithelial-lined cysts of non-odontogenic origin are thought to be derived from embryonic epithelial residues in the nasopalatine canal. The fusion of facial processes in the embryologic development of the maxilla results in the formation of a pair of epithelial strands; the nasopalatine ducts, that traverse the incisive canals downward and forward, connecting the nasal and oral cavities(8). The nasopalatine ducts ordinarily undergo progressive degeneration; however, the persistence of epithelial remnants may later become the source of epithelia that gives rise to nasopalatine duct cyst, from either spontaneous proliferation or proliferation following trauma (eg, removable dentures), bacterial infection, or mucous retention. Genetic factors have also been suggested. Nasopalatine duct cysts can form within the incisive canal, which is located in the palatine bone and behind the alveolar process of the maxillary central incisors, or in the soft tissue of the palate that overlies the foramen, then called the cyst of the incisive

papilla. Nasopalatine duct cysts are developmental, epithelial, nonneoplastic cysts that are considered to be the most common, 32.8-73.2% (9), of the nonodontogenic cysts and approximately 12% of all jaw cysts. This cyst is unique in that it develops in only a single location, which is the midline anterior maxilla. It may occur in the nasopalatine canal or in the soft tissues of the palate. The condition is most prevalent in age group 30-70 years but can occur in age from 10 years. The frequency is in the literature higher in males. No racial predilection is known.

The clinical presentation is often swelling in the anterior region of the midline of palate, sometimes also at the labial aspect. Small cysts in the early stages of their development are frequently asymptomatic. Large cysts can be responsible for a variety of symptoms, including swelling in the anterior part of the midline of the palate and pain defined as a burning sensation in the anterior part of the maxilla that occasionally radiates into the bridge of the nose. Discharge of mucoid character is often present; described as a salty taste, or purulent. Tooth displacement is a common finding, having been reported to occur in 78% of patients, whereas bony expansion is noted in only 1.4% of patients (8). Nasopalatine duct cysts clinically demonstrate slow and progressive growth and may exceed 60 mm in diameter. The mean radiographic diameter is reported to be 17 mm.

Panoramic, occlusal, and periapical radiographs are the standard X-rays in the radiographic evaluation of suspected nasopalatine duct cyst. In some cases, obtaining a 3-dimensional view of the lesion may be necessary. Radiographic examination typically discloses a well-defined, ovoid, round or inverted, heart- or pear-shaped radiolucency located in the midline of the maxilla, which is inter-radicular and apical to the roots of the maxillary central incisor teeth. Larger lesions resorb the surrounding maxillary cortex. The shaped may be due to that they become notched by the nasal septum during their expansion or because the nasal spine is superimposed on the radiolucent area or if there are bilateral cysts. It may be difficult to decide whether a radiolucency in the actual area is a cyst or a large incisive fossa. Roper-Hall in 1938, investigatigated 2162 skulls: 2154 were absent or small. Five were medium size, one was enlarged, two were large and cystic. The cyst was always found in the midline of the palate, above or between the roots of the central incisor teethThe teeth should be vital and lamina dura intact around the tooth apices, as in this actual case.

Concerning histological features; the epithelial linings are variable. Stratified squamous, pseudostratified columnar, cuboidal, columnar or primitive flat epithelium may be seen. Goblet cells may be found. A valuable diagnostic feature of nasopalatine duct cysts is the presence of nerves and blood vessels in the fibrous capsule. Small foci of mucous glands were found in the fibrous capsules of approximately one-third of cases in the series of Abrams *et al* in 1963. 24 % were relatively free of inflammatory cell infiltrate, 39% with mild, chronic inflammatory cell infiltrate and 20% moderate chronic inflammatory process. 11% had severe inflammatory cell infiltrate. Small islands of hyaline cartilage may be seen in the cyst walls.

The treatment is surgical enucleation. A palatal flap is reflected after an incision along the gingival margins of the teeth. The cyst is exposed, in necessary by the removal of bone. The cyst is then carefully dissected from the bony canal. Blood clot is allowed to fill the cavity and the flap is then sutured. Complete bone regeneration within the bony defect is expected postoperatively. Recurrences are very rare. If the sphenopalatine nerve is damaged during surgery, paresthesia to the anterior palate may happen. After surgical treatment, recurrence is uncommon, having been reported in 0-11% of patients. Only 2 cases of malignant change in the lining epithelium of a nasopalatine duct cyst have been published (8).

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