UNIVERSITY OF OSLO

FACULTY OF DENTISTRY

Department of Endodontics

Postgraduate Program in
Endodontics

Case Book
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Endodontic Treatment Guidelines

Treatment of Tooth without Apical Periodontitis

Preoperative radiograph
Anesthesia
Removal of plaque, caries and leaking fillings
Tooth build-up if required for isolation
Access cavity preparation
Localization of canal orifices
Application of rubber dam
Disinfection of the working area with 0.5% chlorhexidine in 70% ethanol
Measurement of working length, using apex locator and working length radiograph

- Goal: 0.5-1mm short of the anatomic apex

Instrumentation to desired apical length and size (figure 1) with

- Frequent irrigation with 1% sodium hypochlorite (NaOCl)
- Final irrigation with 17% ethylenediaminetetraacetic acid (EDTA) ($C_{10}H_{16}N_2O_8$)

Drying of the canals with paper points
Adaptation of master point
Master point radiograph

Root filling:

Obturation techniques:

- Lateral compaction
- Warm vertical compaction

Sealers:

- AH Plus
- Epiphany/Real Seal

Core materials:

- Gutta-percha
- Resilon

Removal of core material and sealer from the pulp chamber
Temporary IRM top filling with a 2 mm IRM plug in the canal orifice
In special situations topped by a temporary composite filling
Removal of rubber dam
Final radiograph

Treatment of Tooth with Apical Periodontitis:

First Visit:

Anesthesia
If required building up the tooth for aseptic reasons
Removal of plaque, caries and leaking fillings
Application of rubber dam
Disinfection of the working area with 0.5% chlorhexidine in 70% ethanol

Access cavity preparation
Localization of canal orifices
Measurement of working length, using apex locator and working length radiograph

- Goal: 0.5-1 mm short of the anatomic apex

Instrumentation to desired apical size (figure 1)

- Frequent irrigation with 1% sodium hypochlorite (NaOCl)
- Final irrigation with 17% ethylenediaminetetraacetic acid (EDTA) and a final flush with 1% NaOCl
- In retreatment cases: Final irrigation with 17% EDTA and then 2% chlorhexidine digluconate (CHX)

Drying of the canals with paper points
Intra-canal dressing: calcium hydroxide ($Ca(OH)_2$)
Cleaning the pulp chamber
Temporary top filling: IRM
In special situations topped by a temporary composite filling
Removal of rubber dam

Second Visit:

If the patient is without symptoms and no sensitivity to palpation and percussion test from the tooth, the root canals are filled. (See above description of treatment of tooth without apical periodontitis.)

Time Plan:

Tooth without apical periodontitis:

- One-appointment treatment is the standard (goal)
- When time does not allow or there are other reasons, e.g. difficulty in controlling bleeding in the canal, the canal is filled with $Ca(OH)_2$ and the treatment will be finished at the second appointment, preferably 1-2 weeks later.

Tooth with Apical Periodontitis:

- Two-appointment treatment is the standard (goal)
- 1-3 weeks between first and second appointment is the standard
- Long-term $Ca(OH)_2$ treatment (first for 2-3 weeks, then radiographic and clinical control after 3 months) is to be considered when:
  - A large lesion is present
  - Sinus tract does not close
  - Other symptoms continue

Emergency Treatment:

Acute Pulpitis:

- Eugenol pulpotomy
  - ZOE filling in a deep cavity
- Eugenol pellet in pulp chamber + IRM top filling
- Systemic medications
  - NSAID prescribed when pain is a problem
  - Systemic antibiotics not recommended

Acute Apical Periodontitis:

- Incision of abscess and drainage, if applicable
- In some cases 1-2 mm over-instrumentation with #10 K-file to release pus
- Preparation of canals and Ca(OH)2 treatment is the optimal treatment
- Ca(OH)2 dressing
- Systemic medications
    - NSAID prescribed when pain is a problem
    - Systemic antibiotics when general indications present

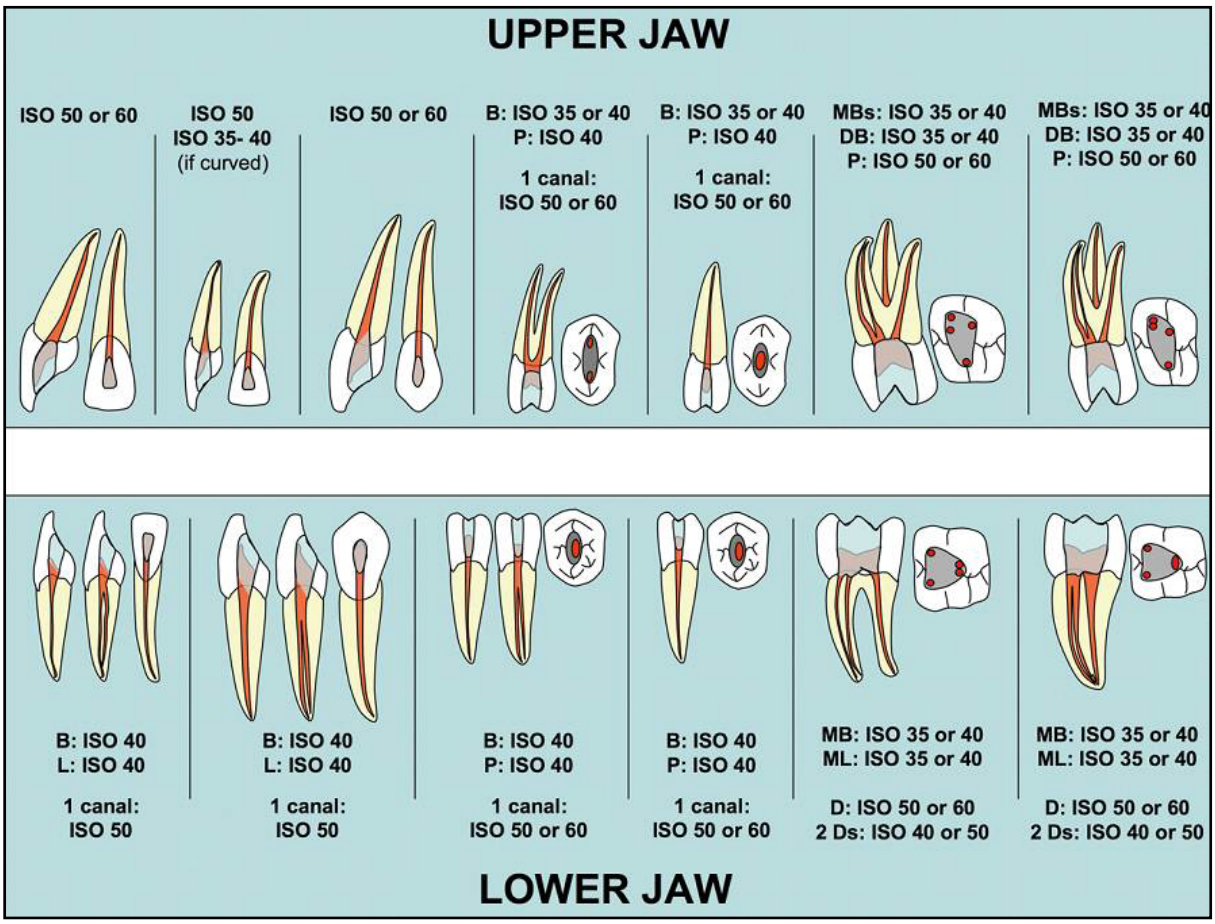

Figure 1: Normative apical sizes for safe and effective disinfection in permanent teeth. The clinician must use his or her clinical judgment in choosing apical sizes for each individual tooth. (Courtesy of Dr. G. Debelian)

Endodontic files for instrumentation of canals

Hand files:

- K-files
- Stainless steel files (SS files)
- Hedstroms files
- Nickel-titanium files (NiTi files)

Engine driven files

- ProTaper® (figure 2)
- BioRace® (figure 3)
- Race®

Figure 2: ProTaper®

Figure 3: BioRace®

Endodontic Surgery

- All relevant radiographs mounted on viewer or screen
- Anesthesia
- 1 minute mouth rinse with Corsodyl® (chlorhexidine 2mg/ml)
- Incision:
    - To provide a clearly defined opening to bone for maximum tissue thickness reflection, and to establish an easily identifiable and accessible border for re-approximation and reattachment.
- Elevation:
    - To gain access to 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.
- Retraction:
    - To hold the flap away from the surgical site, providing maximum access and visibility, without causing harm to the flap or the surrounding tissues.
- Flap design:
    - Intrasulcular flap:
        - Mainly indicated for treatment of cervical resorptions, perforations, and resections of short roots. Also mainly used in posterior apical surgery.
        - Comprises a horizontal incision extending to one or two teeth mesial and distal of the involved tooth and one vertical-releasing incision, usually placed at the mesial end of the flap.
        - If the access is too limited, the triangular flap can easily be converted into a rectangular flap by placing an additional releasing incision at the distal end of the horizontal incision.

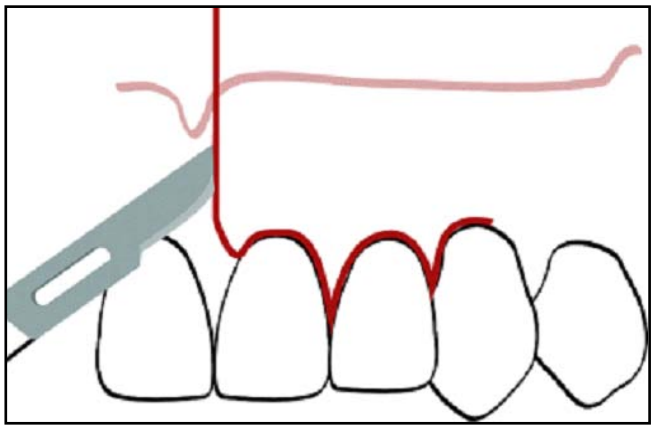

Figure 4: Triangular flap with intrasulcular incision
(Velvart et al. 2002)

- Submarginal flap:
    - Fear of even small recessions is the driving force for considering the submarginal flap.
    - When properly planned and performed, the submarginal flap will leave the marginal gingiva untouched and does not expose restoration margins.
    - The submarginal flap design, also referred to as an Ochsenbein–Luebke flap, is similar to the rectangular flap, with the difference that the horizontal incision is placed within the attached gingiva.
    - The two vertical incisions are connected by a scalloped horizontal incision, performed roughly parallel to the marginal contour of the gingiva.
    - The submarginal incision should only be used when there is a broad zone of attached gingiva with a minimum of 3 mm.

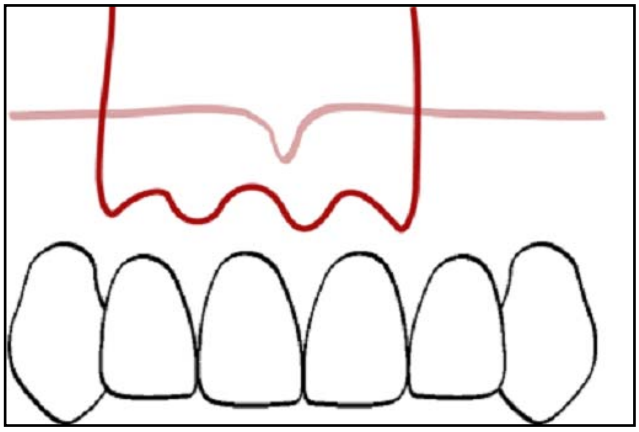

Figure 5: Submarginal flap (Velvart et al. 2002)

- Osseous entry or osteotomy:
  Involves removal of cortical and cancellous bone to gain direct access to the apical portion, and the lateral aspects if necessary, of the root or roots of a tooth where periradicular periodontitis is present. There may be fenestration through the buccal cortical plate, thus providing instant access to the root tip. A periradicular soft tissue lesion may have perforated the cortical plate, in which case curettage of the lesion permits access to the root either without bone removal or minimal extension of the borders of the defect for improved access. Frequently, however, there will be an intact cortical plate that requires removal to expose the surgical site. This is achieved routinely by using rotary instruments. 3-4 mm of the apical portion of the root should be clearly exposed. Following resection of the required 3 mm of root tip, there should be good visibility of the resected root surface for the next stage of the procedure.
- Surgical curettage:
  To remove all pathological tissue, foreign bodies, and root and bone particles from the periradicular area.
- Biopsy:
  Although there is agreement in the literature that the vast majority of soft tissue lesions are either granulomas or radicular cysts, any soft tissue lesion removed during the surgical procedure should be submitted for biopsy.
- Root-end resection:
  To expose the foramen/canal for inspection by sectioning the apical segment of the root and/or bevelling it to the line of sight.
- Ultrasonic root-end preparation:
  To provide a clean, well-shaped class I cavity in an apically resected root that is parallel to the long axis of the root, sufficiently centered to offer adequate root wall thickness, and deep enough to receive and retain a non-toxic, biocompatible filling material.

- Hemorrhage control:
    - To maintain a clean, dry and highly visible surgical site, and spontaneously manage and control any abnormal bleeding. This is achieved through use of:
    - Local anesthetic solutions possessing vasoconstrictor properties - Xylocaine Adrenaline® (lidocaine hydrochlorid 10 mg/ml, epinephrine 5 μg/ml), Septocaine® (articaine hydrochloride 4% with epinephrine 1:200,000) or Septocaine® Forte (articaine hydrochloride 4% with epinephrine 1:100,000)
    - Stryphnon gauze (adrenalonchloride 0,33 mg/cm^2)
    - Ferric sulfate ($Fe_2(SO_4)_3$)
- Root-end filling using either IRM or MTA:
    - The surgical site must be aspirated of all fluids and bleeding controlled.
    - The cavity preparation is flushed clean and thoroughly dried with short-cut segments of sterile paper points.
    - The IRM or MTA is carried to the preparation in small semisolid increments with plastic instruments or carvers.
    - Use of the MAP system® (Micro-Apical Placement) or the MTA pellet forming block will ease the application of MTA.
    - Pluggers of various sizes and angles are used to effectively condense the material to the depth of the preparation.
- Prior to wound closure, the surgical site is irrigated with saline solution to remove debris, and tissue edges are re-approximated in their correct position to promote healing by primary intention. Compression of the repositioned tissue with a saline-moistened gauze will reduce the coagulum to a thin fibrin layer between the repositioned tissue and cortical bone. Tissue margins should rest passively in the desired place before suturing.
- Wound closure using non-absorbable suture material in sizes 4-0 and 6-0.
- Postoperative radiograph is taken for control of procedures and as reference for follow-up
- Postsurgical care:
    - A disposable ice pack is covered with a soft towel, and the patient instructed on where and how to hold the icepack firmly in position against the facial tissues approximating the surgical site.
    - Unless contraindicated for some reason, the patient is instructed to take 400 mg ibuprofen every 4 to 6 hours for the first 48 hours.
    - The patient is advised to rinse with Corsodyl® twice daily until suture removal.
- Suture removal:
    - The epithelial seal at the wound edges is evident within 2 days; suture removal can take place earliest after 48 h but not later than 6-7days.

- Standard prescription of:
    - Analgesics:
        - Ibuprofen 400 mg. No 30. Every 4 to 6 hours in 3 days.
    - Antibiotics (only on indications):
        - Phenoxymethylpenicillin (penicillin V) 660 mg. no 30 (1+1+2 per day for 7 days)

Chronic Pulpitis

Introduction

69 year old white Northern European female

Figure 1: Frontal view

Chief complaint

28 May 2008

Brown colored maxillary right canine

Medical history

Non-contributory

Dental history

February 2008: Started endodontic treatment of tooth 13 at dental student clinic, University of Oslo (UiO). Because obliteration of root canal the dental student did not locate the canal. The patient was scheduled for crown treatment tooth 13. Referred to the Department of Endodontics, UiO, for endodontic treatment of tooth 13.

Clinical findings

28 May 2008

Figure 2: Lateral view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	14	13	12
Cold	Yes	No	Yes
Percussion	No	No	No
Palpation	No	No	No
Mobility	No	No	No
PPD (periodontal probing depth in mm)	4	4	4
Restoration	Porcelain fused to metal crown	IRM (DP)	Porcelain fused to metal crown

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 14: porcelain fused to metal crown
Tooth 13: IRM restoration on the occlusal and palatinal aspects of the crown, caries on the buccal, distal and palatinal aspects of the crown
Tooth 12: porcelain fused to metal crown

Radiographic findings

28 May 2008

Tooth 15: Widen lamina dura apically. PAI 2. Root canal filled. Metal crown with post. Normal marginal bone level.

Tooth 14: Normal lamina dura. PAI 1. Metal crown. Normal marginal bone level.

Tooth 13: Normal lamina dura. PAI 1. Filling material in the most coronal part of the root. Obliterated root canal. Normal marginal bone level.

Tooth 12: Normal lamina dura. PAI 1. Metal crown. Some reduced marginal bone level.

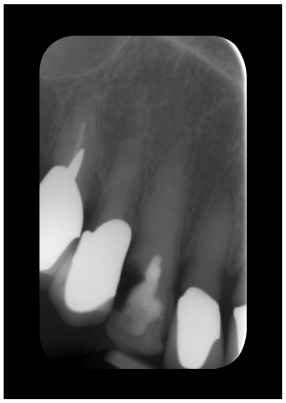

Figure 4: Periapical radiograph

Diagnosis

Tooth 13:

Pulpal: Necrotic (K04.1)
Apical: Within normal limits
Marginal: Within normal limits

Problem list

Obliteration of the root canal

Treatment plan

Orthograde endodontic treatment of non-vital pulp tooth 13

Treatment

28 May 2008

Clinical examination. Tooth diagnosed with necrotic pulp. 1.8 ml Septocaine®. Removal of caries. Rubber dam. OralDam® was used to isolate the rubber dam. Preparation of access cavity and localization of obliterated root canal with the use of LN-bur (no. 10). Vital pulp tissue. The pulpal diagnosis was altered to chronic pulpitis (K04.03). Length of the canal was determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically with Gates-Glidden burs, K- and NiTi hand files, in conjunction with PreRace® to size:

One canal: R60/23.5mm/incisal edge

1% NaOCl and 17% EDTA were used for chemical root canal disinfection. The canal was dried with paper points and filled with AH Plus and gutta-percha. A temporary IRM filling was applied. The patient was referred back to undergraduate dental student for treatment of crown with post tooth 13.

Figure 5: Pre-operative radiograph

Figure 6: Working length radiograph

Figure 7: Master point radiograph

Figure 8: Post-operative radiograph

Result

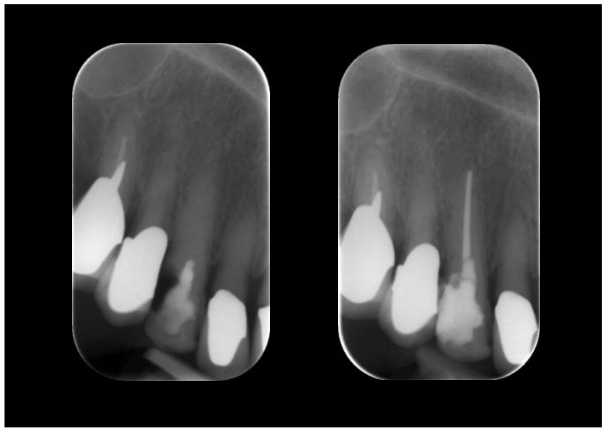

Figure 9: Pre- and post treatment periapical radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

6 March 2008 (nine months after endodontic treatment)

Radiograph showed normal lamina dura and no apical radiolucency tooth 13.

The patient was asymptomatic and without clinical findings.

The tooth has undergone treatment for post and crown.

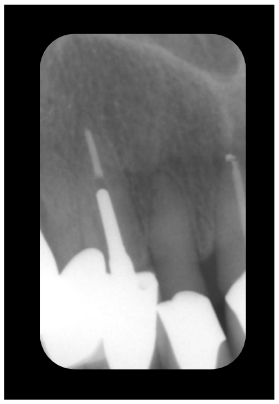

Figure 10: Periapical radiograph at follow-up examination

Discussion

With vital pulpectomy, the clinical aim is removal of the entire vital pulp tissue short of the anatomical apex followed by a bacteria tight, biocompatible and stable root filling. With this treatment inflamed tissue is removed to an apical level where wound surface can be kept to a minimum, the residual pulp tissue is well vascularized, and the conditions for healing are optimal, provided the entire treatment can be carried out under aseptic conditions.[1] Given the fact that even following a carious exposure the infectious process does not reach far into the pulpal space[2], a one-step treatment seems reasonable since the procedure is basically surgical and does not demand as strong an emphasis on canal disinfection as the case with infected pulp necrosis. The one-step treatment certainly presents several advantages.[3] The total time for treatment is reduced and it saves the patient both travel time and expenses. From a treatment point of view, a one-appointment treatment also offers the advantage that curvatures, irregularities and other aberrations in the canal anatomy as well as working length determinations are current to the operator, thus facilitating a filling procedure that is likely to be easier than at a later appointment. Studies have also indicated that the occurrence of post operative pain may not be more prevalent in teeth permanently filled in one-step treatments than two or more multiple visits.[4] Another factor of importance for the successful outcome of pulpectomy seems to be the distance from the anatomical apex to the termination of the root-filling. The placement of the wound surface in vital teeth is guided by other concerns than those for treating infected root canals. The optimal wound level in teeth with vital pulp appears to be 1-2 mm from the radiographic apex.[5] Thus, studies have shown that a distance from radiographically apex to root-filling exceeding 3 mm reduces the success rate compared to a termination of the filling 0-3 mm from the radiographically apex.[6, 7] As there is no concern about hard or soft tissue infection when a vital pulp is present, the main objective will be to optimize the technique of atraumatic and aseptic pulp surgery. The aim is placement of the

wound at the so called apical constriction.[8] Overfilling should be avoided for the primary reason of not inducing more than necessary tissue toxic, allergenic or foreign body reaction, which in turn may compromise apical wound healing, induce an apical lesion and thereby endanger the possibility of properly assessing of the treatment.[9] If the pulp remnant left in the root canal is more than 2 mm long, the risk of pulp necrosis is high due to amputation injury. It is crucial for the treatment outcome of vital pulp therapy that the remaining pulp will stay alive after surgery.[5] If the remaining pulp is short, the chances for revascularization are higher than if the pulp stump is long, as the ratio between remaining pulp length and size of apical constriction is small. It has been demonstrated however, that if the pulp is removed completely when strict asepsis is maintained, healing will occur even if the root canal filling is placed 2-4 mm short of the working length.[5] In cases with necrotic pulp, however, great efforts must be spent on the most apical part of the root canal, because disinfection of this area is crucial. The most apical part of the infected pulp space has often a branching of the main canals, and extensive apposition of cementum, that makes disinfection and mechanical debridement less effective and difficult. Furthermore, conventional antimicrobial agents are often diluted or inhibited by tissue fluids.[5] As the major concern in necrotic cases is related to elimination of all infected soft and hard tissues from the apical part of the root canal, the placement of the wound surface must be further apically than what is required in treatment of vital cases. The need for close apical preparation of teeth with necrotic pulp has been confirmed in several clinical studies of treatment outcome.[5]

In controlled clinical and radiographical studies[6, 7, 10, 11, 12, 13, 14, 15, 16, 17], success after pulpectomy can be obtained in about 74-97% of the cases with favorable aseptic conditions, due to the fact that the vital pulp and the dentin are not initially infected.[5]

Time is required to observe the treatment outcome. While in the absence of infection, resolution to the surgical trauma should not take more than a couple of weeks, the development of a lesion due to infection may require months or even years to become diagnosable. The chemical irritation and foreign body reaction initiated by the root filling material may also cause periapical bone lesions that may take time to resolve.[9] Consequently, the treatment outcome observed after a short time period may differ from that observed at later time periods. Ørstavik[17] recorded that the peak incidence of emerging apical periodontitis was at one year. Failures in these teeth may be caused by pulpal infection, although radiographic evidence of apical periodontitis is initially absent. The canals may also be contaminated during treatment, with bacteria from a bordering carious lesion or with saliva[18], through coronal leakage [19, 20] and through exposed dentinal tubules communicating with periodontal defects.[21]

Study	Operator	Follow-up (years)	Number of cases	Recall rate (%)	Success (%)
Strindberg (1956)[16]	D	4	187 (roots)	74	80
Grahnén &Hansson (1961)[6]	S	4-5	570 (roots)	54	74
Engström & Lundberg (1965)[13]	S	3.5-4	173	73	78
Ashenaz (1979)[10]	D	1-2	145	-	97
Kerekes & Tronstad (1979)[7]	S	3-5	260 (roots)	78	92
Pettersson et al. (1982)[14]	D	3-6.5	156 (roots)	82	92
Molven & Halse (1988)[12]	S	10-17	174	-	79*
Sjögren et al. (1990)[15]	S	8-10	267	46	96
Friedman et al. (1995)[11]	D	0.5-1.5	108	78	93
Ørstavik (1996)[17]	D	1-4	473	82	94

D, dentist; S, students; * cases classified as “uncertain” excluded

Table 2: Success rates reported in various clinical follow-up studies on pulpectomy in which it is possible to distinguish vital from non-vital pulp therapies

In this case the tooth was treated under aseptic control, and the distance from the apex was correct. Therefore the prognosis is favorable. According to selected studies the success rate of the pulpectomy would be from 74 to 97% (table 2), but at the lower range of this interval the studies have not used modern endodontic methods (e.g. nickel-titanium files). A successful outcome with no development of apical periodontitis, is therefore expected in approximately 90-95% of teeth treated with pulpectomy.

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Chronic Apical Periodontitis - Obturation with Resilon

Introduction

28 year old white Northern European male

Figure 1: Frontal view

Chief complaint

22 February 2008

Some lingering pain from mandibular left first molar. Referred to the Department of Endodontics, UiO, from dental student clinic, UiO, for examination and treatment of tooth 36.

Medical history

Non-contributory

Dental history

2006: Emergency dental treatment because of severe pain from tooth 36.

Clinical findings

10 March 2008

Figure 2: Lateral view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	35	36	37
Cold	Yes	No	Yes
Electrical test (0-80)	28	No	34
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	2	2	2
Furcation involvement	No	No	No
Restoration	No	O (amalgam) OD (IRM)	O (amalgam)

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 35: within normal limits

Tooth 36: amalgam restoration on the occlusal aspect, IRM filling on the occlusal and distal aspects

Tooth 37: amalgam restoration on the occlusal aspect

Radiographic findings

10 March 2008

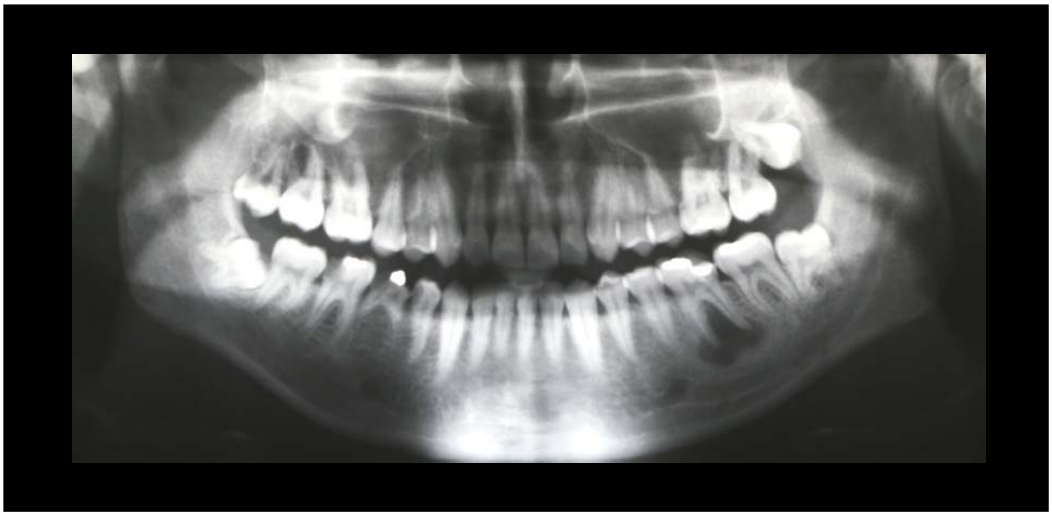

Figure 4: OPG

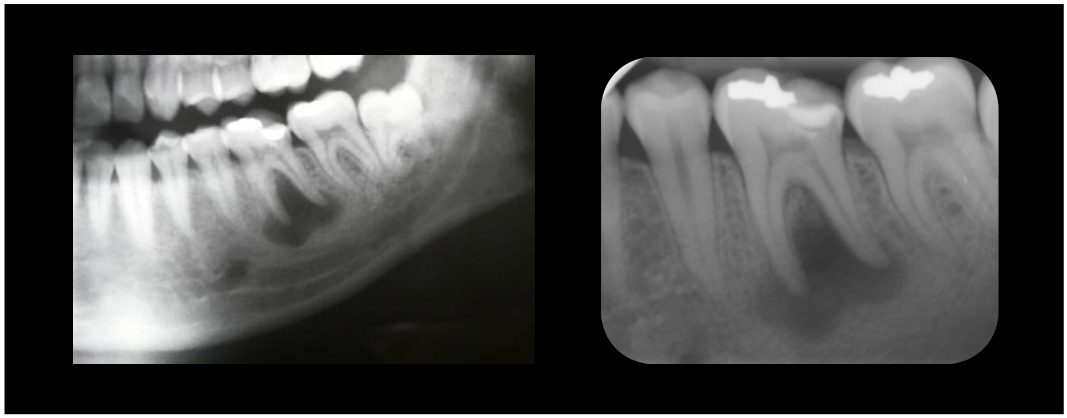

Figure 5: OPG

Figure 6: Periapical radiograph

Tooth 35: Normal lamina dura. No apical radiolucency. PAI 1. Normal marginal bone level.

Tooth 36: Discontinued lamina dura. Apical radiolucency at the mesial and distal roots (Ø 15 mm). PAI 4. Radiopaque material on the occlusal and distal aspects of the crown. Normal marginal bone level.

Tooth 37: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the occlusal aspect of the crown. Normal marginal bone level.

Note: Tooth 85 with severe caries. Tooth 46 with deep caries on the occlusal and distal aspects of the crown. Tooth 38 partially embedded.

Diagnosis

Tooth 36:

Pulpal: Necrosis (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Apical periodontitis

Treatment plan

Treatment of non-vital pulp 36
Long-term $Ca(OH)_2$-treatment

Treatment

10 March 2008

Clinical examination. Tooth 36 diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Access cavity preparation. Localized four canal orifices. Rubber dam applied. Root canal lengths were determined by apex locator (Root ZX®) and a periapical

radiograph. Root canals disinfection was done mechanically with Gates-Glidden burs, K-files and ProTaper® to sizes:
MB: R45/20.5 mm/mesiobuccal cusp
ML: R45/20 mm/mesiolingual cusp
DB: R55/20.5 mm/mesiobuccal cusp
DL: R55/20 mm/mesiobuccal cusp
Ultrasonic irrigation with Irrisafe® was also used for further cleaning of the canals. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

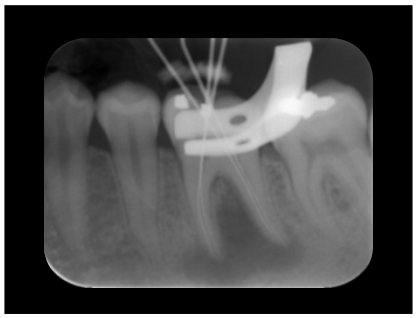
Figure 7: Working lengths radiograph

8 April 2008

1.8 ml Septocaine®. Rubber dam. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an long-term intra-canal dressing. IRM was applied as a temporary filling.

1 October 2008

Patient had previously cancelled two appointments. Patient had no percussion or palpation sensitivity from tooth 36. Radiograph showed evidence of healing. 1.8 ml Septocaine®. Rubber dam. 1% NaOCl and 17% EDTA were used for cleaning of the canals. Epiphany® and Resilon® were used as root filling materials. IRM was applied as a temporary filling.


Figure 8: Master point radiograph

Figure 9: Radiograph before cutting the Resilon® points

Figure 10: Final periapical radiograph

Result

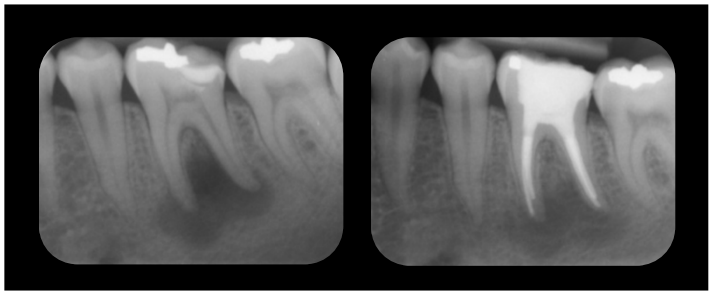
Figure 11: Pre- and post-treatment radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

4 March 2009 (five months after endodontic treatment)

The patient was asymptomatic and experienced no sensitivity to percussion or palpation tests on tooth 36.

The radiograph showed evidence of healing of the apical periodontitis.

Figure 12: Periapical radiograph at follow-up examination

Discussion

The root filling is thought to be critical for the long-term outcome of root canal treatment.[1, 2] A root filling may entomb surviving bacteria, and prevent apical and coronal leakage, i.e. stop influx of periapical tissue-derived fluid from nourishing the remaining microbiota and prevent re-infection of the root canal system.[3] Animal and human outcome studies have shown that the currently used root filling materials and techniques are not optimal[4], and fail to fulfill the desired requirements. Therefore, the development and maintenance of a seal is desirable and considered to be a major prerequisite to improve the outcome of root canal treatment.

In 2004, a new core material, Resilon, in conjunction with an adhesive system, Epiphany, was introduced. This new thermoplastic-filled polymer core (polycaprolactone-based) and the resin composite sealer have the potential to bond simultaneously together and to intra-radicular dentin.[5] However, this filling material must bond to root dentine that is less than ideal in terms of its cleanliness and surface characteristics. Beside irregular structures such as accessory root canals, resorption and repaired resorption areas, there are a lower number of dentinal tubules, irregular secondary dentine and cementum-like tissue in the apical portion of the root canal wall.[6] Physiological phenomena such as tubular sclerosis and dentinal fluid transudation must also be considered in this technique-sensitive treatment approach.[7]

Several leakage studies have been published comparing Resilon and Epiphany with gutta-percha and conventional sealers. Using a fluid transport model, some authors reported that Resilon and Epiphany were better at preventing fluid movement when compared with gutta-percha and AH Plus or AH26.[8, 9] Some reports concluded that there were no differences between the above mentioned root filling materials when using the fluid filtration model.[10, 11, 12] However, all these results were obtained either immediately after root filling or up to 3 months afterward. It is known from coronal application of dentine bonding systems that de-bonding can occur over time.[13] Furthermore, Resilon is biodegradable via enzymatic and alkaline hydrolysis.[14, 15] Paqué and Sirtes[16] reported that initially, Resilon/Epiphany root fillings prevented fluid movement to the same degree as gutta-percha/AH Plus counterparts, but showed more fluid movement when tested at 16 months. They also used the fluid filtration model described by Wu et al.[17] In a retrospective study of a total of 117 treated teeth, with recall times ranging from 2-25 months, teeth obturated with gutta-percha and Kerr Pulp Canal Sealer or Resilon and Epiphany sealer had statistically indistinguishable differences in clinical outcome.[18]

The decision to use Resilon and Epiphany in this case was based on the fact that these root filling materials may have the same clinical success rates as gutta-percha and AH Plus.

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Horizontal Root Fracture

Introduction

25 year old white Northern European male

Figure 1: Frontal view

Chief complaint

12 June 2008

Some tenderness and pus from maxillary right central incisor.

Medical history

Non-contributory, but daily usage of snuff tobacco.

Dental history

1990: The patient suffered trauma to tooth 11 after an accident. The tooth was displaced. According to the patient the loose fragment was put back in place and he did not receive any further treatment.

March 2008: The patient received emergency dental treatment because of pain and pus from tooth 11. The tooth was diagnosed with acute apical periodontitis. It was prescribed Apocillin® (phenoxymethylpenicillin). He was referred to the Department of Endodontics, UiO, for treatment and examination of tooth 11.

Clinical findings

12 June 2008

Figure 2: Lateral view with gutta-percha cone for tracing of sinus tract

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	12	11	21
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	2	5	2
Restoration	No	Comp. (M)	Comp. (M)

Table 1: Clinical findings

Soft tissue: Periodontal pockets within normal limits. Sinus tracts buccally and in the palatinal periodontal pocket tooth 11. Hyperkeratinized oral mucosa in the maxillary buccal fold. Good oral hygiene.

Dental:

Tooth 12: within normal limits
Tooth 11: composite filling on the mesial aspect of the crown, grey discoloration
Tooth 21: composite filling on the mesial aspect of the crown

Radiographic findings

12 June 2008

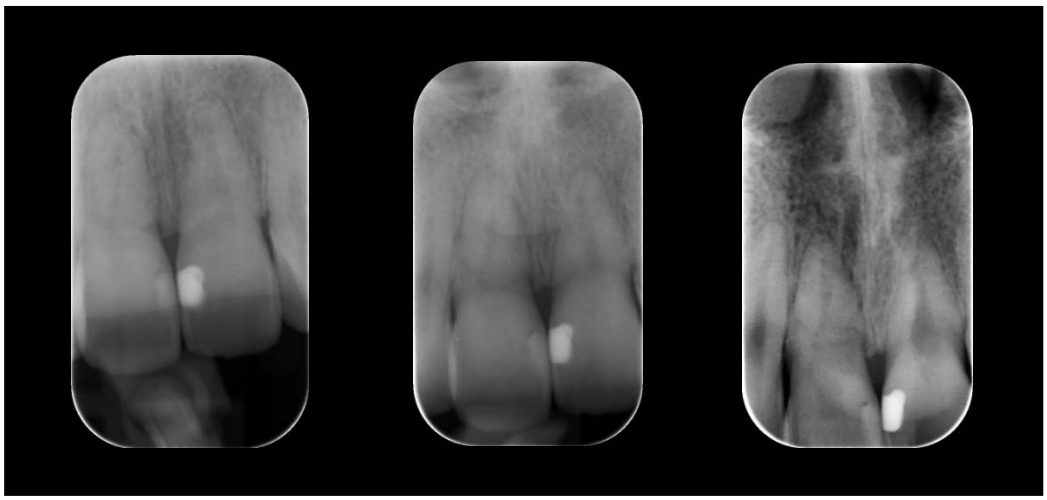

Figure 4: Periapical radiographs in three different vertical cone angulations which revile a horizontal root fracture of tooth 11.

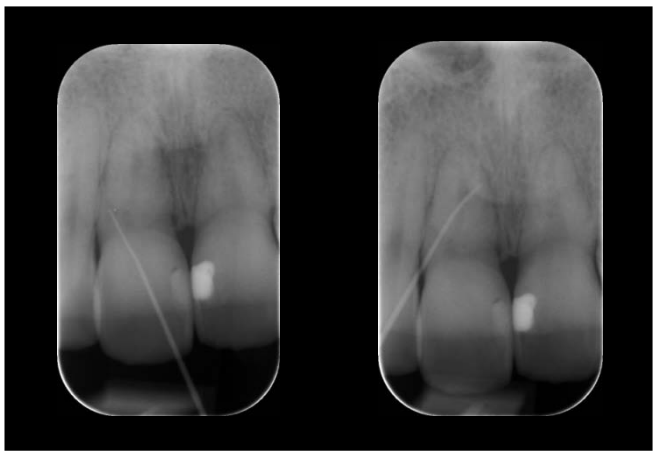

Figure 5a: Periapical radiograph with gutta-percha cone in buccal sinus tract

Figure 5b: Periapical radiograph with gutta-percha cone in palatinal sinus tract

Tooth 12: Normal lamina dura. No apical radiolucency. PAI 1. Normal marginal bone level.

Tooth 11: No apical or periradicular radiolucency. PAI 1. Coronal part of the root is obliterated. Small radiopaque filling material on the mesial aspect of the crown. Tracing radiograph shows that the gutta-percha cone ends buccally in the middle part of the root, and palatinally in the apical part of the root. The radiographs show a horizontal root fracture (in an oblique direction). Normal marginal bone level.

Tooth 21: No widening of the lamina dura. No apical radiolucency. PAI 1. Small radiopaque filling at the mesial aspect of the crown. Normal marginal bone level.

Diagnosis

Tooth 11:

Tooth: Horizontal root fracture (S02.5)
Pulpal: Necrotic (K04.1)
Periradicular: Periradicular abscess with sinus tract (K04.62)
Apical: Within normal limits
Marginal: Within normal limits

(Hyperkeratinized oral mucosa in the maxillary buccal fold from usage of snuff tobacco.)

Problem list

Horizontal (in an oblique direction) root fracture in the cervical (facial surface) and middle part (palatinal surface) of the root

Treatment plan

Orthograde endodontic treatment of non-vital pulp tooth 11

Treatment

12 June 2008

Clinical examination. Tooth 11 diagnosed with periradicular abscess with sinus tract. 1.0 ml Septocaine®. Preparation of access cavity and localization of root canal. The pulpal diagnose was altered to partial pulp necrosis, because there was vital pulp tissue in the middle and apical part of the root. Rubber dam using the split dam technique. OpalDam® was used to seal the rubber dam. Root canal length was determined by a radiograph. It was decided to also instrument the apical fragment of the root, because it was difficult to exactly decide where the root fracture was located. Root canal disinfection was done mechanically with Gates-Glidden burs, K-, Hedstroms-, and NiTi hand files to size:

One canal: R70/21 mm/incisal edge.

Figure 6: Working length radiograph

Irrisafe® used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

18 September 2008

The patient was asymptomatic from tooth 11. The tooth was not sensitive to palpation or percussion. Sinus tracts were no longer present. 1.0 ml Septocaine®. Rubber dam using the split dam technique. OpalDam® was used to seal the rubber dam. Removal of temporary filling. Root canal disinfection was done with 1% NaOCl and 17% EDTA. Ultrasonic irrigation was done with Irrisafe®. The canal was filled with grey MTA (Angelus, Brazil) with the use of the MAP-system®. A cotton pellet with saline water was placed on top of the MTA. IRM was used as a temporary filling.

Figure 7: Sinus tract is no longer present

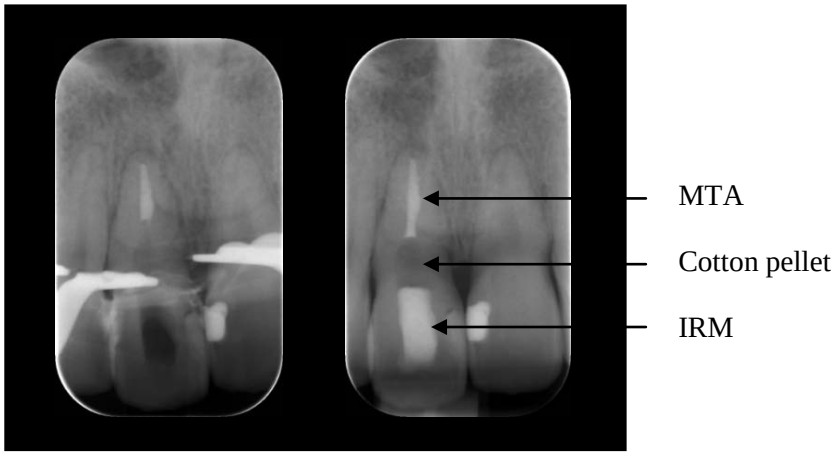

Figure 8: Periapical radiographs

25 September 2008

The patient was asymptomatic from tooth 11. The tooth was not sensitive to palpation or percussion. Rubber dam using the split dam technique. OpalDam® was used to seal the rubber dam. Removal of temporary filling and cotton pellet. An intra-coronal bleaching was performed (acid etch, sodium bicarbonate and H_2O_2). A temporary IRM filing was applied.

2 October 2008

Tooth 11 was less discolored than before the bleaching. The patient was satisfied with the result. A composite filling was placed on top of the MTA (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Flow (A3) in the apical part, Filtek™ Supreme (A3D and A2B) in the coronal part).

Figure 9: Post-treatment radiograph

Figure 10: Post-treatment frontal view

Result

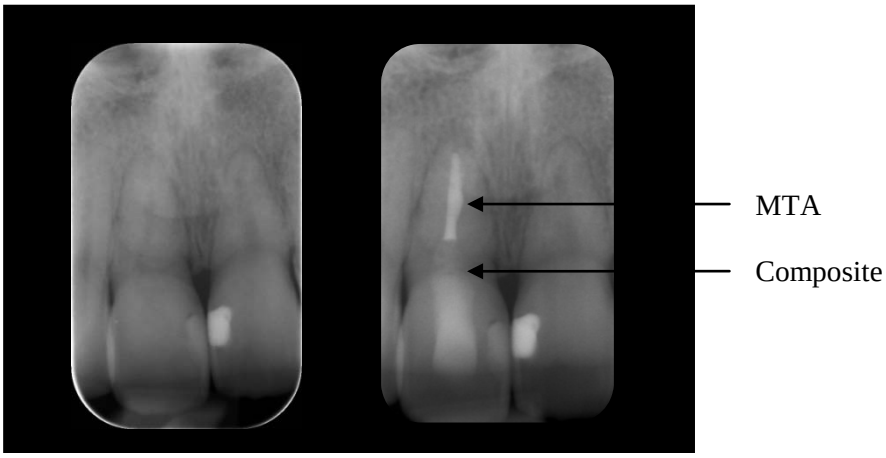

Figure 11: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root canal filling and composite filling appeared dense and good.

Prognosis

Endodontic: uncertain - because of coronal placement of the horizontal root fracture.
Tooth: uncertain - because of coronal placement of the horizontal root fracture.

Follow-up examination

31 March 2009 (six months after endodontic treatment)

Extra-oral examination: within normal limits

Intra-oral examination:

	12	11	21
Cold	Yes	No	Yes
Percussion	No	No	No
Palpation	No	No	No
Mobility	No	No	No
PPD (mm)	2	2	2
Restoration	No	Comp. (P and M)	Comp. (M)

Table 2: Clinical findings at follow-up examination

Soft tissue: Periodontal pockets within normal limits. A grey discoloration of the crown tooth 11 was present.

The periapical radiograph showed that the lamina dura continued around the entire root. No periradicular radiolucency was evident.

Figure 12: Periapical radiograph at follow-up examination

Figure 13: Frontal view at follow-up examination

Figure 14: Frontal view at follow-up examination

Discussion

Root fracture is defined as a fracture that involves the cementum, dentin and pulp. The incidence of root fractures is relative low, occurring in fewer than 3% of all dental injuries.[1] Incompletely formed roots with vital pulp rarely fracture horizontally.[2] When a root fractures horizontally, the coronal segment is displaced to a varying degree, but generally the apical segment is not displaced. Because the apical pulpal circulation is not disrupted, pulp necrosis in the apical segment is extremely rare. Pulp necrosis of the coronal segment results because of its displacement and occurs in about 25% of cases.[3, 4, 5] Clinical presentation of root fractures is similar to that of luxation injuries. The extent of displacement of the coronal segment usually indicates the location of the fracture and can vary from none (apical fracture), to severe (cervical fracture). Radiographic examination of root fractures is important, because a root fracture is usually oblique (facial to palatal). It is important to take three radiographs with different vertical cone angulations.

Emergency treatment of root fractures involves repositioning of the segments in as close proximity as possible and splinting to adjacent teeth for 2 to 4 weeks.[6]

Andreasen and Hjørting-Hansen[7] have described four types of healing of root fractures:

1. Healing with calcified tissue
2. Healing with interproximal connective tissue
3. Healing with interproximal bone and connective tissue
4. Interproximal inflammatory tissue without healing

The first three types of healing patterns are considered successful. The fourth type of healing pattern is typical when the coronal segment loses is vitality. The infective product in the coronal pulp causes an inflammatory response and typical radiolucencies in the fracture line.[7]

Treatment of complications with root fractures is dependent on the site of the fracture. Historically, fractures in the cervical segment were considered to have a poor prognosis and extraction of the coronal segment was recommended. Research does not support this treatment; in fact, if these coronal segments are adequately splinted, chances of healing do not differ from those associated with mid-root and apical fractures.[1] If reattachment of the fractured segments is not possible, extraction of the coronal segment is indicated. Pulp necrosis occurs in 25% of root fractures, with a vast majority in the coronal segment with vitality in the apical segment. Endodontic treatment is therefore only indicated in the coronal root segment unless periapical pathosis is seen in the apical segment. In most cases the pulpal lumen is wide at the apical extent of the coronal segment so that long-term calcium hydroxide treatment or an MTA apical plug is indicated.

The prognosis in this case is uncertain because the horizontal root fracture is in the cervical segment of the root. The patient was informed of the prognosis and that a dental implant is a possible treatment option in the further.

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Warm Vertical Compaction of Gutta-Percha

Introduction

21 year old white Northern European female

Figure 1: Frontal view

Chief complaint

21 February 2008

Brown colored maxillary right central incisor. Referred to the Department of Endodontics, UiO, from the Department of Prosthodontics, UiO, for examination and treatment of tooth 11.

Medical history

Epilepsy from age 5 to 16 years
Smokes more than 20 cigarettes per day
In 12th week of pregnancy

Dental history

1994: Trauma to tooth 11 and 21 during an epileptic seizure (at eight years of age).
1998: Tooth 21: root canal treatment completed.
2007: March: Root canal treatment of tooth 11 (instrumentation and $Ca(OH)_2$-dressing).
August: Diagnosed root fracture tooth 21. Referred to the Department of Prosthodontics, University of Oslo for treatment and replacement of tooth 21.
December: extraction of tooth 21 – spoon denture as a temporary replacement. Awaiting single-tooth implant 21.

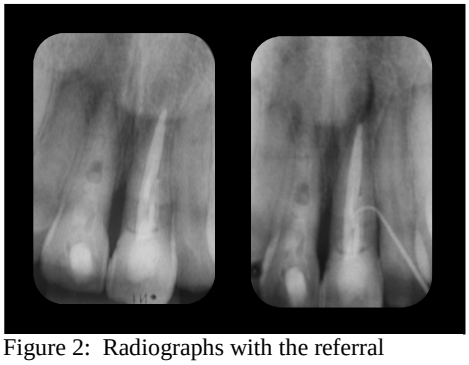

Figure 2: Radiographs with the referral (November 2007)

Clinical findings
21 February 2008


Figure 3: Frontal view


Figure 4: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	12	11	21	22
Cold	Yes	No	-	Yes
Percussion	No	Yes	-	No
Palpation	No	No	-	No
Mobility	No	No	-	No
PPD (in mm)	2	4	-	2
Restoration	No	P (IRM)	-	No

Table 1: Clinical findings

Soft tissue: General gingival bleeding on probing. Poor oral hygiene.

Dental:
Tooth 12: within normal limits
Tooth 11: temporary filing on the palatinal aspect
Tooth 21: missing
Tooth 22: within normal limits

Radiographic findings
21 February 2008

Tooth 11: Discontinued lamina dura apically. Apical radiolucency (Ø 5 mm). PAI 3. Diffuse radiopaque material in wide root canal. Radiopaque filling in the crown. Some reduced marginal bone level on the mesial aspect.

Tooth 21: missing


Figure 5: Periapical radiograph

Diagnosis

Tooth 11:

Pulpal: Necrosis (K04.1)

Apical: Chronic apical periodontitis (K04.5)

Marginal: Within normal limits

Problem list

Open apex
Wide root canal
Brown colored crown
Apical periodontitis

Treatment plan

Treatment of non-vital pulp 11
$Ca(OH)_2$-treatment for at least two weeks
Crown-root reinforcement with composite filling

Treatment

21 February 2008

Clinical examination. Tooth 11 diagnosed with chronic apical periodontitis. 1.8 ml mepivacaine. Access cavity preparation extended to include the whole of the pulp chamber without any undermined dentin. Rubber dam. There was a perforation apically from previous instrumentation. Root canal length was determined by apex locator (Root ZX®). Root canal disinfection was done mechanically with SS-, Hedstroms- and NiTi hand files to size: One canal: R90/24 mm/incisal edge.
Irrisafe® was also used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

Figure 6: Working length radiograph

6 March 2008

The patient presented with no symptoms from tooth 11. Clinical examination showed no percussion or palpation sensitivity from the tooth. The canal was irrigated and dried with paper points. Grey Mineral Trioxide Aggregate (MTA) (Angelus, Brazil) was applied with MAP-system®, as an apical barrier to prevent extrusion of gutta-percha during root canal filling (approximately 1 mm thick). AH Plus was applied to the canal walls. The obliteration was performed with warm vertical compaction of gutta-percha. SybronEndo Elements Obturation Unit® in conjunction with Buchanan hand pluggers were used for this purpose. The pulp chamber was cleaned and dried. In the coronal part the canal composite was used (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Flow (A3) in the apical part, Filtek™ Supreme XT (A3D and A3B) in the coronal part). Intra-canal bleaching was not performed.

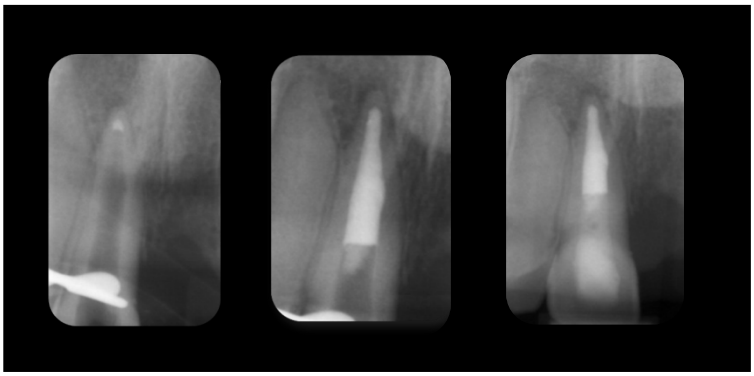

Figure 7: Apical MTA-plug

Figure 8: Warm vertical compacted gutta-percha

Figure 9: Final radio-graph

Result

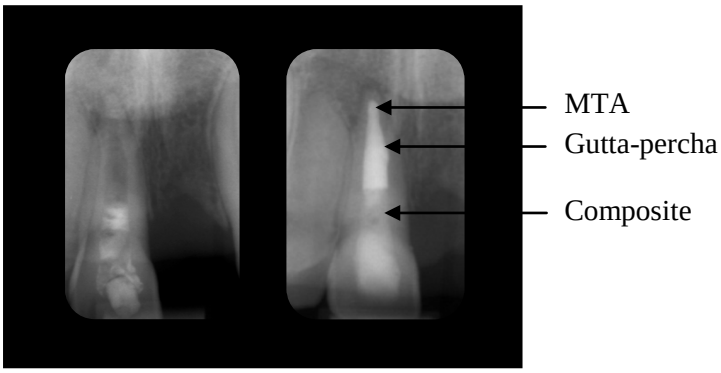

Figure 10: Pre- and post-treatment radiographs

Figure 11: Pre-treatment frontal view

Figure 12: Post-treatment frontal view

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: good

Tooth: uncertain - because of thin root canal walls and a higher risk of tooth fracture

Follow-up examination

6 January 2009 (ten months after endodontic treatment)

No symptoms. Tooth 11was an abutment for a Maryland bridge from tooth 11 to tooth 22 for replacement of tooth 21. A dental implant for replacement of tooth 21 was planned when the patient reaches the age of 25 years.

The radiograph showed evidence of healing.

The clinical examination revealed a vertical infraction line in the crown of tooth 11. There was a periodontal probing depth of 2 mm at the buccal aspect of the tooth 11. The crown of tooth 11 was discolored (brown).

Figure 13: Follow-up periapical radiograph

Figure 14: Frontal view at follow-up examination

Figure 15: Frontal view at follow-up examination

Figure 16: 2 mm periodontal probing depth

Figure 17: Trans-illumination showed a vertical infraction in the crown of tooth 11

Discussion

Schilder[1] described in a classic article the vertical compaction technique as an alternative to lateral compaction. This technique was based on a single cone adaptation and compaction, followed by additional segments of gutta-percha, a technique previously described by Berg.[2] There has been many studies on comparison of canal wall adaptability and microleakage between lateral compaction and warm gutta-percha/vertical compaction. Brothman[3]found "no statistically significant difference in filling efficiency," but found that more accessory canals were filled with sealer using vertical compaction. Torabinejad and coworkers[4] compared multiple obturation techniques and found that all gave favorable results, but the vertical method resulted in closer adaptation to the canal walls in the middle and apical thirds. I a study that compared homogeneity/replication of canal walls using chloropercha, lateral compaction, and warm gutta-percha vertical compaction without sealer, found that the best results with the latter technique.[5] With regard to microleakage, Brenner et al.[6] used radioisotopes to study the difference in three obturation methods, including warm gutta-percha/vertical compaction and found no significant differences. In a study by a Toronto group[7] the proportion of healed teeth with initial apical periodontitis treated with the classic Schilder technique - flared canal preparation with ample irrigation and root filling with vertically-compacted warm gutta-percha-is significantly higher than (10% difference) than in teeth treated with step-back or modified step-back instrumentation and lateral compaction of gutta-percha. This study was not a randomized clinical trial. I the re-treatment study of the Toronto Study series[8], the difference in healing between the same two techniques was smaller and not significant. In a meta-analysis by Peng et al.[9] where they compared warm vertical compaction and cold lateral compaction with gutta-percha, they ended up with evaluating 10 studies. They concluded that warm vertical gutta-percha obturation demonstrated a higher rate of overextension than cold lateral condensation, and that postoperative pain prevalence, long-term outcomes, and obturation quality were similar between the two groups.

In this case warm vertical compaction of gutta-percha was used because of better adaptation of the material against irregular canal walls than cold lateral condensation, and to prevent high loads on dentin during lateral condensation.

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Apical MTA Barrier

Introduction

66 year old white Northern European male
(No clinical photos available from the examination.)

Chief complaint

5 November 2007

Horizontal crown fracture of the maxillary left lateral incisor. Some pain from the maxillary left lateral incisor for the last two of years.
Sought dental treatment for horizontal crown fracture of tooth 22 at private dental office, Hønefoss, Norway.

Medical history

Non-contributory

Dental history

Tooth 22: Root canal treatment 30 years ago.

23 June 1977

Teeth 21 and 22: No sensitivity and radiographs showed a large lesion.
Root canal treatment of teeth 21 and 22.

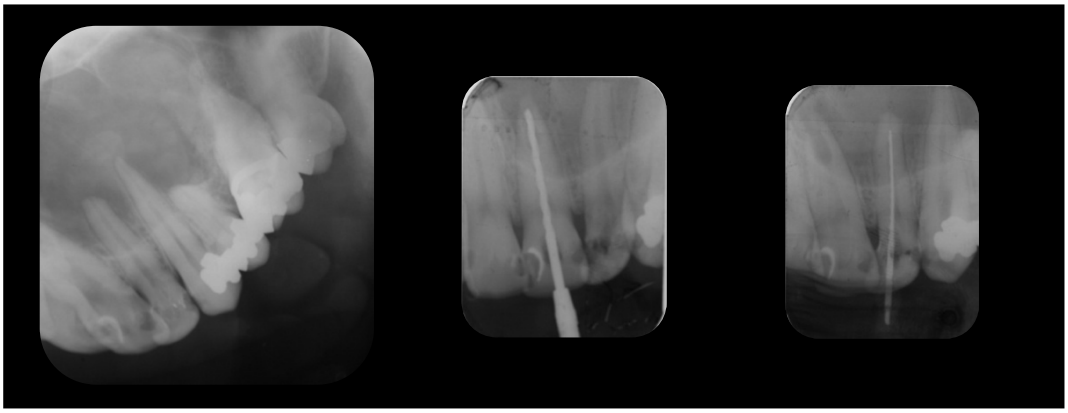

Figure 1: Occlusal radiograph

Figure 2: Working length radiograph tooth 21

Figure 3: Working length radiograph tooth 22

August 1977

Referred to Ullevål hospital, Oslo, from general dentist, because of buccal sinus tract from tooth 22 and large radiolucency from teeth 21 to 24.

18 August 1977

Removal of maxillary cyst. During the operation a wide opening was detected between the maxillary sinus and the cyst. The cyst was not in contact with the root of tooth 23.
Root amputations performed on teeth 21 and 22.

December 1978

Negative sensitivity test on tooth 23. Root canal treatment was performed on tooth 23 (Fig. 4).

December 1983

Pain from area of the left fossa canina.

Diagnosed with polypous sinus maxillaries, and there was performed an enucleation of cyst from the mucosa in the maxillary left sinus. Tooth 24 had undergone root canal treatment between 1978 and 1983.

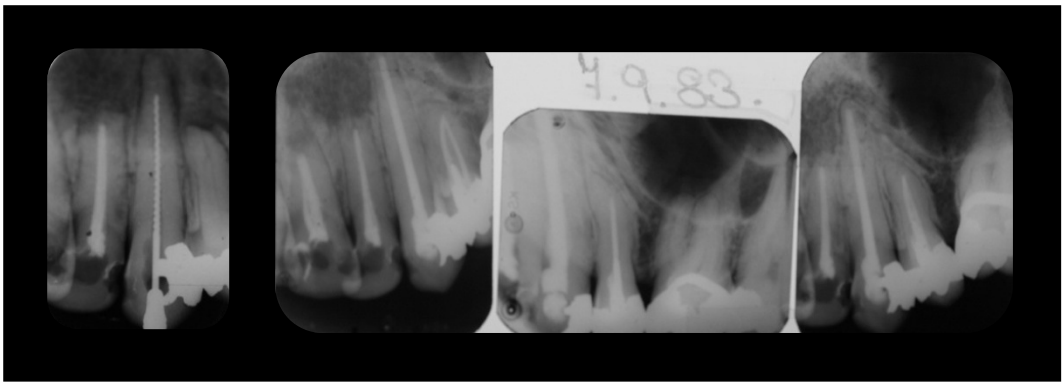

Figure 4: Working length radiograph tooth 23 (December 1978)

Figure 5: Periapical radiographs from September 1983

Patient chart showed no symptoms in 1992, 1996 (Fig. 6) and 2005 (Fig. 7) from teeth 21 and 22 .

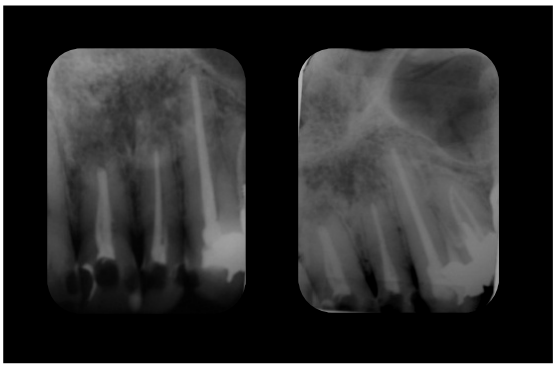

Figure 6: Periapical radiographs taken in 1996

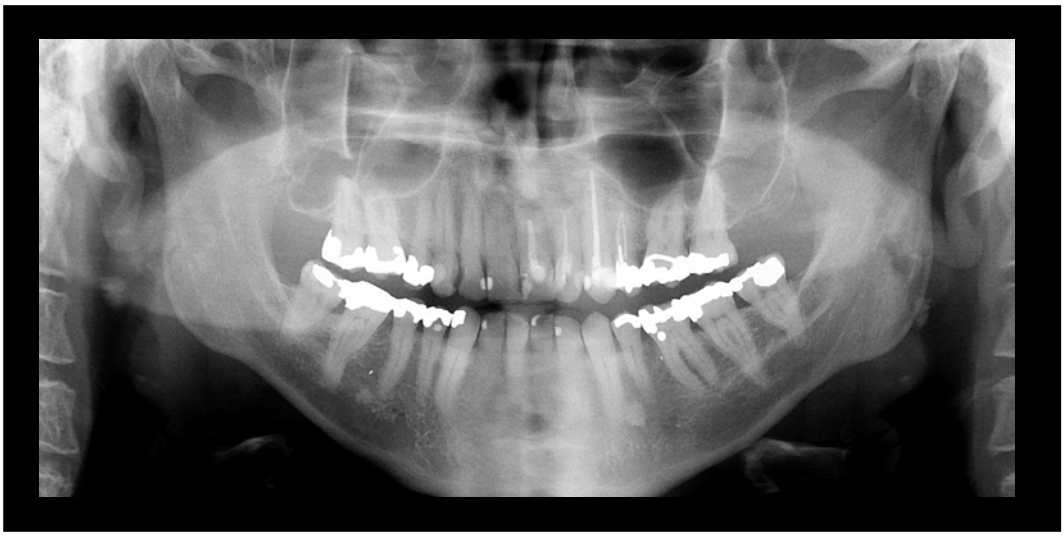

Figure 7: OPG taken in 2005

Clinical findings

5 November 2007

Extra-oral examination: within normal limits

Intra-oral examination:

	21	22	23
Cold	No	No	No
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	2	2	3
Restoration	Comp. (MI, D)	-	Comp. (DP) and amalgam (M)

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 21: composite restoration on the mesial, distal and incisal aspects of the crown
Tooth 22: horizontal crown fracture 2 mm over the gingival margin.
Tooth 23: composite restoration on the distal and palatinal aspects of the crown and amalgam restoration on the mesial aspect of the crown

Radiographic findings

5 November 2007

Tooth 21: Normal lamina dura. No apical radiolucency. Radiopaque material on the mesial, occlusal and distal aspects of the crown. Root canal filled. Short root. Normal marginal bone level.

Tooth 22: Diffuse lamina dura. Horizontal crown fracture. Short root. Normal marginal bone level.

Figure 8: Periapical radiograph

Diagnosis

Tooth 22

Pulpal: Root filled (K04.19)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Prior apicoectomy
Wide apical foramen

Treatment plan

Root canal retreatment of tooth 22

Treatment

5 November 2007

Clinical examination. Tooth 22 diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Access cavity preparation. Localized one canal. Rubber dam. Root canal length was determent by a radiograph. Root canal retreatment and disinfection was done mechanically with Gates-Glidden burs, Hedstroms- and SS hand files to size:
One canal: R90/15.0 mm/incisal edge.
1% NaOCl and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling and a temporary crown was made and cemented with Nobetec®.

Figure 9: Working length radiograph

16 November 2007

Patient had no percussion or palpation sensitivity from tooth 22. 1.0 ml Septocaine®. Rubber dam. 1% NaOCl and 17% EDTA were used for cleaning of the canal. Grey MTA (Angelus, Brazil) was used as root filling material. A cotton pellet with saline water was placed over the MTA. IRM was applied as a temporary filling and the temporary crown was attached with Nobetec®.

Figure 10: MTA in the root canal

30 November 2007

The patient was asymptomatic. No palpation or percussion sensitivity from tooth 22. Rubber dam applied. Removal of temporary crown, IRM and cotton pellet. Composite filling (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Flow (A3) in the apical part, Filtek™ Z250 (A2B) in the coronal part).

4 January 2008

Placement of a porcelain fused to metal crown. The patient was asymptomatic and had no sensitivity when palpation and percussion tests were performed on tooth 22.

Figure 11: Frontal view after placement of crown tooth 22

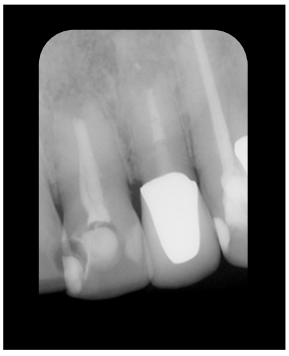

Figure 12: Post-operative periapical radiograph

Result

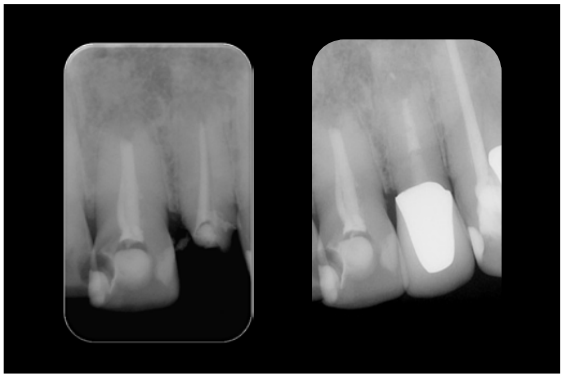

Figure 13: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root filling appeared adequate.

Prognosis

Endodontic: good

Tooth: uncertain - because of thin root canal walls and a higher risk of tooth fracture

Follow-up examination

13 March 2009 (14 months after endodontic treatment)

The patient was asymptomatic from tooth 22. No palpation or percussion sensitivity from tooth 22.

The radiograph showed no definite signs of apical periodontitis.

Figure 14: Periapical radiograph at follow-up examination

Discussion

Mineral trioxide aggregate (MTA) was developed by Torabinejad et al.[1] in the early 1990s, mainly as a root-end filling material. The main constituents of this material are calcium silicate ($CaSiO_4$), bismuth oxide (Bi_2O_3), calcium carbonate ($CaCO_3$), calcium sulfate ($CaSO_4$), and calcium aluminate ($CaAl_2O_4$). Hydration of the powder produces a colloidal gel that solidifies into a hard structure consisting of discrete crystals in an amorphous matrix. The crystals are composed of calcium oxide, and the amorphous region is composed of 33% calcium, 49% phosphate, 2% carbon, 3% chloride, and 6% silica.[2] Initially MTA has a pH of 10.2, which rises to 12.5 three hours after mixture.[2] The pH has been reported to be approximately 9.5 at 168 hours after mixing.[3] MTA is less cytotoxic than amalgam, Super-EBA, or IRM root-end fillings.[4] Endodontic surgery studies in dogs and monkeys have reported less periradicular inflammation and cementum deposition immediately adjacent to the

root-end filling material.[5, 6, 7] Holland et al.[8, 9] theorized that the tricalcium oxide in MTA reacts with tissue fluids to form calcium hydroxide, resulting in hard-tissue formation. When MTA has been tested in various in vitro leakage models, MTA prevented leakage as well as composite resin and GIC.[10, 11, 12, 13] However, the setting and subsequent leakage of MTA are not affected by the presence of blood.[14]

A study[15] of various thickness of MTA used as root-end filling has shown that 4 mm was significantly more effective than lesser amounts in preventing dye leakage.

Recently, a variation of the original formula of grey MTA was introduced. This material, which is white cream color, is often called white MTA. The chemical composition of white MTA is very similar to that of the original. White and grey ProRoot MTA® materials differ by less than 6% in any one component. When white MTA was implanted in the subcutaneous connective tissue of rats, the results were similar to those reported for grey MTA.[16]

There are two products available on the market: ProRoot® (ProRoot MTA; Dentsply) and MTA-Angelus® (Angelus; Prod. Odont. Ltda, Londrina, PR, Brazil). It was recently demonstrated that the composition, as well as, particle size and shape of these materials are different.[17, 18, 19, 20, 21] MTA-Angelus® has no addition of calcium sulfate to reduce setting time (2 hours for ProRoot MTA® and 15 minutes for MTA-Angelus®) According to Duarte et al.[3], the pH of MTA-Angelus® is higher than that of ProRoot®; whether or not this has any effect on the performance of these materials in pulp healing is yet to be addressed.

In this case MTA was used to create an apical barrier. Because of short root no gutta-percha or other root filling materials was used.

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Dens Invaginatus

Introduction

15 year old white Northern European female

Figure 1: Frontal view

Chief complaint

28 February 2008

Some lingering pain from maxillary left lateral incisor. Referred from endodontic specialist to the Department of Endodontics, UiO, for examination and treatment of tooth 22.

Medical history

Born with unilateral (sinister) cleft lip and palate.

Dental history

Born with unilateral cleft lip and palate.

Tooth 22:

Impacted (K01.1). Orthodontically treated.

Treatment at the Department of Odontology, Rikshospitalet, Oslo.

Porcelain crown November 2007.

Referred to endodontic specialist in Tromsø, because of apical periodontitis.

Figure 2: Periapical radiograph taken at referring endodontic specialist

Clinical findings

28 February 2008

Figure 3: Frontal view

Figure 4: Frontal view

Extra-oral examination: Visible scar on the upper lip. No further findings.

Intra-oral examination:

	21	22	23
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	2	2	2
Restoration	No	Porcelain crown	No

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 21: composite fixed retainer
Tooth 22: porcelain crown – composite fixed retainer
Tooth 23: within normal limits

Radiographic findings

28 February 2008

Tooth 21: Normal lamina dura. No apical radiolucency. Composite fixed retainer. Normal marginal bone level.

Tooth 22: Broken lamina dura. Apical radiolucency (Ø 11 mm). Dens invaginatus. Porcelain crown. Composite fixed retainer. Normal marginal bone level.

Tooth 23: Normal lamina dura. No apical radiolucency. Normal marginal bone level.

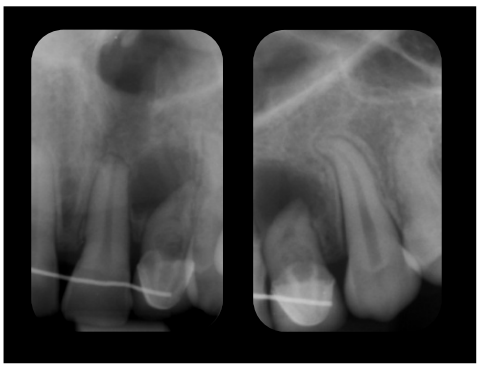


Figure 5: Periapical radiographs tooth 22

Patient referred to The Department of Oral Radiology, UiO, for CT-scan of tooth 22.

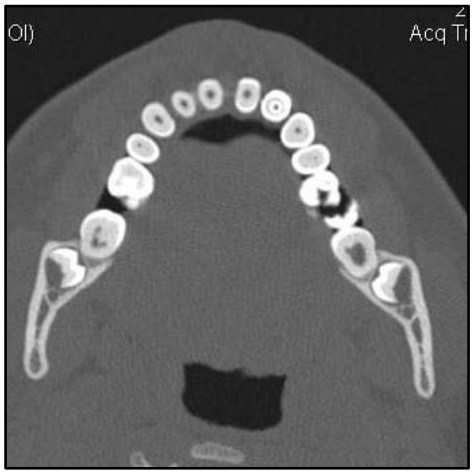


Figure 6: Axial CT-image in the coronal parts of maxillary teeth

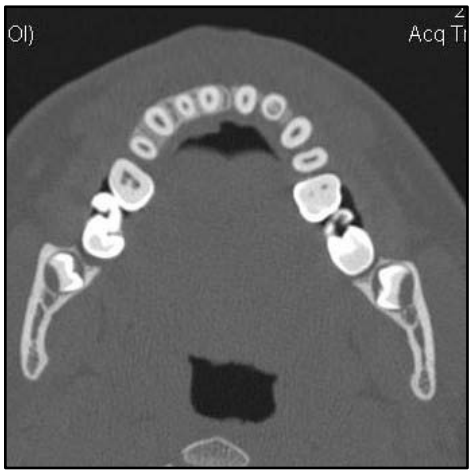


Figure 7: Axial CT-image in the level of the marginal bone crista

Figure 8: Axial CT-image in the apical parts of maxillary teeth. Note the cortical bone breakdown around the apex of tooth 22

Figure 9: Axial CT-image in the level of the palatoschisis

Figure 10: Axial CT-image in the apical parts of maxillary teeth with the direction for the saggital image (fig. 11)

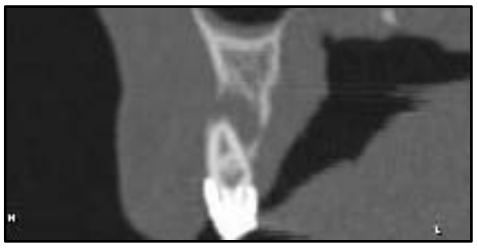
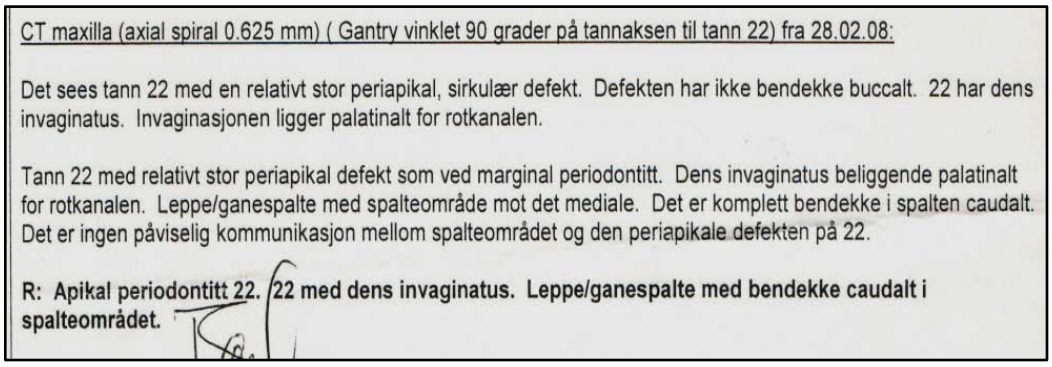


Figure 11: Saggital CT-image of tooth 22



CT maxilla (axial spiral 0.625 mm) (Gantry vinklet 90 grader på tannaksen til tann 22) fra 28.02.08:

Det sees tann 22 med en relativt stor periapikal, sirkulær defekt. Defekten har ikke bendekke buccalt. 22 har dens invaginatus. Invaginasjonen ligger palatinalt for rotkanalen.

Tann 22 med relativt stor periapikal defekt som ved marginal periodontitt. Dens invaginatus beliggende palatinalt for rotkanalen. Leppe/ganespalte med spalteområde mot det mediale. Det er komplett bendekke i spalten caudalt. Det er ingen påviselig kommunikasjon mellom spalteområdet og den periapikale defekten på 22.

R: Apikal periodontitt 22. 22 med dens invaginatus. Leppe/ganespalte med bendekke caudalt i spalteområdet.

Figure 12: Answer from specialist in oral radiology, UiO (in Norwegian)

Translation of answer from CT-scan:

CT maxilla:

Tooth 22 is seen with a relatively large periapical, circular lesion. The lesion has no buccal bone coverage. Tooth 22 has dens invaginatus. The invagination is placed palatinal to the root canal.

Tooth 22 with a relative large periapical lesion like that of marginal periodontitis. Dens invaginatus placed palatinally to the root canal. Cleft lip and palate with column area against the medial aspect. There is compact bone coverage in the column caudally. There is no shown communication between the column and the periapical lesion tooth 22.

R: Apical periodontitis tooth 22. Tooth 22 with dens invaginatus. Cleft lip/palate with bone lesion caudally in the column area.

Diagnosis

Tooth 22:
Dens invaginatus (K0.02)
Pulpal: Necrosis (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Dens invaginatus
Porcelain crown

Treatment plan

Treatment of non-vital pulp 11
Long-term $Ca(OH)_2$-treatment
Root filling with MTA

Treatment

28 February 2008

Clinical examination including CT-scan of tooth 22. Tooth diagnosed with apical abscess without sinus tract. 1.8 ml Septocaine®. Preparation of access cavity, with removal of palatinal composite fixed retainer. An enamel barrier around 11 mm for the incisal edge of the crown was present in the apical part of the pulp chamber (Fig. 14). Rubber dam applied using a split dam technique and sealed with OralDam®. Enamel in the apical part of the pulp chamber was removed using LN-burs and diamond coated ultrasonic tips.

Root canal length was determined by apex locator (Root ZX®). Root canal disinfection was done mechanically with Hedstroms- and NiTI hand files to size:
One canal: R60/16 mm/incisal edge.
Ultrasonic tips (Irrisafe® and diamond coated) were also used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

Figure 13: Working length

Figure 14: Enamel-barrier in the apical part of the access cavity

Figure 15: $Ca(OH)_2$-dressing applied

26 March 2008

Change of $Ca(OH)_2$-dressing at referring endodontic specialist in Tromsø, Norway.

9 June 2008

Change of $Ca(OH)_2$ intra-canal dressing at referring endodontic specialist in Tromsø, Norway. Signs of healing are evident on radiograph (Fig 16).

Figure 16: Periapical radio-graph (June 2008)

11 September 2008

Radiograph showed evidence of healing of the apical lesion tooth 22.
The patient had no clinical signs or symptoms.1.8 ml Septocaine®. Rubber dam applied using a split dam technique. $Ca(OH)_2$-dressing removed with 1% NaOCl and 17% EDTA in conjunction with Irrisafe®. Grey Mineral trioxide aggregate (MTA) (Angelus, Brazil) was applied with the MAP-system® in the apical third of the tooth. The MTA was allowed to set for 15 minutes with the use of a wet cotton pellet. IRM was applied in the mid part of the tooth. A composite filling was applied in the coronal part of the tooth

(etch, 3M Adapter, 3M Filtek Flow (A3), 3M Filtek Supreme (A3D and A3B)). The filling was polished.

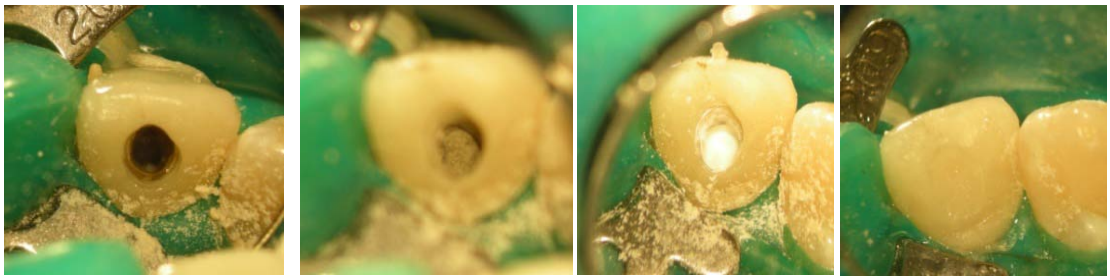


Figure 17: A - Canal prepared B- MTA C – IRM D – Composite filling

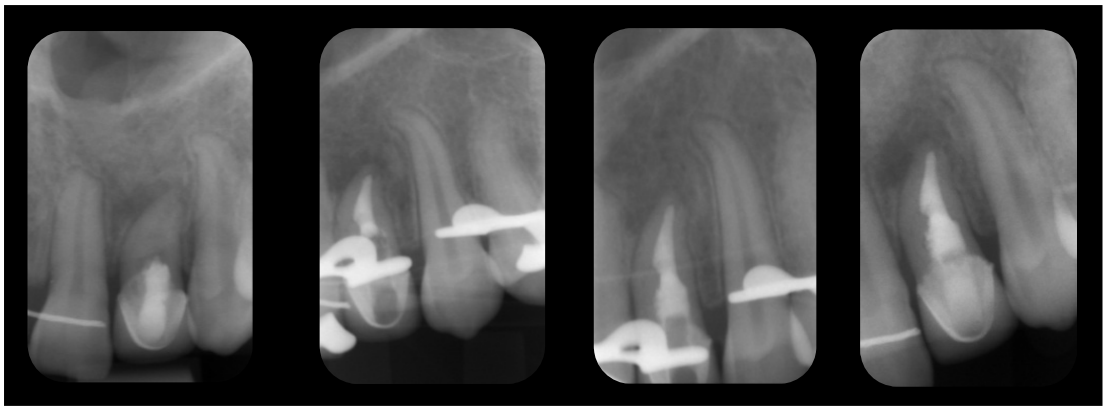


Figure 18: A - Evidence of healing B – MTA C – IRM D – Composite filling

Figure 19: Frontal view

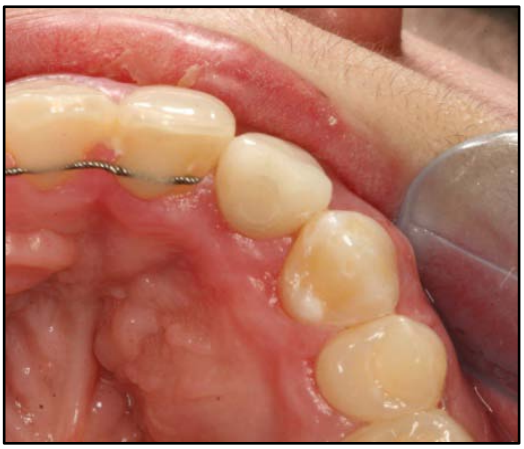


Figure 20: Occlusal view

Result

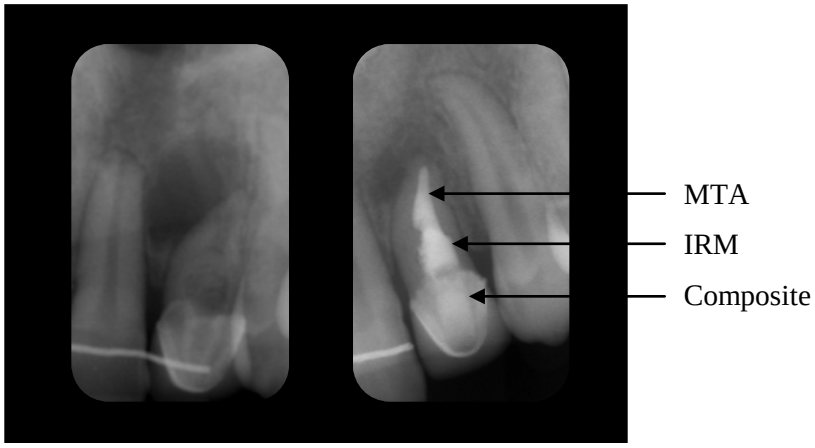


Figure 21: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: good

Tooth: uncertain - because of thin root canal walls and a higher risk of tooth fracture

Follow-up examination

25 March 2009 (six months after endodontic treatment)

The patient was free of symptoms. Tooth 22 was not sensitive to percussion or palpation tests.

The periapical radiograph showed complete healing of the apical periodontitis with intact lamina dura around the entire root (Fig. 22).

(Follow-up examination done by specialist in endodontics in Tromsø, Norway)

Figure 22: Periapical radiograph at follow-up examination

Discussion

Dens invaginatus has been defined as a defect in tooth development, characterized by invagination of the enamel organ before the calcification phase.[1] Other names for this type of malformation are dens in dente, invaginated odontoma, dilated gestant odontoma, dilated composite odontoma, tooth inclusion, and dentoid in dente.[2]

Socrates in 1856 was the first to report a dens in dente in human teeth.[3] Several theories have illustrated the etiology of dens invaginatus, however at the present time they remain unclear. Kronfeld[4] speculated that dens invaginatus is caused by a failure in growth of the internal dental epithelium while at the same time there is also a proliferation of the surrounding normal epithelium, producing a static area of engulfing. Oehlers[5] considered that the distortion of the enamel organ during tooth development and the subsequent protrusion of a part of this can lead to a formation of a lineal enamel canal that ends at the cingulum and in some cases at the incisal border, producing an irregular crown shape.

The incidence of dens invaginatus has been reported to be in a range of 0.04% and 10%,[6.7] with the upper lateral incisors the teeth most commonly involved. Isolated cases have been reported in the mandibular region and in the deciduous dentition.

Dens invaginatus has been classified into the following 3 types according to the depth of the invagination and the degree of communication with the periodontal ligament or the periradicular tissue (Fig. 23).[5]

• Type I: invagination confined inside the crown, not extending beyond the cementum enamel junction (CEJ).

• Type II: invagination extending beyond the CEJ, it may or may not communicate with the pulp and not reach the periradicular tissue.

• Type III (D and C according to Oehlers classification): invagination extending beyond the CEJ penetrating the root and exhibiting a second foramina in the apical third within the periradicular tissue.

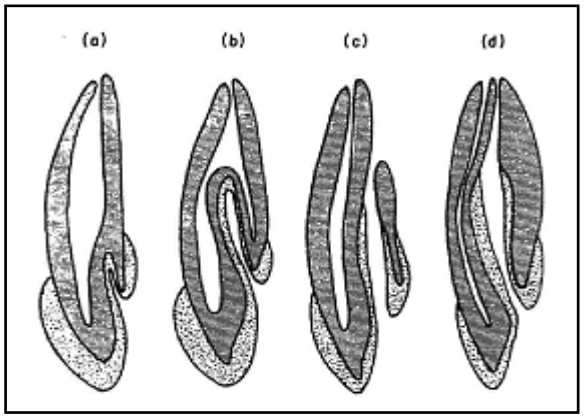


Figure 23: Classification of invaginated teeth by Oehlers (1975)

Most cases of dens invaginatus are detected after a routine radiographic evaluation with a panoramic x-ray and confirmed with a periapical film. Clinically, a morphologic alteration of the crown or a deep foramen coecum can serve as an indication for the diagnosis of dens invaginatus. On the other hand, the main reasons for consultation are acute pain and inflammation. Histological, fragile hypomineralized enamel is frequently seen at the site of the invagination; this condition facilitates the formation of dental caries and the penetration of microorganisms from the saliva directly into the pulp, leading to pulp necrosis and the development of a periradicular inflammatory process.[2]

Several treatment modalities have been described for these teeth, all of them related to the degree of complexity of its anatomy. They include nonsurgical endodontic treatment,[8]endodontic surgery,[9] intentional replantation,[9] and finally extraction.[10] In cases in which there is an immature apex, the use of calcium hydroxide inside the root canal has been proposed to stimulate apexification.[11]

Witherspoon and Ham[12] have described an apical closure technique in a single appointment using mineral trioxide aggregate (MTA) in teeth with pulp necrosis and immature apex, reporting it as an alternative to the traditional apexification technique with calcium hydroxide. Other authors also have reported clinical success with the apical closure technique with MTA.[13, 14 , 15]

In this case the dens invaginatus was likely a type II invagination, because only one foramen was found during the treatment.

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Apical Abscess in the Mandible

Introduction

16 year old white Northern European male

Figure 1: Frontal view

Chief complaint

7 June 2007

Lingering pain from left side of the mandible. Multiple prescriptions with antibiotics last three years, because of pain from left side of the mandible.

Medical history

Non-contributory

Dental history

2000: Trauma against anterior mandible. Luxation of teeth 31 and 41.
2002: Endodontic treatment of tooth 31.
Nov 2006: Started endodontic treatment of teeth 32 and 41 at general dentist for acute abscess in the anterior part of the mandible. The patient has had multiple treatments with Apocillin since November 2006.
March 2007: Referred to the Department for Oral Surgery, UiO, for examination and treatment of abscess in the mandible. After examination at the Department for Oral Surgery, including a CT-scan of the mandible, a tentative diagnose was osteomyelitis in the mandible. The patient was referred to the Department of Endodontics, UiO, for endodontic treatment of teeth 31, 32 and 41.

Clinical findings

7 June 2007

Figure 2: Facial view

Figure 3: Occlusal view

Extra-oral examination: elevation of the skin in the left anterior part of the mandible.

Intra-oral examination:

	42	41	31	32	33	34
Cold	Yes	No	No	No	Yes	Yes
Percussion	No	Yes	Yes	Yes	Yes	No
Palpation	No	Yes	Yes	Yes	Yes	No
Mobility	No	No	No	No	No	No
Pocket (mm)	2	2	2	2	2	2
Restoration	No	IRM (L)	Comp. (L)	IRM(L)	No	No

Table 1: Clinical findings

Soft tissue: Dolor of the oral mucosa in the buccal fold area of teeth 31 and 32

Dental:

Tooth 42: within normal limits
Tooth 41: IRM restoration on the lingual aspect
Tooth 47: composite restoration on the lingual aspect
Tooth 32: horizontal enamel-dentin crown fracture, IRM restoration on the lingual aspect
Tooth 33: within normal limits
Tooth 34: within normal limits

Radiographic findings

7 June 2007

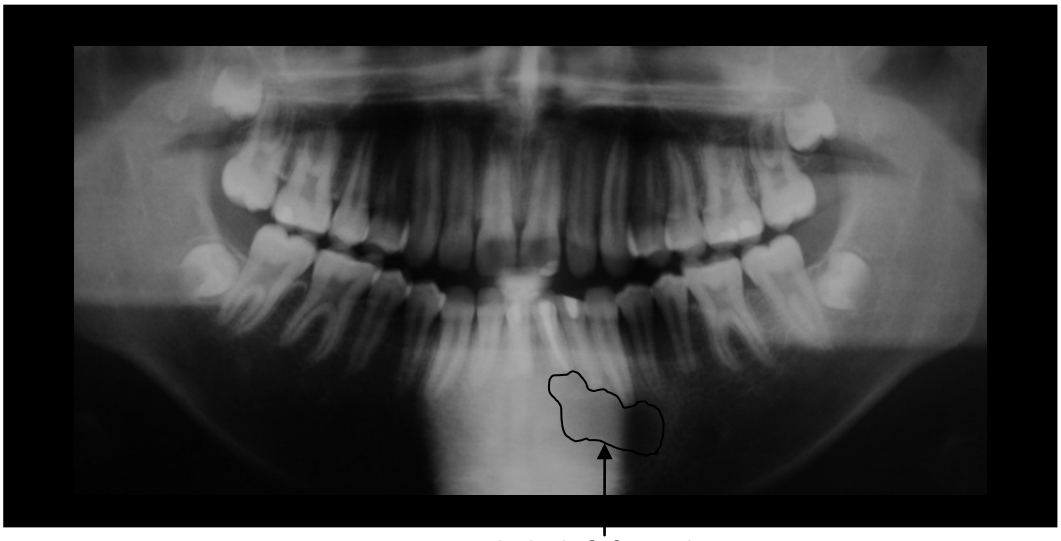

Figure 4: OPG (radiolucency)

Figure 5: Axial CT-image in the inferior part of the mandible

Figure 6: Axial CT-image 1.3 mm superior to the section in Fig. 5

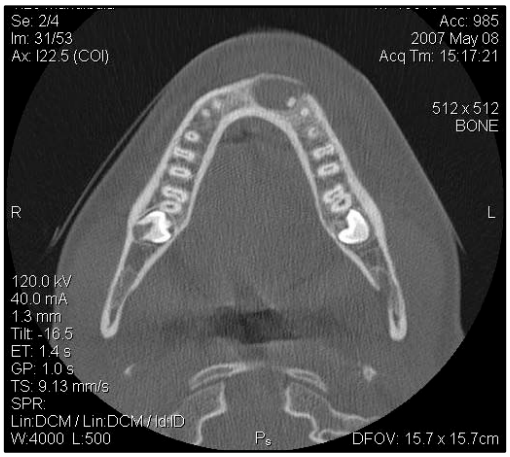

Figure 7: Axial CT-image 1.3 mm superior to the section in Fig. 6

Figure 8: Axial CT-image 1.3 mm superior to the section in Fig.7

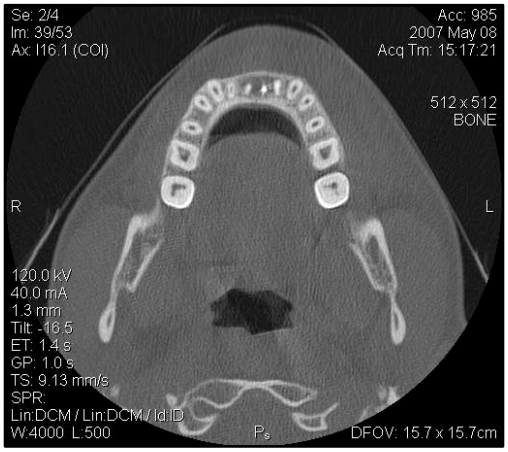

Figure 9: Axial CT-image 1.3 mm superior to the section in Fig. 8

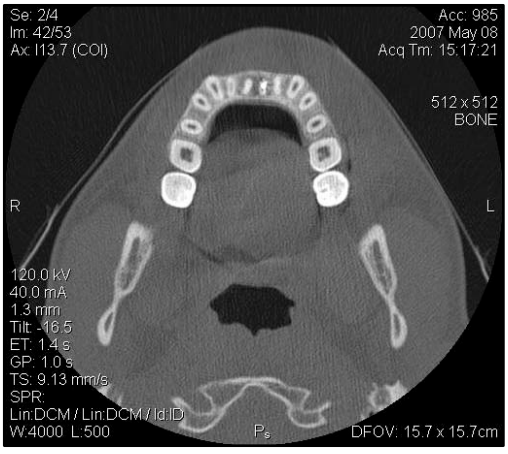

Figure 10: Axial CT-image 1.3 mm superior to the section in Fig. 9

The Department of Oral Radiology, UiO, made a tentitative diagnosis of osteomyelitis in the mandible (K10.2).

Tooth 42: Normal lamina dura. PAI 1. Normal marginal bone level.

Tooth 41: Discontinued lamina dura. Apical radiolucency (~20*10 mm). PAI 4. Filling material in the crown. Diffused radiopaque material in the root canal. Normal marginal bone level.

Tooth 31: Discontinued lamina dura. Apical radiolucency (~20*10 mm). PAI 4. Filling material in the crown. Radiopaque material in the root canal. Normal marginal bone level.

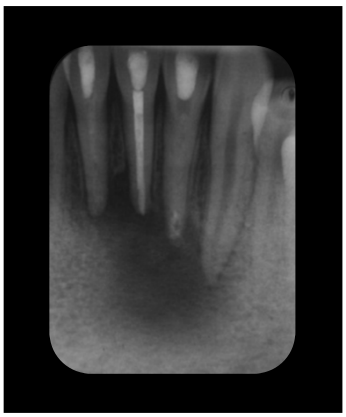

Figure 11: Periapical radiograph

Tooth 32: Discontinued lamina dura. Apical radiolucency (~20*10 mm). PAI 4. Filling material in the crown. Diffused radiopaque material in the root canal, with a denser material in the apical part of the root. Normal marginal bone level.

Tooth 33: Normal lamina dura. PAI 1. Normal marginal bone level.

Tooth 34: Normal lamina dura. PAI 1. Normal marginal bone level.

Note: OPG and CT-scan were taken on May 8th 2007. The CT-scan showed the presence of two canals in the mandibular incisors.

Diagnosis

Tooth 41:

Pulpal: Necrotic (K04.1)
Apical: Apical abscess without sinus tract (K04.7)
Marginal: Within normal limits

Tooth 31:

Pulpal: Root canal filled (K04.19)
Apical: Apical abscess without sinus tract (K04.7)
Marginal: Within normal limits

Tooth 32:

Pulpal: Necrotic (K04.1)
Apical: Apical abscess without sinus tract (K04.7)
Marginal: Within normal limits

Problem list

Apical abscess in the anterior mandible

Treatment plan

Orthograde endodontic treatment of non-vital pulp teeth 31, 32 and 41

Treatment

7 June 2007

Clinical examination. The patient diagnosed with apical abscess without sinus tract teeth 31, 32 and 41.

Endodontic treatment of tooth 31:

Rubber dam. Preparation of access cavity. Gutta-percha removed with the use of Gates-Glidden burs and Hedstroms files in conjunction with small amounts of chloroform. Two canals, not totally separated and of which only one root was filled, were found. Lengths of the canals determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically, with K- and NiTi hand files to sizes:

Buccal: R80/20 mm/incisal edge

Lingual: R80/20 mm/incisal edge

1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

Figure 12: Working length radiograph tooth 31

14 June 2007

Endodontic treatment of tooth 31:

Rubber dam. Removal of temporary IRM filling. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as a long-term intra-canal dressing in the two root canals. IRM was applied as a temporary filling.

Endodontic treatment of tooth 32:

Rubber dam. Temporary IRM filling removed. Two canals, which were not totally separated, were found. Lengths of the canals were determined by apex locator (Root ZX®) and a radiograph. Root canal disinfection was done mechanically with K-, Hedstroms- and NiTi hand files to sizes:

Buccal: R60/20 mm/incisal edge

Lingual: R60/20 mm/incisal edge

1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

Figure 13: Working length radiograph tooth 32

Endodontic treatment of tooth 41:

Rubber dam. Temporary IRM filling removed. Two canals, which were not totally separated, were found. Lengths of the canals were determined by apex locator (Root ZX®) and a radiograph. Root canal disinfection was done mechanically with K-, Hedstroms- and NiTi hand files to sizes:

Buccal: R90/21 mm/incisal edge

Lingual: R90/21 mm/incisal edge

1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. Ca(OH)2 was placed as an intra-canal dressing. IRM was applied as a temporary filling.

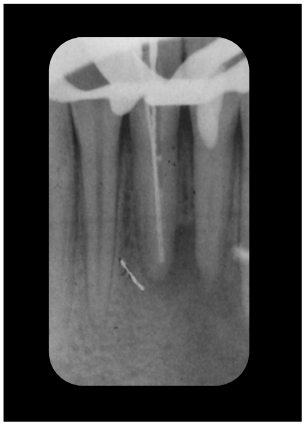

Figure 14: Working length radiograph tooth 41

18 June 2007

The patient had pain and swelling of the skin after endodontic treatment. His general dentist prescribed Apocillin® 660 mg no 30.

4 October 2007

The patient was asymptomatic and with no elevation of the skin or oral mucosa. No clinical findings. Radiograph showed evidence of healing. The decision was made to change the $Ca(OH)_2$ intra-canal dressing in the three teeth. A rubber dam. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as a long-term intra-canal dressing. IRM was applied as a temporary filling. This treatment was done with teeth 31, 32 and 41.

Figure 15: 4 October 2007

13 March 2008

The patient had not showed up for two scheduled appointments. The patient was asymptomatic and with no elevation of the skin or oral mucosa. No clinical findings. Radiograph showed evidence of healing. The decision was made to change the $Ca(OH)_2$ intra-canal dressing in all three teeth. A rubber dam. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as a short-term intra-canal dressing. IRM was applied as a temporary filling. This treatment was performed on teeth 31, 32 and 41.

Figure 16: 13 March 2008

17 April 2008

The patient was asymptomatic and with no elevation of the skin or oral mucosa. No clinical findings. Radiograph shows evidence of healing (fig. 18). The decision was performed on root canal fill teeth 31, 32 and 41.

Figure 18: 17 April 2008

Rubber dam using the split dam technique was applied (figure 19).

Figure 19: Rubber dam with OralSeal®

Endodontic treatment of tooth 31:
Removal of temporary IRM filling. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. P30 (Plaster of Paris - $CaSO_4$) was placed as an apical barrier. To ensure that the P30 was not in the canal a SS-file of size 90 was engaged to the working length of 20 mm. A 3 mm plug of grey MTA (Angelus, Brazil) was placed in the apical area of the root. AH Plus was applied to the canal walls with the use of a paper point. The System B part of The Elements Obturation Unit® was used to fill the root canals with warm vertical compacted gutta-percha. A Buchanan plugger was used for compaction of the gutta-percha. The access cavity was cleaned with chlorhexidine-ethanol. A temporary IRM filling was placed over the root filling.

Figure 20: MTA in the applied apical part of teeth 41 and 32. $CaSO_4$ through the apical foramen tooth 41 to create a barrier.

Endodontic treatment of tooth 32:
Removal of temporary IRM filling. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. A 3 mm plug of grey MTA (Angelus, Brazil) was placed in the apical area of the root. AH Plus was applied to the canal walls with the use of a paper point. The System B part of The Elements Obturation Unit® was used to fill the root canals with warm vertical compacted gutta-percha. A Buchanan plugger was used for compaction of gutta-percha. The access cavity was cleaned with chlorhexidine-ethanol. A temporary IRM filling was placed over the root filling.

Endodontic treatment of tooth 41:
Removal of temporary IRM filling. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. A 3 mm plug of grey MTA (Angelus, Brazil) was placed in the apical area of the root. AH Plus was applied to the canal walls with the use of a paper point. The System B part of The Elements Obturation Unit® was used to fill the root canals with warm vertical compacted gutta-percha. A Buchanan plugger was used for compaction of gutta-percha. The access cavity was cleaned with chlorhexidine-ethanol. A temporary IRM filling was placed over the root filling.

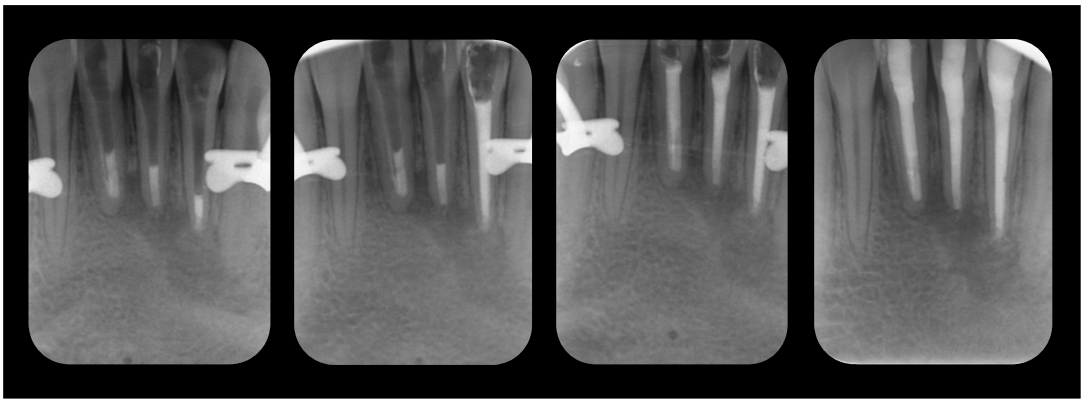

Figure 21: MTA in the apical part of teeth 31, 32 and 41

Figure 22: Teeth 31 root canal filled with warm compaction of gutta-percha

Figure 23: Teeth 31, 32 and 41 root canal filled with warm compaction of gutta-percha

Figure 24: Post-treatment periapical radiograph

29 May 2008

The patient was asymptomatic. There was no sensitivity to palpation or percussion on tooth 31, 32 and 41.
Rubber dam applied. Removal of temporary IRM fillings tooth 31, 32 and 41. A composite filling was placed (etch, Adapter, Filtek Supreme A3B) on tooth 31, 32 and 41. The fillings were polished.

Figure 25: Frontal view

Figure 26: Occlusal view

Result

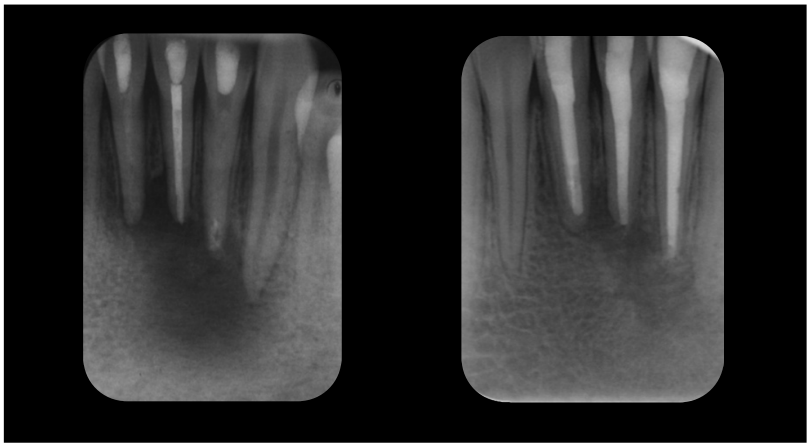

Figure 27: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root fillings appeared dense and good.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

20 November 2008 (five months after endodontic treatment)

The patient did not show up to follow-up examination at the Department of Endodontics, UiO. The follow-up examination was done at a public dental office. The patient was without any symptoms and with no clinical findings from teeth 31, 32 and 41. The periapical radiographs showed evidence of healing.

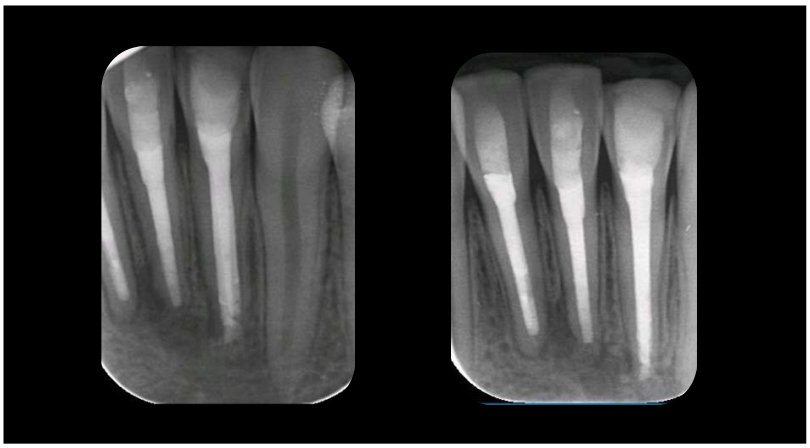

Figure 28: Periapical radiographs at follow-up examination

Discussion

Teeth not responding to conventional therapy or for which a conventional retreatment is not possible require surgical intervention.[1] When the surgical approach is chosen, the precise extent of the apical lesion should be known, as well as its relation to the root and neighboring anatomic structures, such as the mandibular neurovascular bundle. Three-dimensional anatomic and pathologic observations are advantageous for surgical performance in endodontic procedures. In approaching the root with the adjacent pathologic condition, position of the tooth in the bone and specific root configuration with its root canal ramifications are of interest. Effort must be made to avoid damage to anatomic structures such as the alveolar nerve, yet not miss a portion of or an entire root. Without surgically treating all the roots of the involved tooth, including all root canal ramifications, great success cannot be expected.[2,3]Various radiographic methods are available to visualize the anatomic and pathologic details. Radiographs are two-dimensional images and provide limited information related to the mandibular canal, bone thickness, root anatomy, and size and location of the lesion. Although conventional periapical radiographs produce acceptable details in the mesial–distal direction, the observation of details in bucco-lingual dimension is inadequate.[4] In 1961 Bender and Seltzer[5] pointed out the difficulties in visualizing radiolucencies because of superimposition of bone. They concluded that a lesion could only be detected if a significant amount of bone was lost because of the pathologic lesion. In addition, they observed that the radiographs not only might miss pathologic lesions but also might not show their actual size.[6] Objects positioned along the long axis of an x-ray beam are projected to the same spot on the film. Buccal and lingual root canals cannot be differentiated on the radiographs because they are superimposed. The mandibular canal can be projected as being in close relation to the root apex or to the lesion without having a close proximity in reality or vice versa. Most of the transversal information is missing in conventional dental radiography. Conventional tomography has been suggested to localize anatomic structures before endodontic surgery.[7] However, this technique may result in magnification and distortion of the image.[8] Numerous authors have shown that computed tomography (CT) provides three-dimensional information and better visualization of bone structures, as well as of the bone's relationship with anatomic structures such as the maxillary sinus and mandibular canal.[9] Hounsfield[10] first described this method in 1973. Since then significant improvements have lead to better resolution of the images, faster exposure time, and lower radiation doses. Although CT has advantages over conventional tomography, it also has some disadvantages such as motion and metal artifacts, increased radiation exposure, limited availability, and higher cost.[11]

In dentistry CT has been widely used in oral implantation to determine the structure of the mandible. The inferior alveolar neurovascular bundle has been shown in cross-sectional CT scans with a high predictability.[4] The CT images were found to reflect the osseous topography of the mandible more accurately than conventional dental radiography.[12] In the field of endodontics very few articles have dealt with the use of CT. There was an attempt to differentiate between apical granulomas and cysts by using CT.[13] Because it has been suggested that true cysts will not respond to conventional root canal therapy[14] and require surgical treatment, the cyst identification would be crucial. The identification of a cyst in conventional radiography is not possible,[15] as confirmed in the study by Trope et al.[13] Another article reported a single case in which CT was used for diagnosis and to evaluate the healing of an extensive periapical lesion after surgical treatment.[16] In this clinical case of an extensive symptomatic periapical lesion, CT helped to evaluate the true extent of the lesion and its spatial relationship to important anatomic landmarks. Bony repair was obtained as seen in the follow-up CT scan. In study by Velvart et al.[17]conventional radiographs was compared with CT. The results showed that conventional radiographs considerably less information for the detection of an apical lesion and for surgical treatment planning compared with CT. Important anatomic structures, such as mandibular canal and mental foramen, could be consistently detected with CT, as well as their position and distance to the apical lesion and/or root (Table 2).

	CT	Diagnosis by radiograph	Surgery
Lesion diagnosed	78	61	78
Mandibular canal diagnosed	80	31	-

Table 2: Cases with detection of the lesion and mandibular canal (Velvart et al. 2001)

In the last decade cone beam CT (CBCT) has been developed for dental usage. CBCT has been specifically designed to produce undistorted three-dimensional information of the maxillofacial skeleton as well as three-dimensional images of the teeth and their surrounding tissues. This is usually achieved with a substantially lower effective dose compared with conventional medical computed tomography (CT). Periapical disease may be detected sooner using CBCT compared with periapical views, and the true size, extent, nature and position of periapical and resorptive lesions can be assessed. Root fractures, root canal anatomy and the true nature of the alveolar bone topography around teeth may be assessed. CBCT scans are desirable to assess posterior teeth prior to periapical surgery, as the thickness of the cortical and cancellous bone can be accurately determined as can the inclination of roots in relation to the surrounding jaw. The relationship of anatomical structures such as the maxillary sinus and inferior dental nerve to the root apices may also be clearly visualized.[18]

The CT-scan in this case showed a large lesion in the mandible. It also gave indications of the presence of two canals in the mandibular incisors.

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Removal of Separated Endodontic Instrument

Introduction

44 year old white Northern European male

Figure 1: Frontal view

Chief complaint

30 October 2008

Pre-prosthodontic endodontic retreatment of mandibular right second molar. Referred from dental student clinic, Institute of Dentistry, UiO, because of separation of endodontic file in the mesiobuccal canal during endodontic retreatment tooth 47. No symptoms from the tooth.

Medical history

Non-contributory

Dental history

February 2008: Started endodontic retreatment of tooth 47 at dental student clinic, UiO, because the tooth was scheduled for crown treatment. The initial root canal filling was deemed as unsatisfactory.

Clinical findings

30 October 2008

Figure 2: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	48	47	46
Cold	-	No	No
Percussion	-	No	No
Palpation	-	No	No
Mobility	-	No	No
PPD(mm)	-	3	3
Restoration	-	Comp (ODL), IRM (P) & amalgam (B)	Abutment (FPD teeth 47-44)

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 48: extracted
Tooth 47: composite restoration on the occlusal, distal and lingual aspects, IRM restoration on the occlusal aspect and amalgam restoration on the buccal aspect
Tooth 46: abutment for porcelain fused to metal FPD from tooth 47 to tooth 44
Tooth 45: extracted

Radiographic findings

30 October 2008

Tooth 48: missing

Tooth 47: Broken lamina dura. Apical radiolucency (Ø 4 mm). PAI 3. Radiopaque filling on the mesial, occlusal and distal aspects of the crown. No root filling material, but a seperated endodontic file in the mesial root. Normal marginal bone level.

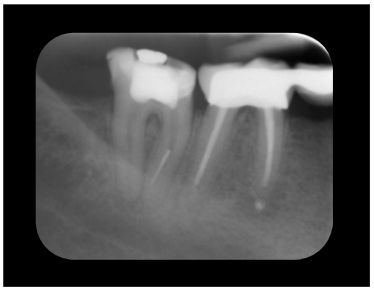

Figure 3: Periapical radiograph

Tooth 46: Normal lamina dura. Dens and homogen root canal filling. Excess root canal sealer apically to the mesial root. Abutment for bridgde. Normal marginal bone level.

Tooth 45: missing

Diagnosis

Tooth 47:

Pulpal: Necrotic (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Separated endodontic file in the mesial root of tooth 47

Treatment plan

Orthograde endodontic treatment of non-vital pulp tooth 47

Treatment

30 October 2008

Clinical examination. Tooth diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Rubber dam. Preparation of access cavity and localization of three root canals. Length of the MB and D canals determined by apex locator (Root ZX®) and a periapical radiograph. A modified Gates-Glidden bur (Fig. 6) was used to create a shelf over the separated endodontic file. An ultrasonic driven K 25/21 file was used to loosen and retrieve the separated endodontic file. Root canal disinfection was done mechanically with K- and NiTi hand files in conjunction with ProTaper® to size:

MB R45/17 mm/mesiobuccal-cusp
ML R45/17 mm/ mesiobuccal-cusp
MB R60/18 mm/ mesiobuccal-cusp

Irrisafe® used for further cleaning of the canals. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a

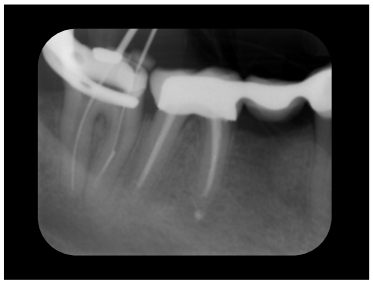

Figure 4: Working length radiograph with separated file in the mesio-buccal canal

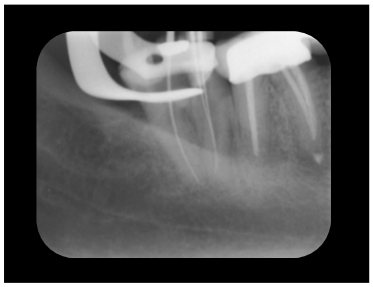

Figure 5: Working length radiograph without separated file in the mesio-buccal canal

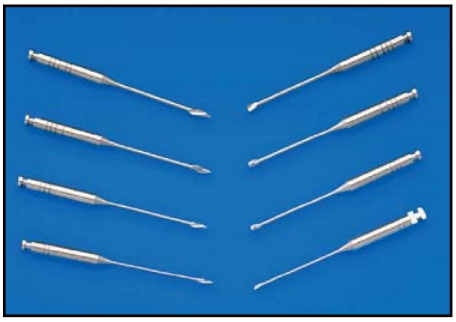

Figure 6: Gates-Glidden (left) and modified Gates-Glidden (right) burs

14 January 2009

The patient had cancelled two appointments since the last treatment. He presented without any symptoms. The clinical examination showed no sensitivity to palpation or percussion. 1.8 ml Septocaine®. Rubber dam. 1% NaOCl and 17% EDTA were used for cleaning of the canals. Epiphany® and Resilon® were used as root filling material. Cavit G® and IRM applied as a temporary filling. The radiograph showed evidence of apical healing.

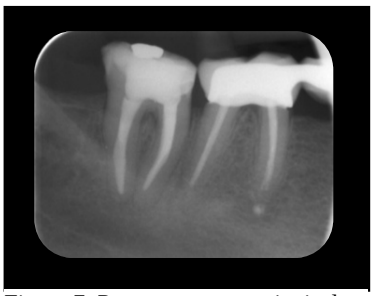

Figure 7: Post-treatment periapical radiograph

Result

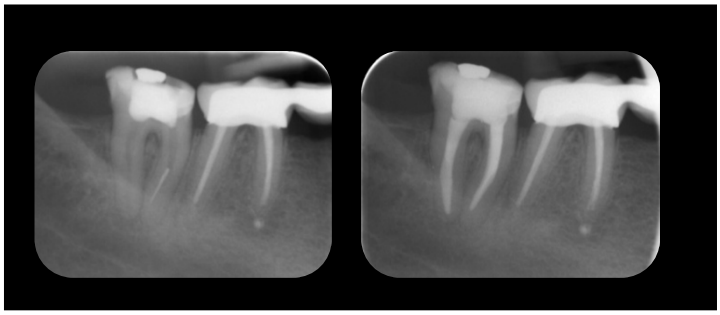

Figure 8: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good. The radiograph, taken on January 14th 2009, showed evidence of healing tooth 47.

Prognosis

Endodontic: good

Tooth: good

Follow-up examination

21 April 2009 (three months after endodontic treatment)

No symptoms and no clinical findings, and the periapical radiograph showed complete healing tooth 47 (Fig. 9).

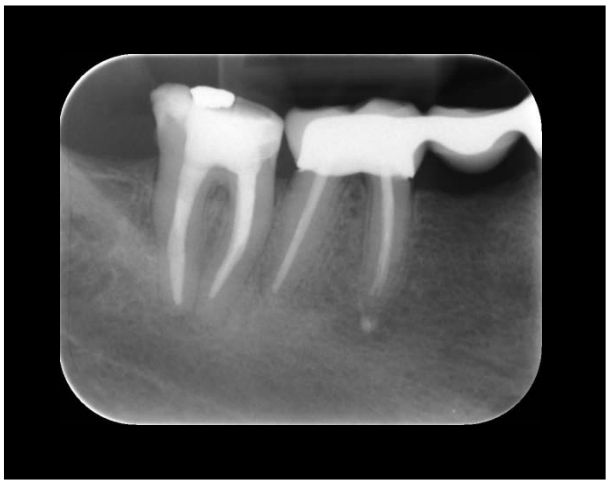

Figure 9: Periapical radiograph at follow-up examination

Discussion

When an endodontic instrument fractures during use in a root canal, the best option is to remove it, if possible. Only after removal can the root canal be negotiated, cleaned and shaped properly. If the root canal cannot be cleaned and shaped successfully, remnants of pulp tissue and bacteria may remain and compromise the outcome of root canal treatment.[1] However, attempts to remove fractured instruments may lead to ledge formation, over-enlargement and transportation of the prepared root canal, or root perforation. There are several methods for removing fractured instruments. Ultrasound is often used. In short, the steps are:

A. Creation of straight line access to the coronal end of the instrument under microscope (Gates-Glidden burs or other alternatives).
B. With aid of a microscope create a groove around the coronal end of the instrument using ultrasound (size 25 K-file tip or other alternatives).
C. Ultrasonic file is kept in contact with, or best bypass, the fractured instrument until movement registered.
D. Loosened instrument removed by flushing with irrigation or Hedstrom-file, pliers or Masseran-kit.
This does not always work. Suter et al.[2] have evaluated the possibilities of success. There were no significant differences in the success rate according to the type of root the instrument was removed from (incisor, premolar, molar). The position of the fractured instrument did not seem to make a difference unless lodged beyond the apical foramen:
Instrument in coronal third of root canal 17 of 19 removed (89, 5 %).
Instrument in middle third of root canal 27 of 31 removed (87, 1 %).
Instrument in apical third of root canal 35 of 40 removed (87, 5 %).
Instrument beyond the apical foramen 0 of 2 removed (0 %).
There was a significant correlation between the amount of time needed to remove the instrument and the corresponding reduction in the success rate. The criteria for success were complete removal of the instrument without root perforation. What was not evaluated was the curve of the root where the files came out compared to those where the instrument did not. In clinical practice the apically placed fractured instruments in curved canals are those where establishment of straight access to, and a groove around the coronal part of the instrument may prove impossible without perforating. It was found that NiTi instruments, lentulo-spirals and SS-files were prone to fracture when using ultrasound. This happened in 30 % of the cases, and more often with NiTi files. The over-all success rate of removing fractured instrument was 78 %. This was an operator-derived success-rate and does not necessarily apply to others.

In certain clinical situations it may also be better to leave a fractured instrument in the root canal, for example when the instrument fractures in a canal with a vital pulp, if it fractures when removing a calcium hydroxide dressing or in a late stage of the shaping and cleaning of canal. This is based on the assumption that it is the infection and not the instrument in itself that creates the problem. Studies on treatment outcome indicate that the fractured instrument has an impact on prognosis only in cases with apical periodontitis.[1,3]

In this case the tooth was diagnosed with chronic apical periodontitis. It was important to retrieve the separated endodontic file to properly clean the canal.

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Unusual Morphological Variation Tooth 27

Introduction

49 year old white Northern European female

Figure 1: Frontal view

Chief complaint

25 November 2008

Some dull pain from maxillary left first molar.

Medical history

Clinical depression

Zoloft® (Sertraline hydrochloride)

Smokes approximately 20 cigarettes per day

Dental history

August 2008: Started initial endodontic treatment of tooth 27. Three canals located. According to the referral a Hedstrom file #30 separated in the distal canal. Fixed partial denture planed form tooth 25 to tooth 27, with teeth 25 and 27 as abutments.
Tooth 24 extracted during adolescence because of orthodontic treatment.
Referred from a public dental office, to the Department of Endodontics, UiO, for examination and treatment of tooth 27.

Clinical findings

15 January 2009

Figure 2: Lateral view

Extra-oral examination: within normal limits

Intra-oral examination:

	25	26	27	28
Cold	Yes	-	No	-
Percussion	No	-	Yes	-
Palpation	No	-	Yes	-
Mobility	No	-	No	-
PPD (mm)	5	-	4	-
Furcation involvement	-	-	I	-
Restoration	Temporary crown	-	IRM (MODP)	-

Table 1: Clinical findings

Soft tissue: Increased periodontal probing depths. Moderate oral hygiene.

Dental:

Tooth 24: temporary crown

Tooth 25: missing

Tooth 26: IRM filling on the mesial, occlusal, distal and palatinal aspects of the crown

Radiographic findings

25 November 2008

Tooth 25: Discontinued lamina dura. Apical radiolucency. PAI 3. Metalic post. Reduced marginal bone level especially on the mesial aspect.

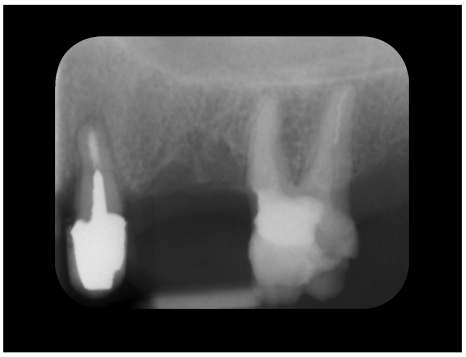

Figure 3: Periapical radiograph

Tooth 26: Missing

Tooth 27: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque restoration on the mesial and occlusal aspects of the crown. An approximately 4 mm long separated endodontic file in apical part of the palatinal root. The radiograph shows evidence of 4 root canals. Some reduced marginal bone level.

Tooth 28: Missing

Diagnosis

Tooth 27:

Pulpal: Necrotic (K04.1)
Apical: Within normal limits
Marginal: Chronic marginal periodontitis (K05.3)

Problem list

Separated endodontic file in the apical part of the palatinal canal.

Treatment plan

Orthograde endodontic treatment of non-vital pulp with removal of separated endodontic file, tooth 27.
Informing the referring dentist about chronic apical periodontitis tooth 25.

Treatment

25 November

Clinical examination. Tooth 27 diagnosed with necrotic pulp. 1.8 ml Septocaine®. Rubber dam. OralDam® was used to isolate the rubber dam. Preparation of access cavity and localization MB1-, DB- and P-canals. The MB2-canal was not located. A perforation in the tri-furcation close to the palatinal canal was found. A modified Gates-Glidden was used to create a shelf over the separated endodontic file in the palatinal canal. An ultrasonic instrument (K 25/21 file) was used in a contra-clockwise movement to loosen the separated endodontic file. 17% EDTA was used as irrigation. The separated file was loosened and retrieved. MB1-, DB- and P-canal lengths were determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically with K-files and ProTaper® to sizes:
MB: R45/16 mm/mesiobuccal ridge
DB: R45/19 mm/mesiobuccal ridge
P: R70/20 mm/mesiobuccal ridge
1% NaOCl and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. During the negotiation of the canals the perforation was protected with Gavit-G®. IRM was applied as temporary filling in the orifices. The bleeding in the perforation was controlled with the use of $Ca(OH)_2$. After hemorrhage control the perforation was carefully rinsed with 1% NaOCl. Undermined dentin was removed from the edges of the perforation with the use of a LN-bur. Grey MTA (Angelus, Brazil) was applied in the perforation with the use of the MAP-system®. A cotton pellet with saline water was placed over the MTA and a temporary IRM filling was applied.

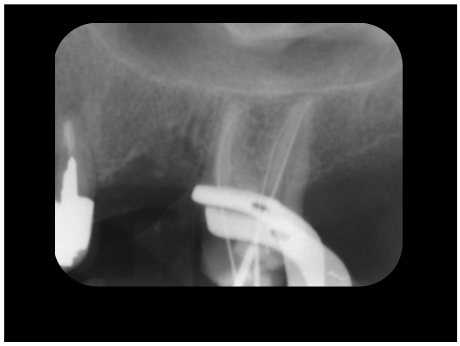

Figure 4: Working length radiograph after removal of separated endodontic instrument

Figure 5: MTA applied in the perforation

27 January 2009

Patient had no percussion or palpation sensitivity from tooth 27. 1.8 ml Septocaine®. Rubber dam. OralDam® was used to isolate the rubber dam. The MTA had not properly set. A change of the intra-canal dressing was performed. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. IRM fillings were placed at least 2 mm in to the canal orifices. A build-up of about 1 mm with IRM around the MTA was created. The MTA was removed and grey MTA (Angelus, Brazil) was applied with the use of the MAP-system®. A cotton pellet with saline water was placed over the MTA. IRM was applied as a temporary filling.

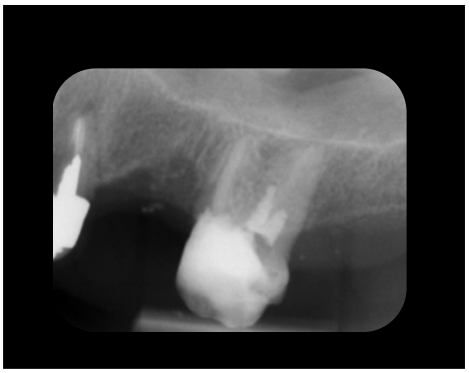

Figure 6: MTA in the perforation

10 February 2009

Patient had no percussion or palpation sensitivity from tooth 27. 1.8 ml Septocaine®. Rubber dam. OralDam® was used to isolate the rubber dam. The MTA had properly set. A mesiopalatinal canal was located. To confirm that the canal was a mesiopalatinal canal a disto-eccentric periapical radiograph was taken. The root canal length was determined by apex locator (Root ZX®). Root canal disinfection was done mechanically with K-files and ProTaper® to sizes:

MP: R45/13 mm/mesiopalatinal ridge

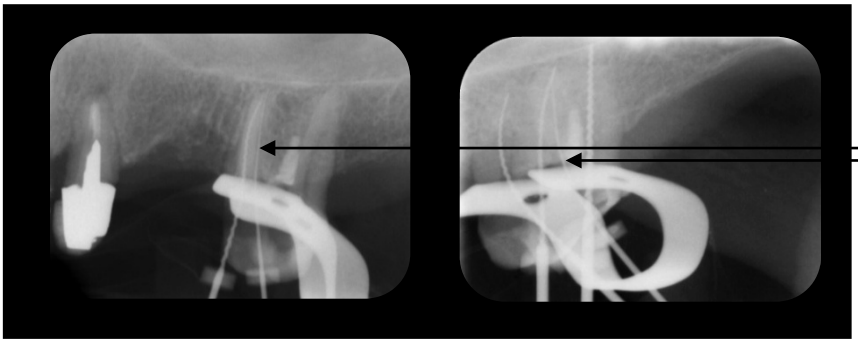

Figure 7: Working length of the mb- and mp-canals in a parallel angulation

Mesiopaltinal canal

Figure 8: Working length radiograph in a disto-eccentric angulation

1% NaOCl and 17% EDTA were used for chemical root canal disinfection. The root canals were dried with paper points and filled with AH Plus and gutta-percha. Extrusion of root canal sealer from the DP- and MP-canals was evident on the periapical radiograph. IRM was applied as a temporary filling. The referring dentist was informed of the treatment of tooth 27 and the presence of chronic apical periodontitis tooth 25.

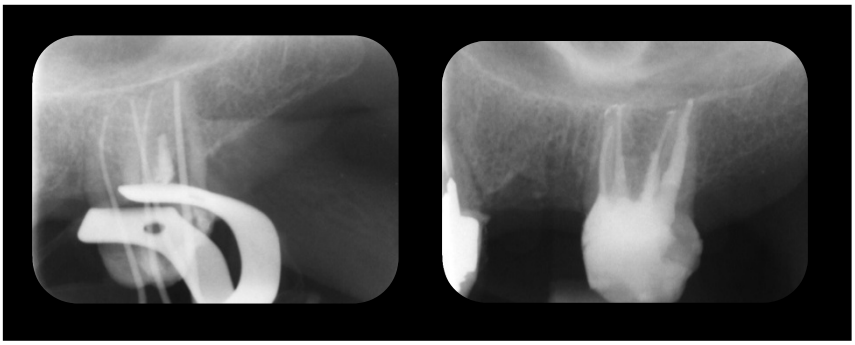

Figure 9: Master point radiograph taken in a disto-eccentric angulation

Figure 10: Post-treatment radiograph

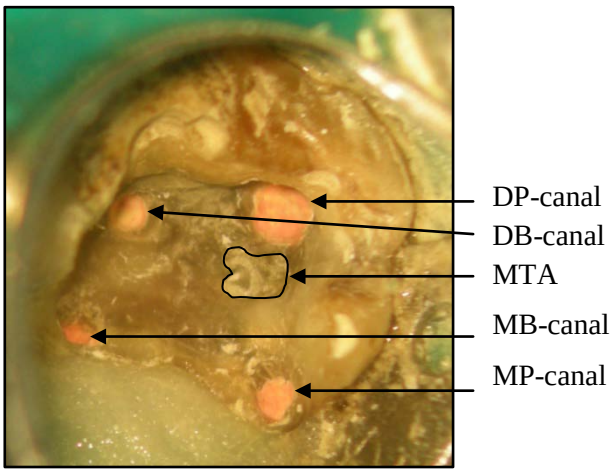

Figure 11: Access cavity after root filling

Result

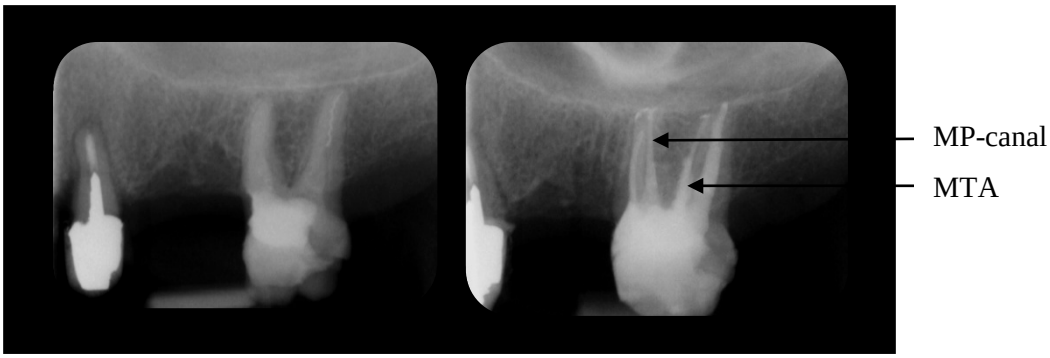

Figure 12: Pre- and post-treatment periapical radiographs

Evaluation

Separated endodontic file was removed from the distopalatinal canal. Perforation in the tri-furcation was found and sealed during the endodontic treatment. The root canal filling appeared dense and good.

Prognosis

Endodontic: uncertain because of a perforation in the tri-furcation was left untreated for at least four months.

Tooth: uncertain because of severe loss of tooth structure.

Follow-up examination

No follow-up examination because the treatment was performed from November 2008 to February 2009.

Discussion

Maxillary molar with two palatinal roots

Maxillary molars, which have three roots, often have four canals. Dentists should emphasize that the mesiobuccal root, with its broad buccal to lingual dimension, will often have a double canal system in what appears on the radiograph to be a single root.[1] Most of the clinical literature reports deal with this fourth mesiobuccal canal of maxillary molars[2], but this condition is also common to other roots in the mouth that have a broad buccal to lingual dimension.[3] If these double canal systems are suspected, they may be recognized on the radiograph.[4] There are also reports in the literature that emphasize the need to search the floor of the chamber to locate each canal orifice.[5]

An anomalous root morphology which occurs infrequently, such as two palatal roots on the maxillary molar, is rarely mentioned in the literature. Diamond[6], in 1952, shows two extracted teeth that are identified as first molars and have two widely divergent palatal roots. Carlsen[7] shows an extracted four-rooted molar also, which is identified as a third molar. Even the classic early study by Hess and Zurcher[8] only mentions rare cases of a fourth root in maxillary molars. They thought it originated in the mesiobuccal root and showed rudimentary development.

Case reports of maxillary molars with four or more canals also describe maxillary molars with three buccal roots[9], maxillary molars with three roots and six root canals[10, 11], maxillary molars with five canals[12], and maxillary molars with two canals in the palatal root.[13-18] The least frequent anomaly appears to be that of the double palatal root. Slowey[4], in 1974, first reported on endodontic treatment of maxillary molars with two palatal roots as well as showing another second molar with four separate roots. Thews et al. [16], in 1979, also reported the endodontic treatment of two maxillary molars with aberrations of the palatal root. The first tooth they described had two widely divergent palatal roots, and the second case had two root canals which joined at the apex in the single palatal root. Five years after his first report, Slowey[14] showed an example of a second molar in which the second palatal root might have been missed had not the radiograph been examined carefully during endodontic treatment.

Similar cases have been reported and some attempt has been made at establishing the incidence of occurrence of the double palatal root of maxillary molars. Stone and Stroner[17] examined more than 500 extracted molars and found less than a 2% incidence of more than one palatal canal when both anomalies were included. Libfeld and Rotstein[19] reported on an examination of 1000 radiographs and 200 maxillary second molar endodontic treatments and found a 0.4% incidence. Von Weiland and Wendt[20] also describe a case report that began as a retrograde pulpitis and was not resolved until the extra palatal root was located.

Furcal perforation

Furcal perforation may be the consequence of procedural error or a pathologic process such as caries and root resorption.[21] The etiology and location of the perforation as well as the size and the time delay before perforation repair are significant factors for the prognosis and treatment planning.[22]

A good prognosis can be expected in case of fresh, small, coronal, and apical perforation.[22, 23] When left untreated, perforations in the cervical third of the root or on the floor of the pulp chamber have the worst prognoses.

The time elapsed from the development of the defect is another critical factor influencing the posttreatment prognosis; a delay in repairing a perforation opens the way to bacterial

contamination. In animal studies, teeth with contaminated intentional lateral perforation were associated with a poorer repair process than teeth with no contaminated defects.[24 25]

Ideally, a material with good sealability might be used to prevent continuous exposure to a contaminating environment.[26] Using different leakage approaches, fluid filtration technique,[27, 28] dye-leakage model,[29, 30] bacterial leakage model,[31, 32] and dye-extraction leakage method,[33] mineral trioxide aggregate (MTA) experimentally showed better sealing ability than other materials, such as amalgam,[31] zinc oxide-eugenol cement,[30] resin-modified glass ionomer cements,[31] and resin materials.[27]

The use of biocompatible materials to repair perforations might be advocated to reduce the incidence of inflammatory reactions in the surrounding tissues.[26,34] When MTA was used to seal intentional furcal perforations in dog teeth, cementum was formed over the MTA; furthermore, there was no inflammatory cells infiltrate.[35] In addition, the material of choice for repairing root perforations should be nontoxic and insoluble in the presence of moisture, and it should be able to promote the healing of the periradicular tissue.[36] MTA has the properties of the ideal material for perforation repair.

In cases of teeth with large-size furcal perforation, the repair material can extrude into the interradicular area, triggering tissue inflammation and foreign body reaction.[27, 38] The use of biocompatible material has been advocated to avoid extrusions and the ensuing complications.[38, 39]

In a recent animal study in which MTA without internal matrix was used to repair contaminated intentional furcal perforations, there was a low score of inflammation and a high score of bone deposition.[37] Treating contaminated root perforation is not infrequent in daily clinical practice.

A recent PUBMED search for MTA to repair root and pulp chamber perforation produced one long-term case series study[40] and numerous case reports showing the good healing results when MTA was used to seal root and pulp chamber perforations.[41, 42, 43]

In this case the maxillary second molar had four roots (two buccal and two palatinal). It was also performed a repair of perforation in the tri-furcation with MTA.

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Perforation of Root Canal

Introduction

49 year old white Northern European male

Figure 1: Frontal view

Chief complaint

15 January 2009

Some tenderness when eating from maxillary left first molar.

Medical history

Non-contributory

Dental history

23 September 2008:

Tooth 26 diagnosed with apical abscess with sinus tract. Endodontic treatment started by dental student. A step was made in the mesiobuccal canal approximately 4 mm from the radiographic apex. Distobuccal and palatinal canals were instrumented to correct lengths. $Ca(OH)_2$ dressing was applied.

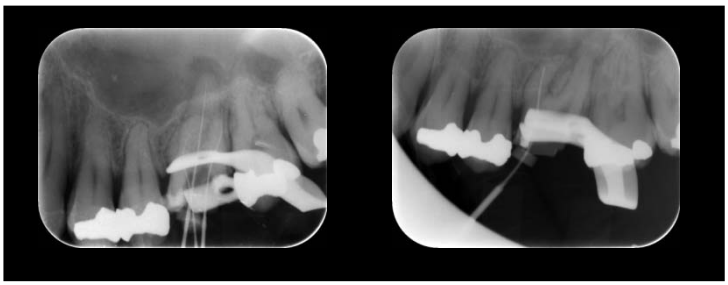

Figure 2: Working lengths (treatment by dental student)

Figure 3: Step in mb-canal (treatment by dental student)

9 October 2008:

Endodontic instructor separated a SS-file # 25 when attempting to by-pass step in the mesiobuccal canal. The distobuccal and palatinal canals were root filled with AH Plus and gutta-percha. Treatment of the mesiobuccal root was referred to post graduate student at the Department of Endodontics, UiO.

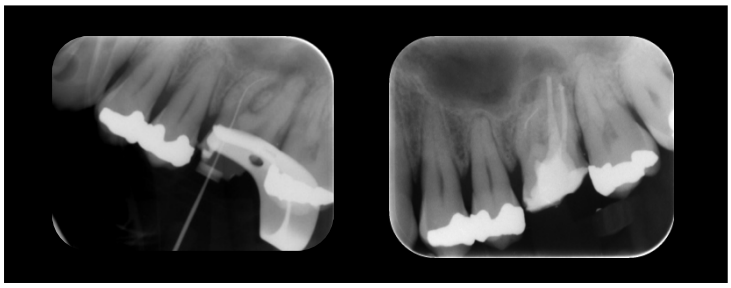

Figure 4: Working length mb-canal (treatment by dental student)

Figure 5: Separated SS-file #25 in the mb-canal (treatment by dental student)

Clinical findings

15 January 2009

Figure 6: Lateral view

Figure 7: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	25	26	27
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	3	3	4
Furcation involvement	-	I	I
Restoration	Amalgam (MOD)	IRM (O)	Amalgam (MO)

Table 1: Clinical findings

Soft tissue: Periodontal pockets within normal limits. No sinus tract. Good oral hygiene.

Dental:

Tooth 25: amalgam restoration on the mesial, occlusal and distal aspects of the crown
Tooth 26: IRM restoration on the occlusal aspect of the crown
Tooth 27: amalgam restoration on the mesial and occlusal aspects of the crown

Radiographic findings

9 January 2009

Tooth 24: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque restoration on the occlusal and distal aspects of the crown. Some reduced marginal bone level.

Tooth 25: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque restoration on the mesial, occlusal and distal aspects of the crown. Some reduced marginal bone level.

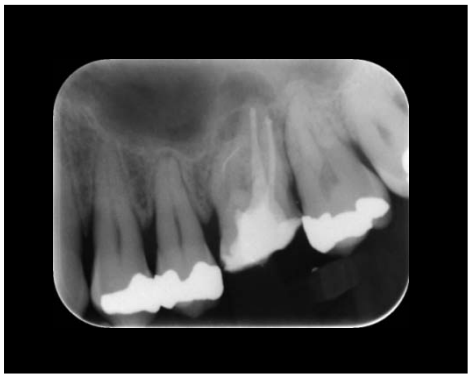

Figure 8: Periapical radiograph

Tooth 26: Discontinued lamina dura. Apical radiolucency at the mesial, distal and palatinal roots (Ø 9mm). PAI 4. Radiopaque restoration on the mesial, occlusal and distal aspects of the crown. The root canal filling of distobuccal and palatinal roots appear dense and good. An approximately 3 mm long separated endodontic file in the apical part of the mesio-buccal root. Curved mesiobuccal root. Some reduced marginal bone level.

Tooth 27: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque restoration on the mesial and occlusal aspects of the crown. Some reduced marginal bone level.

Diagnosis

Tooth 26:

Pulpal: Necrotic (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Separated endodontic file in the apical part of curved mesiobuccal root

Treatment plan

Orthograde endodontic treatment of non-vital pulp with removal of separated endodontic file, tooth 26.

Treatment

15 January 2009

Clinical examination. Tooth 26 diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Rubber dam. Preparation of access cavity and localization MB1 and MB2 canals. A modified Gates-Glidden was used to create a shelf over the separated endodontic file. An ultrasonic instrument (K 25/21 file) was used in a contra-clockwise movement to loosen the separated endodontic file. 17% EDTA was used as irrigation.

The separated file was loosened and retrieved. MB1 root canal length was determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically with pre-curved SS-files to size:
R35/14 mm/mesiobuccal ridge.
MB2 root canal length was determined by apex locator (Root ZX®) and a Periapical radiograph. Root canal disinfection was done mechanically with K-hand files and BioRace® to size:
R40 (BioRace® file: BR5)/13.5 mm/mesiobuccal ridge.
Irrisafe® used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

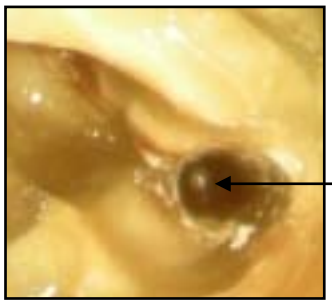

Figure 9: Separated endodontic file in the mb-canal

Separated endodontic file

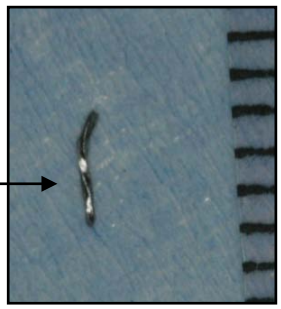

Figure 10: Separated endodontic file after retrieval

Figure 11: Localized the mb2-canal

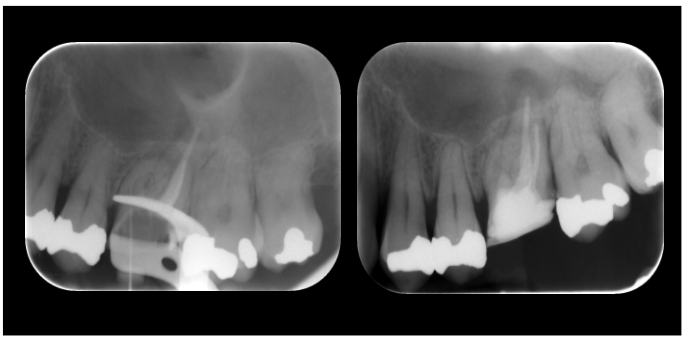

Figure 12: Working length mb-canal after retrieval of separated endodontic file

Figure 13: $Ca(OH)_2$ intra-canal dressing

5 February 2009

Patient had no percussion or palpation sensitivity, or sinus tract from tooth 26.
1.8 ml Septocaine®. Rubber dam. 1% NaOCl and 17% EDTA were used for cleaning of the canals. A perforation of the mesio-buccal canal was located at the level of the original step. IRM was placed in the perforation. The root canals were filled with AH PLUS and gutta-percha (taper 04 in the MB2-canal). Over-extrusion of root canal sealer from mesiobuccal canals. IRM was applied as a temporary filling. The patient was referred to the dental student clinic for treatment of the tooth with a dental crown.

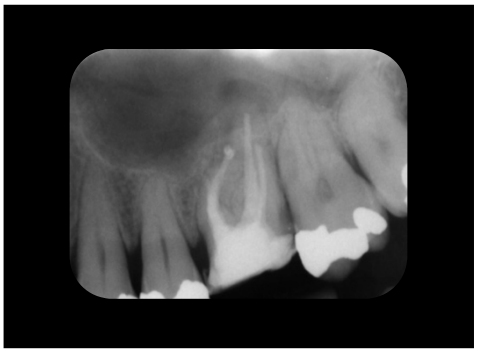

Figure 14: Post-operative periapical radiograph

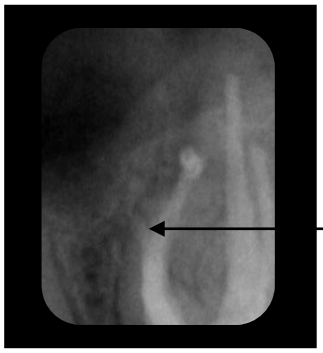

Figure 15: Enlarged post-operative radiograph of the mb-root

Result

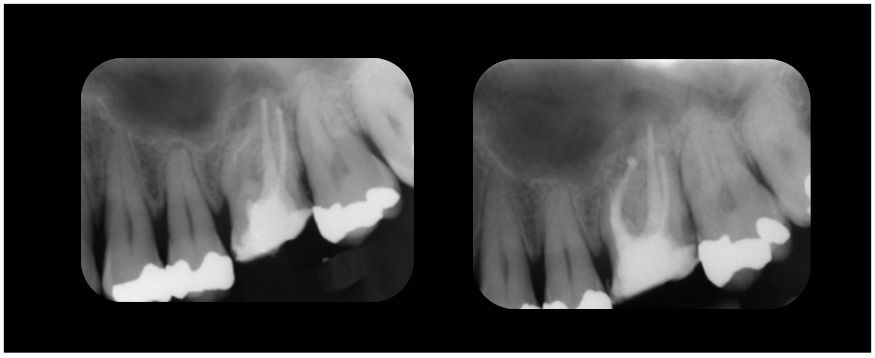

Figure 16: Pre- and post-treatment periapical radiographs

Evaluation

Perforation of the mesiobuccal root canal during treatment. The perforation was sealed immediately with IRM. There was also an over-extrusion of root canal sealer. These intra-operative factors should not significantly compromise the prognosis. The root canal filling appeared dense and good.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

No follow-up examination because the treatment was performed from January to February 2009.

Discussion

The prevalence of apical periodontitis ranges from 20% to over 60% in different studies.[1-4] The cross-sectional study methodology used in these study does not allow collection of all the data pertaining to the treatment histories of the observed root-filled teeth. Therefore, the reported data is subject to interpretation.[5]

The assessment of radiological images is highly inconsistent.[6-10] To address concerns of radiological interpretation and outcome definitions, Ørstavik[11] introduced the periapical index (PAI) for the

radiological appraisal of root-filled teeth. The PAI relies on the comparison of the evaluated radiographs with a set of five radiological images, which represent histologically confirmed periapical conditions[12] These reference images represent a range of periapical conditions, from a healthy presentation (score 1) to severe apical periodontitis (score 5).

Outcome predictors in nonsurgical endodontic treatment

Preoperative factors:

Ørstavik et al.[13] reported a better outcome after initial treatment in older patients; however, in many other initial treatment studies[13-19], and in the only retreatment study that examined these factors[20], the patients' age and gender have not been significantly associated with outcome.

Strindberg[21] reported that the patient's health did not influence the outcome. In a recent study, however, Marending et al.[22] reported that in patients with a compromised nonspecific immune system the prognosis regarding teeth with apical periodontitis was poorer than in healthy patients. A similar observation in diabetic patients was reported in a nonselected study.[23] Thus, a clear relationship between the patient's systemic health and the prognosis of nonsurgical endodontic treatment has not been established.

Ørstavik et al. [13] observed a better outcome in mandibular than in maxillary teeth. A survival analysis of teeth after endodontic treatment[24] suggested that the chance of survival was significantly lower for mandibular molars than for other teeth. Kerekes and Tronstad[15] observe a better outcome in specific teeth (maxillary canines and second premolars, mandibular canines) than in other teeth, but generally report a comparable outcome in anterior, posterior, maxillary, and mandibular teeth. Apart from these conflicting findings, no association between the outcome of treatment and tooth location has been shown in other studies on initial treatment[16-18, 25, 26] and retreatment.[20]

Preoperative symptoms may be a reflection of the bacterial types and numbers in the root canal system.[27] Nevertheless, a comparable treatment outcome has been reported for asymptomatic teeth and for teeth presenting with preoperative symptoms, in studies on initial treatment [13, 16, 17, 19, 26, 28] and retreatment.[20]

A better outcome has been reported in teeth with vital rather than necrotic pulps.[16, 29] The healed rate reported after initial treatment of teeth affected by apical periodontitis, has been significantly (10–15%) lower than in teeth without the disease [93,177,246,248,302,304,327,405].[13, 16 , 21, 22, 29, 30-32] Similarly, in studies on retreatment this difference is 10–20% [93,103,391,405].[19-21, 30]

A better prognosis has been reported in teeth with small lesions, up to 5 mm in diameter, than in teeth with larger lesions after initial root canal treatment[13, 21, 26, 29, 30] and retreatment.[34] This was explained by a correlation between the size of the lesion and the number of root canal bacteria.[28] However, statistically nonsignificant differences between small and large lesions have been reported in other studies on initial treatment[16-19, 20, 28,] and retreatment.[20]

The condition of the marginal periodontal tissues has received little consideration with regard to the prognosis of teeth undergoing nonsurgical endodontic treatment. Ørstavik et al.[13] observed a better outcome in teeth with better marginal support; however, according to the few other studies that address this factor[16, 19, 20], the periodontal status did not influence the prognosis. Friedman et al. [129] observed that of the total of 21 teeth lost within 4–6 years

after initial root canal treatment, over 50% had been extracted because of marginal periodontitis. Similarly, in a survival analysis of root-filled teeth with marginal periodontitis, 66% of lost teeth in a period of 9 years were extracted for periodontal reasons.

The outcome of retreatment in teeth with apical periodontitis is significantly (15%) better in teeth where the previous root canal filling appears to be inadequate in regards to length, density or both, compared to teeth with apparently adequate root canal fillings.[20]

A nonselected study[34] reported 58% healing around perforations repaired with amalgam or gutta-percha. A selected study[20] reported a 36% healed rate in teeth with apical periodontitis where perforations were repaired with resin-modified glass-ionomer cement. In a more recent caseseries study[35] all 16 teeth with MTA-repaired perforations appeared to be healed a year or longer after treatment.

One study[20] reported a comparable outcome for teeth retreated within a year or longer after initial treatment.

Intraoperative factors

The extent of the root canal filling has been shown to influence the outcome in studies on initial treatment[13, 17, 19, 21, 30], but not in others.[16, 18, 26, 28, 32, 36, 37] One retreatment study[20] reports a poorer outcome in teeth with inadequate (both too long and too short) root filling length, whereas other studies[19, 34] did not corroborate this finding. The importance of the apical extent of treatment is, therefore, ambiguous. Extrusion of filling materials beyond the root-end may impair the prognosis specifically in teeth with preoperative apical periodontitis.[17, 19, 21, 30] Because gutta-percha is well tolerated by the tissue, the impaired prognosis is more likely to result from overinstrumentation and periapical inoculation with infected debris, than from the extrusion of root filling materials per se.[19, 38]

Extensive apical enlargement may enhance the removal of infected dentin and disinfection of the apical part of the canal.[39, 40, 41] Contrary to this expectation, the extent of apical enlargement has not been associated with the outcome of initial treatment in studies[13, 15, 18, 25], while in one study[21] the outcome was poorer in teeth with a larger apical preparation.

Using an advanced anaerobic bacteriological technique during initial treatment, Sjögren et al.[42] reported that 94% of teeth in which the cultures were negative before root canal filling healed, in contrast to only 68% in teeth with positive cultures. Similarly, in a retreatment study[34] [414] 80% of teeth with negative cultures before root canal filling healed, compared to 33% of teeth with positive cultures. In a recent report, Waltimo et al.[43] [455] observed a better outcome in teeth treated in two sessions, where bacteria could not be recovered at the beginning of the second session compared with teeth where bacteria were recovered.

Sjögren et al. [393] have clearly demonstrated that intracanal infection cannot be reliably eliminated in a single treatment session. To maximize disinfection, application of intracanal medication is required.[40, 44-50] Therefore, a better prognosis is expected when treatment is performed in two sessions and an effective intracanal medication is used in the interim. However, the selected studies on initial treatment[16, 18, 26, 51] and retreatment[20] do not support this premise. Differences in healing rates reported in the relevant studies for treatment in one or two sessions have been in the range of 10%, inconsistent and statistically nonsignificant.

Siren et al.[51] who suggested that teeth treated in multiple visits were at a greater risk of becoming infected with Enterococcus faecalis, and developing persistent apical periodontitis.

Several of the initial treatment studies[15, 16, 18-21] and one retreatment study[20] have reported no significant association between the occurrence of flare-ups in the course of treatment and the outcome of treatment.

Materials and techniques used for treatment

Instrumentation technique:

Kerekes and Tronstad[15] suggested that the prognosis may be better using the "standardized" technique than with the "serial" technique. Three studies have reported no significant associations between the outcome of initial treatment and different aspects of canal preparation, including hand- or engine-driven instruments[37], the engine-driven instrument systems[32], and the degree of taper.[25]

Intracanal medication:

Survival analysis has suggested that teeth medicated with $Ca(OH)_2$ have a better chance of survival than teeth that have not been medicated or medicated with other materials.[52]

Sealer:

In a study of a large sample of teeth without and with apical periodontitis, Ørstavik et al.[13] suggested that the choice of sealer might influence the prognosis, but only in teeth without preoperative apical periodontitis. One sealer, Kloroperka N-Ø, was singled out as adversely influencing the outcome. Indeed, in a smaller sample of teeth with apical periodontitis[53] and in three subsequent studies of larger populations[17, 36, 54] comparable outcomes for different sealer types have been reported

Root canal filling technique:

Two recent studies have reported no significant associations between the outcome of initial treatment and different root-filling techniques, including hybrid and vertical compaction[25], and lateral and vertical compaction.[32]

Comprehensive technique:

The reports from the Toronto study[16] have identified a significant difference in outcome in teeth with apical periodontitis treated with two distinct schemes. Use of the classic Schilder technique, including flared canal preparation with ample irrigation and root canal filling with vertically compacted warm gutta-percha, resulted in a significant, 10% improvement in the healed rate compared with teeth treated with step-back or modified step-back instrumentation and lateral compaction of gutta-percha.[16] In the retreatment study from the same group[20],the difference in the healed rate between these two techniques was smaller and not significant.

Perforations of the pulp chamber or root, file breakage that prevents cleaning of the canal and massive extrusion of filling materials have been reported to impair the prognosis to varying extents.[15, 16, 19, 21]

Postoperative factors

An impaired outcome has been reported when a permanent restoration had not been placed in the long term after retreatment[20]. The type of restoration (temporary, permanent, filling, cast) has not been significantly associated with the outcome of initial treatment[16, 42] and

retreatment.[20] However, in one study[19] teeth restored with crowns or serving as bridge abutments had a poorer outcome than teeth restored with fillings. It is clear that the restoration, and particularly its failure, plays an important role in the survival or loss of root-filled teeth.[55] Posts have been implicated in longitudinal root fracture and tooth loss in approximately 9% of cases[55], and also in root perforations that impair the prognosis.[56]

Studies on the outcome of initial endodontic treatment and endodontic retreatment:

Study	Follow-up	Cases observed	Teeth without apical periodontitis	Teeth with apical periodontitis		
			Healed (%)	Healed (%)	Healing (%)	Functional*(%)
Strindberg 1956	0,5-10	258	93	80	-	-
Engström et al 1964	4-5	221	88	73	-	-
Kerekes & Tronstad 1979	3-5	491	97	90	-	-
Byström et al 1987	2-5	79	-	85	9	94
Ørstavik et al 1987	1-4	543	95	-	-	-
Eriksen et al 1988	3	121	-	82	9	91
Sjögren et al 1990	8-10	471	96	86	-	-
Ørstavik 1996	4	599	94	75	13	88
Sjögren et al 1997	<5	53	-	83	-	-
Trope et al 1999	1	76	-	80	-	-
Weiger et al 2000	1-5	67	-	78	16	94
Hoskinson et al 2002	4-5	200	88	74	-	97
Peters & Wesselink 2002	1-4.5	38	-	76	21	97
Friedman et al 2003	4-6	120	92	74	18	97
Farzaneh et al 2004	4-6	242	94	79	-	95
*Proportion of all teeth, with and without apical periodontitis						

Table 2: Selected follow-up studies on the outcome of endodontic initial treatment

Study	Follow-up	Cases observed	Teeth without apical periodontitis	Teeth with apical periodontitis		
			Healed (%)	Healed (%)	Healing (%)	Functional*(%)
Engström et al 1964	4-5	153	93	74	-	-
Sjögren et al 1990	8-10	266	98	62	-	-
Sundqvist et al 1998	4	54	-	74	-	-
Kvist & Reit 1999	4	47	-	58	-	-
Farzaneh et al 2004	4	103	97	86**	6	93
*Proportion of all teeth, with and without apical periodontitis **Excluding teeth with pre-operative perforations (78 percent healed with perforated teeth included)						

Table 3: Selected follow-up studies on the outcome of endodontic orthograde retreatment

In this case the prognosis (healing of apical periodontitis) is expected to be between 73% and 90%.

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Endodontic-Periodontal Lesion

Introduction

41 year old white Northern European female

Figure 1: Frontal view

Chief complaint

19 February 2008

Some tenderness from mandibular right first molar.

Medical history

Smokes approximately 10 cigarettes per day

Dental history

The patient has since 2007 undergone treatment for marginal periodontitis at the Department of Periodontology, UiO. She was referred to the Department of Endodontics, UiO, for treatment and examination of tooth 46.

Clinical findings

19 February 2008

Figure 2: Lateral view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	47	46	45
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD(mm)	4	8	4
Furcation involvement	-	II	-
Restoration	Comp. (MO)	Comp. (O)	No

Table 1: Clinical findings

Soft tissue: General gingival bleeding on probing and increased periodontal probing depths.

Dental:

Tooth 47: composite restoration on the mesial and occlusal aspects of the crown
Tooth 46: composite restoration on the occlusal aspect of the crown
Tooth 45: within normal limits

Radiographic findings

19 February 2008

Tooth 47: Normal lamina dura. No apical radiolucency. PAI 1. Reduced marginal bone level on the distal aspect of the tooth.

Tooth 46: Discontinued lamina dura on the mesial and distal roots. Apical radiolucency on mesial and distal roots (Ø 6mm). PAI 4. Root filled. Opaque filling material on the occlusal aspect of the crown. Reduced marginal bone level in the bi-furcation.

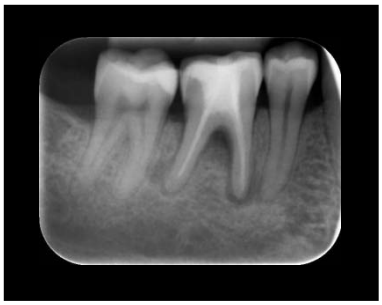

Figure 4: Periapical radiograph

Tooth 45: Normal lamina dura. No apical radiolucency. PAI 1. Some reduced marginal bone level.

Diagnosis

Tooth 46:

Pulpal: Necrotic (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Chronic periodontitis (K05.3)

Problem list

Endodontic-periodontal infection

Treatment plan

Orthograde endodontic retreatment tooth 46

Treatment

15 April 2008

Clinical examination. Tooth 46 diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Preparation of access cavity and localization of four root canals. Rubber dam. Removal of gutta-percha with Gates-Glidden burs and Hedstroms files with the use of small amounts of chloroform. Root canal length was determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was also done mechanically with NiTi hand files and PreRace® to size:

MB R40/18.5 mm/mesiobuccal cusp
ML R45/19 mm/mesiobuccal cusp
DB R55/20.5 mm/mesiobuccal cusp
DL R60/20.5 mm/mesiobuccal cusp

1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

Figure 5: Working length radiograph

Figure 6: Working length radiograph for the two distal root canals

10 June 2008

The patient was asymptomatic from tooth 46. The tooth was not sensitive to percussion or percussion. 1.8 ml Septocaine®. Rubber dam. Removal of temporary filling. Root canal disinfection was done with with 1% NaOCl and 17% EDTA. The canals were filled with Epiphany® and Resilon®. A temporary filling with IRM was placed. The radiograph showed evidence of healing. The patient was scheduled for periodontal surgery in the 4th quadrant at the Department of Periodontology, UiO.

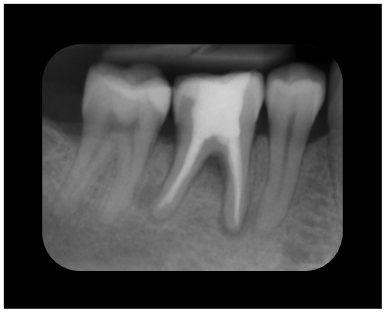

Figure 7: Radiograph of completed root filling

Result

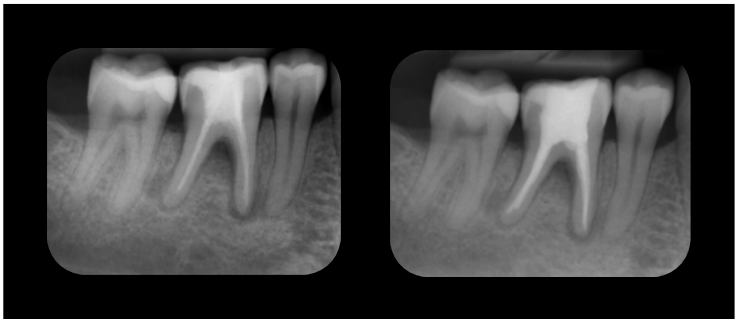

Figure 8: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: good

Tooth: uncertain - because of marginal periodontitis with involvement of the bi-furcation.

Follow-up examination

3 March 2009

Extra-oral examination: within normal limits

Intra-oral examination:

	47	46	45
Cold	Yes	No	Yes
Percussion	No	No	No
Palpation	No	No	No
Mobility	No	No	No
PPD (mm)	4	6	3
Furcation involvement	-	II	-
Restoration	Comp. (MO)	IRM (O)	No

Table 2: Clinical findings

The radiograph showed evidence of apical healing on both mesial and distal roots.

The patient was advised to seek dental treatment to replace IRM filling with a permanent restoration on tooth 46.

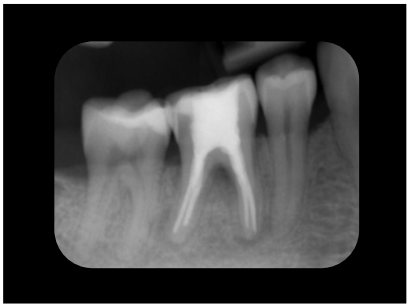

Figure 9: Periapical radiograph at follow-up examination

Figure 10: Frontal view at follow-up examination

Figure 11: Lateral view at follow-up examination

Discussion

Pulpal and periodontal problems are responsible for more than 50% of tooth mortality.[1] According to Dietrich et al.[2] apicomarginal defects are a result of either endodontic infection, periodontal infection, or both. He classifies the defect into different categories (Fig.13).

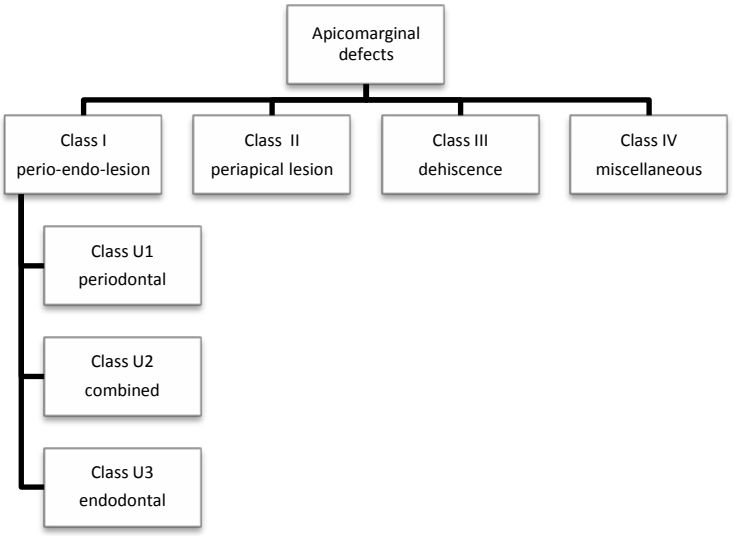

Figure 12: Dietrich et al. 2002

He states that the discrete subdivision of the class I lesions is a difficult task and not always possible.

The pathways of communication and therefore for the extension of disease from a periodontal pocket to the pulp are through patent dentinal tubules, lateral canals, and the apical foramen or foramina.[3,4] Whether such relationship result in pulp necrosis have been looked at in several studies. Tagger and Smukler[5] removed roots from molar teeth that had periodontal disease so severe that root amputation was required, and found that none of the pulps of the resected roots showed inflammatory changes. Czarnecki and Schilder[6] (performed a histological study of intact, caries-free teeth and compared the pulps of teeth with and without periodontal disease. They concluded that no correlations could be made between either the presence or severity of periodontal disease and pulpal changes.

Miyashita et al.[7] investigated whether the infected pulp can be of influence on periodontal health. They used paired samples where a root filled tooth with apical periodontitis was compared to a healthy control tooth. The patients had minor degrees of periodontal disease. The study failed to demonstrate a correlation between a reduced marginal bone support and endodontic status.

Nyman and Lindhe[8] evaluated a group of patients who had lost 50% or more periodontal bone support and endodontically treated teeth. The bone height was followed over a period of time and they found that it was maintained equally well around endodontically treated teeth as around not root filled teeth.

The follow-up radiograph showed no definite evidence of healing of the marginal lesion, but good healing of the apical lesion. The endodontic retreatment was necessary because of the infection causing the apical periodontitis.

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Trigeminal Neuralgia

Introduction

69 year old white Northern European female

Figure 1: Frontal view

Chief complaint

9 April 2008

Intense pain from area of the maxillary right canine. The pain gets elevated by touching the skin in the area of the canine to the infra orbital margin.

Medical history

The patient says she has “a good life”.

Important events in her life the last decade:

1996: stabbed by knife
2001: lost her mother
2004: coronary artery bypass surgery
2005: aortic aneurysm and kidney surgery
2007: surgery on the aorta
2006- to date: dialysis each second week because of lost kidney function

Smokes approximatly10 cigarettes pr day

Medications: Marevan® (warfarin) and three different types of medications against high blood pressure (she does not remember the names). Urologist prescribed Lyrica® for dental pain on 27th March 2008.

Dental history

1980s: fixed partial denture from teeth 12 to 17 and from teeth 23 to tooth 26

2007: extracted tooth 46 and removable partial denture lower jaw

November 2007: Intense pain from right side of the nose. Started endodontic treatment of tooth 13 at her general dentist. Perforation of mesial aspect of root (coronal segment) during access cavity preparation.

February 2008: The pain was increasing in insensitivity. Referred to endodontic specialist, started endodontic treatment of apical periodontitis tooth 17.

March 2008: Intense pain. Referred to the Department of Endodontics, UiO, for examination regarding her oral-facial pain.

Clinical findings

9 April 2008

Extra-oral examination: within normal limits - normal skin color

Intra-oral examination:

	27	26	25	24	23	22	21	11	12	13
Cold	No	-	-	-	No	Yes	Yes	Yes	Yes	No
Percussion	No	-	-	-	Yes (+)	No	No	No	No	No
Palpation	No	-	-	-	No	No	No	No	No	No
Mobility	No	-	-	-	No	No	No	No	No	No
PPD (mm)	4	-	-	-	7 (M)	4	3	3	3	4
Restoration	Abutment	-	-	-	Abutment	Abutment	No	No	Am.(D)	Abutment

Table 1: Clinical findings

Soft tissue: Periodontal pocket on the mesial aspect of tooth 13.Removable partial denture for replacement of teeth 46, 45, 44, 34 and 35. Good oral hygiene.

Figure 21: Lateral view - right

Figure 3: Lateral view - left

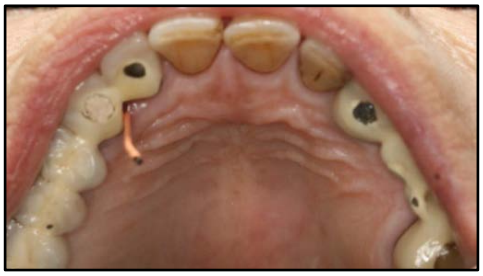

Figure 4: Occlusal view with gutta-percha cone for tracing periodontal pocket tooth 13

Pain questionnaire:

level of pain 0-10	10
area	1. quadrant (also started in 4. quadrant)
circumscribed	yes
diffuse	no
spontaneous	yes
triggered from	touching, chewing, tooth brushing
constant	no
fluctuating, unstable	yes
comes and goes	yes
aching pain	no
sharp, shooting	yes
pulsating	no
started	November 2007
frequency	daily, worse in the evening
duration of the pain	seconds to minutes
factors which increase the pain	touching, chewing, tooth brushing
factors which decrease the pain	none - Pinex Forte® (500 mg paracetamol with 30 mg codeine) does not decrease the pain

Radiographic findings

9 April 2008

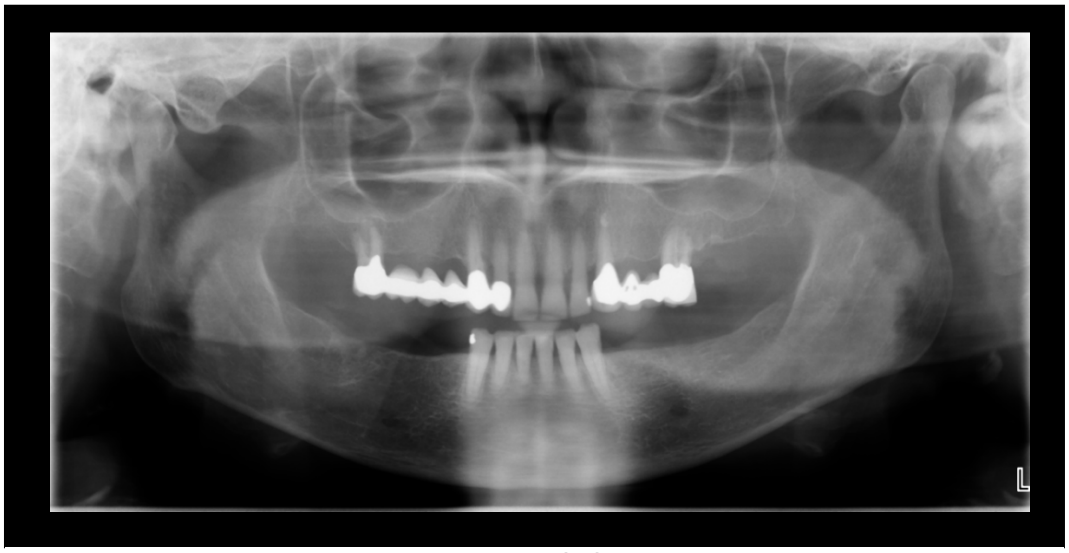

Figure 5: OPG

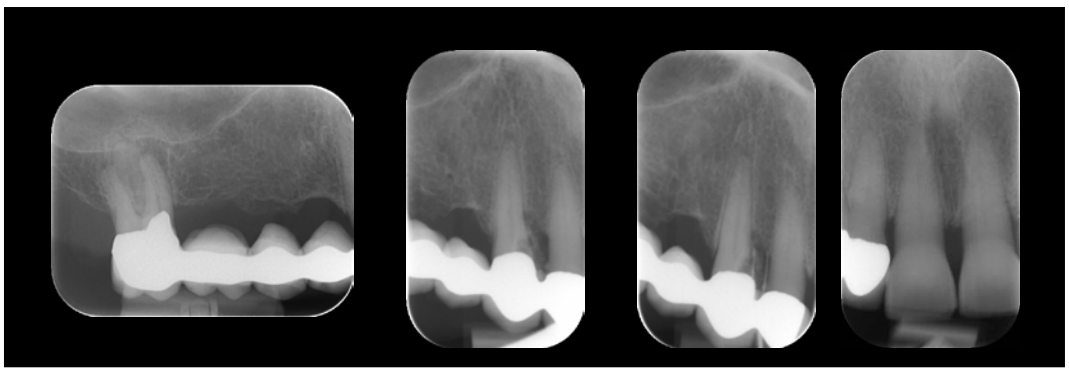

Figure 6: A - tooth 17 B - tooth 13 C - tooth 13 with GP D - teeth 12, 11 and 13

Tooth 17: Discontinued lamina dura. Apical radiolucency mesiobuccal root (Ø 5mm). PAI 3. Abutment for FPD from tooth 17 to tooth 12. Some reduced marginal bone level.

Tooth 13: Discontinued lamina dura. Apical radiolucency (Ø 2mm). PAI 3. Abutment for FPD from tooth 27 to tooth 23. Reduced marginal bone level on the mesial aspect. Perforation of mesial part of the root in the coronal segment.

Tooth 12: Normal lamina dura. No apical radiolucency. PAI 1. Abutment for FPD from tooth 27 to tooth 22.

Tooth 11: Normal lamina dura. No apical radiolucency. PAI 1. Some reduced marginal bone level.

Tooth 21: Normal lamina dura. No apical radiolucency. PAI 1. Some reduced marginal bone level.

OPG gives no other radiographic findings, except that the teeth, 18, 16, 15, 14, 24, 25, 27, 28, 38, 37, 36, 35, 34, 44, 45, 46, 47 and 48, are missing.

Diagnosis

After the anamnesis and clinical examination, the patient was tentatively diagnosed with trigeminal neuralgia (G50.0). An alternative, but less likely diagnosis was acute apical periodontitis (K04.5) tooth 13.

Problem list

Treatment of trigeminal neuralgia

Treatment plan

Prescription of Lyrica® for trigeminal neuralgia
Consultation with her dentist

Treatment

9 April 2008

Clinical examination. The patient diagnosed with trigeminal neuralgia. She had been advised to start with Lyrica® by her urologist. Agreed with the patient that her doctor should prescribe Lyrica®. Telephone consultation with her dentist. Decision made that the endodontic specialist who started treatment of tooth 17 should complete the treatment of tooth 17 and tooth13.

27 May 2008

The patient was still having intense pain, but the pain was not so regular. Endodontic treatment of tooth 17 and tooth 13 not yet complete.

23 October 2008

The patient was asymptomatic. She had been diagnosed with trigeminal neuralgia by specialist in neurology. She was advised to use Lyrica®. Endodontic treatment of tooth 17 and tooth 13 completed by endodontic specialist.

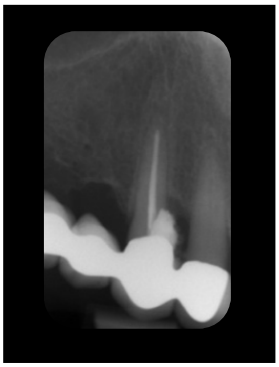

Figure 7: Tooth 13 after endodontic treatment

Result

The patient is asymptomatic with Lyrica®.

Evaluation

No endodontic treatment given at the Department of Endodontics, UiO, but the pain has ceased with use of Lyrica®.

Prognosis

The prognosis of treatment of trigeminal neuralgia with Lyrica® is often good.

Follow-up examination

15 April 2009

Telephone consultation with the patient: The patient was asymptomatic, and did not see any need for further consultation, regarding her trigeminal neuralgia, at the Department of Endodontics, UiO.

Discussion

Trigeminal neuralgia is a paroxysmal neuralgia. Trigeminal neuralgia usually affects one or at most two divisions of the fifth cranial nerve.[1] The mandibular and maxillary divisions are most commonly involved together. The pain is unilateral 96% of the time. Touching and washing of the face, tooth brushing, shaving, chewing, talking or even cold wind against the face may set the trigger and result in pain. Between the attacks, patients are complete pain-free. Long remissions for months or years are not uncommon but tend to decrease with increasing age.[2] Trigeminal neuralgia is twice as common in women as in men and usually starts after the age of 50.[3] Dental pathosis may be minimal or absent. Obvious dental pathosis should be treated. A group reported that 61% of the cases with paroxysmal neuralgias or trigeminal neuralgia were incorrectly diagnosed and treated for dental conditions.[4] Onset of classic trigeminal neuralgia may be quiet sudden. The onset may follow remission produced by previous dental treatment.

Diagnosis	History
	Spontaneous onset
Trigeminal neuralgia, Type 1	*>50% episodic pain*
Trigeminal neuralgia, Type 2	*>50% constant pain*
	Trigeminal injury
Trigeminal neuropathic pain	*Unintentional, incidental trauma*
Trigeminal deafferentation pain	*Intentional deafferentation*
Symptomatic trigeminal neuralgia	Multiple sclerosis
Postherpetic neuralgia	Trigeminal *Herpes zoster* outbreak
Atypical facial pain[a]	Somatoform pain disorder

[a] Cannot be diagnosed by history alone.

Table 2: Classification scheme for facial pains[5]

The first choice for treatment for idiopathic paroxysmal neuralgia is the drug carbamazepine (Tegretol).[6] Baclofen (Lioresal), gabapentin (Neurontin), pregabalin (Lyrica) and diphenylhydation (Dilantin) are also used, alone or in combination. In those infrequent instances for which these medications or combinations thereof are ineffective, or the patient becomes refractory to the medications or cannot tolerate them, either owing to severe drowsiness or frank allergy, neurosurgical intervention remains an option. In trigeminal neuralgia, gamma knife radiosurgery is the newest alternative for treatment. The targeted cells in the trigeminal sensory root adjacent to the pons, are necrotized. The results have been good[7], but there are no long-term follow-up studies.

In this case the patient were probably suffering from trigeminal neuralgia - type 1, because the patient experienced more than 50% episodic pain.

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Separated Endodontic Instrument - Apicoectomy with Retrograde Filling

Introduction

67 year old white Northern European male

Figure 1: Frontal view

Chief complaint

30 October 2007

Some tenderness from maxillary left premolars. Referred to the Department of Endodontics, UiO, from the dental student clinic, UiO, for examination and treatment of pain from maxillary left premolars.

Medical history

Albyl E (acetylsalicylic acid) 75mg per day because of an abnormal narrowing in a blood vessel in the neck (stenosis).

Dental history

Tooth 25:

1970's - root canal treatment and full gold crown (FGC) with post

The patient is attending regular dental treatment at the dental student clinic, UiO.

Clinical findings

30 October 2007

Figure 2: Lateral view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	24	25	26
Cold	No	No	No
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	4	4	4
Restoration	FGC	FGC	FGC

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

Tooth 24: full gold crown
Tooth 25: full gold crown
Tooth 26: full gold crown

Radiographic findings

30 October 2007

Tooth 24: Normal lamina dura. PAI 1. Metal crown with post. Root canal filling of a buccal and a palatinal root. Extrusion of root filling material from the palatinal root. Normal marginal bone level.

Figure 4: Periapical radiograph

Tooth 25: Broken lamina dura. Circumscribed apical radiolucency (Ø 5 mm). PAI 3. S-shaped root morphology. Root canal filling approximately 5 mm short of the apex. Separated endodontic instrument in one of the two canals. Metal crown with post. Normal marginal bone level.

Tooth 26: Normal lamina dura. PAI 1. Metal crown with post. Root canal filled. The mesiobuccal root shows root canal filling ending approximately 6 mm short of the radiographic apex. Normal marginal bone level.

Figure 5: OPG

Diagnosis

Tooth 25:

Pulpal: Root filled (K04.19)

Apical: Chronic apical periodontitis (K04.5)

Marginal: Within normal limits

Problem list

Fractured endodontic instrument in one of the canals

Obliteration of root canals not filled to the correct working length

Post and crown

Treatment plan

Apicoectomy with retrograde filling tooth 25

Treatment

23 April 2008

Pre-operative procedure. Xylocaine Adrenaline® 3 x 1.8 ml. Marginal incision from the distal aspect of tooth 27 to the mesial aspect tooth 23. Vertical releasing incision at the mesial aspect of tooth 23. Elevation of mucoperiostal flap. Osteotomy. Curettage of lesion. Root-end resection of approximately 3 mm of the root. The separated instrument in the canal was not removed. Ultrasonic preparation of retrograde cavity. Homeostasis with stryphnon gauze and ferric sulfate. Filling of retrograde cavity with white MTA (Angelus, Brazil). Suturing of horizontal incision with four 4-0 Supramid® sutures, and vertical realizing incision with three 4-0 silk sutures. Post-operative instructions. Patient given six tablets of 500 mg paracetamol to take one tablet every fourth hour the first day after surgery.

Figure 6: Root of tooth 25 root-end resected

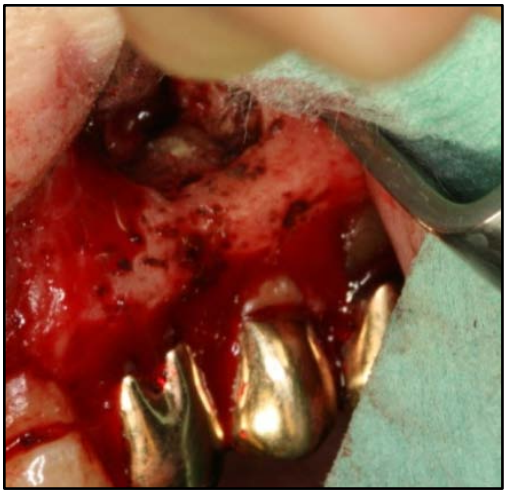

Figure 7: White MTA as retrograde filling

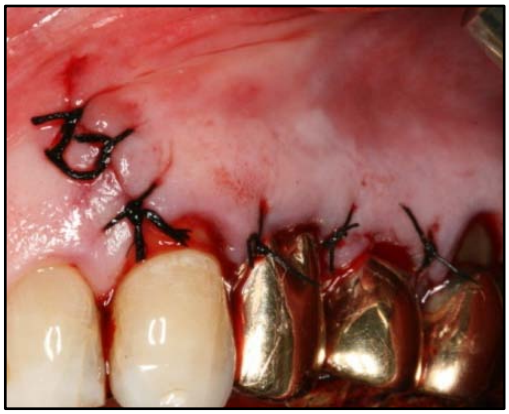

Figure 8: Flap sutured with Supramid® and silk sutures

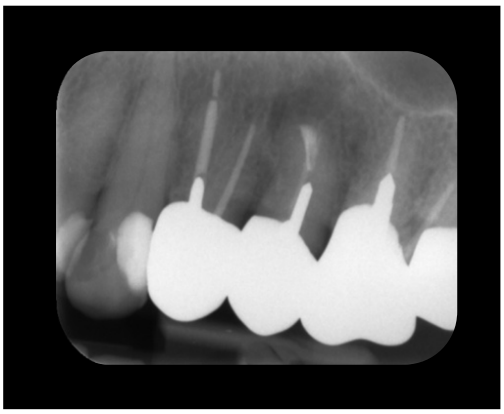

Figure 9: Post-operative periapical radiograph

30 April 2008

Removal of sutures. Good healing. No patient discomfort.

Figure 10: Before removal of sutures

Figure 11: After removal of sutures

Result

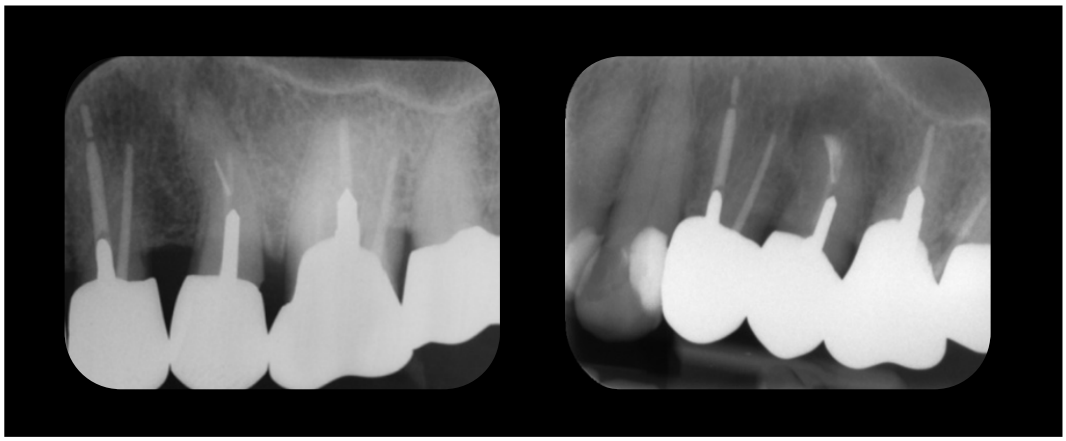

Figure 12: Pre- and post-treatment periapical radiographs

Evaluation

No complications during treatment. Evidence of good soft tissue healing.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

10 December 2008 (eight months after apicoectomy with retrograde filling)

No clinical signs or symptoms. The radiograph showed complete healing of apical lesion tooth 25.

Figure 13: Periapical radiograph at follow-up examination

Discussion

Treatment outcome of surgical endodontics:

There is no clear consensus that small (<5 mm) lesions heal more favorably than larger lesions.[1] Lesions >10 mm do show a lower rate of complete healing and a greater incidence of incomplete healing by scar tissue formation .[2]

Wang et al.[3] conducted a prospective study of endodontic surgery reviewed at 4 and 8 years. The overall healing rate was 74%. This study found that the healed rate was significantly higher for teeth with small (<5 mm) lesions. When the preoperative lesion was >5 mm, the risk of the persistence of the lesion increased almost fourfold. The other significant factor was the length of the root filling. Other factors did not influence the outcome. These factors were the pre-operative categories of age, sex, tooth type and location, signs and symptoms, radiographic appearance of the borders of the lesion, type of root filling material and its technical quality, the periodontal condition, the presence of a perforation, a history of a root filling or retreatment, a history of prior surgery, how the tooth was restored, and whether a post was present. Intra-operative factors were the surgical procedure (apicoectomy, root-end filling, root-end non-surgical retreatment), use of a hemostatic agent, choice of root-end filling material, the root-end preparation depth, any complications during the procedure, whether antibiotics were prescribed, and the results of a biopsy. The post-operative categories included signs and symptoms, how the tooth was restored and whether a post was present, the incidence of root fracture, and the presence of apical periodontitis. The size of the apical lesion is a significant factor influencing a positive outcome following surgical retreatment.

Non-surgical retreatment of the root canals before surgery improves the prognosis for surgery.[4, 5, 6, 7. 8] However, there appears to be no correlation between the quality of the root filling and surgical success.[1]

Using microsurgical techniques, a resection of 3 mm is considered sufficient to eliminate apical pathology.[9] Regarding root-end filling materials, many materials have been studied with inconsistent results.[1] Attention has in the last decades been focused on IRM, Super EBA, dentin-bonded composite and most recently mineral trioxide aggregate, MTA. MTA appears to be very tissue tolerant, and promotes cementum regeneration.[10]

There should be little difference among specialists performing endodontic surgery. However, the outcome could be influenced by experience and skill.[1] Rahbaran et al.[11] compared the outcome of surgery performed in the oral surgery and endodontic units of a teaching hospital. The records were reviewed 4 years following surgery. The complete healing rate in the endodontic unit was approximately double that of the oral surgery department.

Study	Examined sample (teeth)	Follow-up (years)	Treatment approach (%)		Outcome (%)		
			Re-treatment and surgery	Surgery	Healed	Healing	Functional
Zuolo et al (2000)	102	1-4	100	0	91	-	92
Jensen et al (2002)	60*	1	0	100	73	14	≥90
Chong et al (2003)	108	2	0	100	90	6	≥96
Wang et al (2004)	94	4-8	37	63	74	-	91
Gagliani (2005)	231 (roots)	5	0	100	78	10	89
Lindeboom et al (2005)	100	1	0	100	89	10	99
Von Arx et al (2007)	191	1	0	100	84	10	≥94

* Only teeth treated with Retroplast included

Table 2: Follow-up studies on the outcome of apical surgery

In this case the prognosis of the apical surgery is expected to be between 75 to 90%.

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Vertical Root Fracture

Introduction

40 year old Sri Lankan female

Figure 1: Frontal view

Chief complaint

4 June 2008

Swelling and lingering pain from mandibular right first molar. Referred to the Department of Endodontics, UiO, from dental student clinic, UiO, for examination and treatment of tooth 46.

Medical history

Non-contributory

Dental history

Tooth 46:

2004: Non-surgical endodontic treatment

May 2008: Swelling and pain – Rx Apocillin 4 x 660mg/7 days

Figure 2: Periapical radiograph May 2008

Clinical findings

4 June 2008

Figure 3: Lateral view

Figure 4: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	45	46	47
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	3	4	4
Restoration	No	Am. (OD) Enamel-dentin fracture (ODB)	No

Table 1: Clinical findings

Soft tissue: Swelling of the oral mucosa at the buccal aspect of tooth 46.

Dental:

Tooth 45: within normal limits

Tooth 46: amalgam restoration on the occlusal and distal aspects, enamel-dentin cusp fracture of the distobuccal cusp

Tooth 47: within normal limits

Radiographic findings

4 June 2008

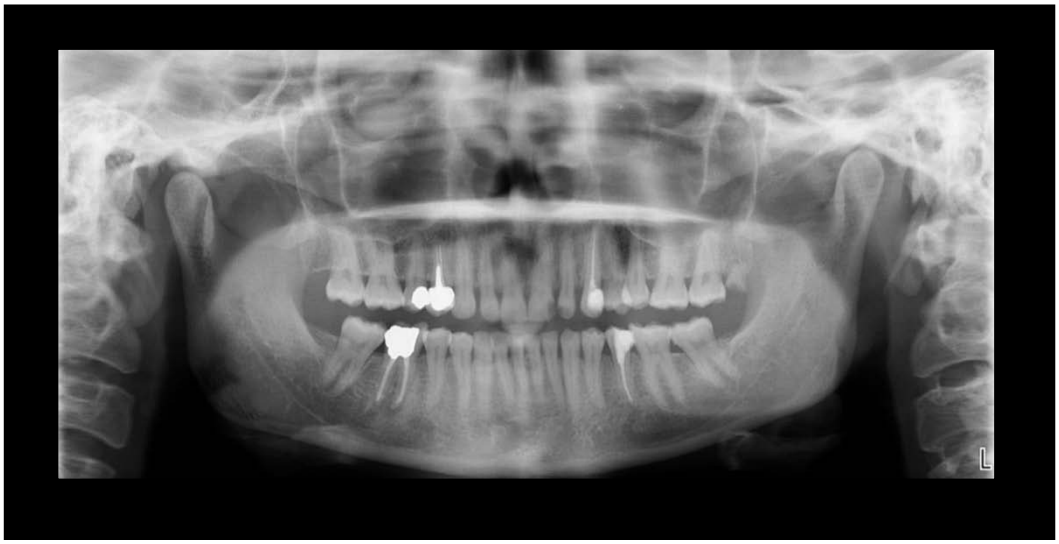

Figure 5: OPG

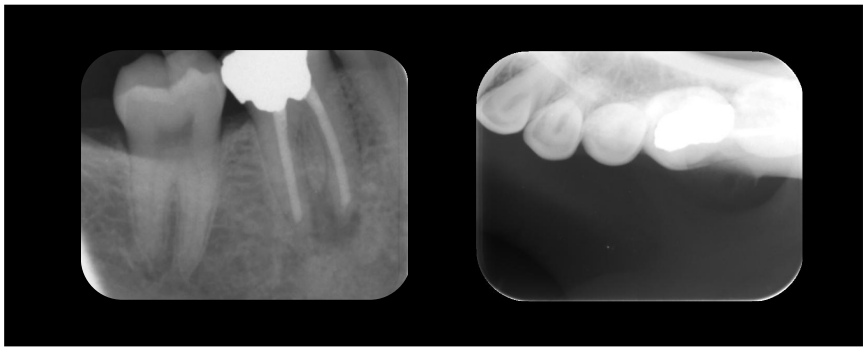

Figure 6: Periapical radiograph Figure 7: Occlusal radiograph

Tooth 45: Normal lamina dura. PAI 1. Normal marginal bone level.

Tooth 46: Discontinuation of lamina dura apically. Apical radiolucency (Ø 6 mm). PAI 4 on the mesial root. The root canal filling appears dense and good. Radiopaque material on the distal and occlusal aspects of the crown. Normal marginal bone level. Occlusal radiograph shows evidence of soft tissue expansion on the buccal aspect of tooth 46.

Tooth 47: Normal lamina dura. PAI 1. Normal marginal bone level.

Note: OPG shows apical radiolucency tooth 14.

Diagnosis

Tooth 46:
Pulpal: Root filled (K04.19)
Apical: Periapical abscess without sinus tract (K04.7)
Marginal: Within normal limits

Problem list

Anatomic - surgery in close proximity to the mental foramen and the inferior alveolar nerve.

Treatment plan

Apicoectomy with retrograde filling 46

Treatment

4 June 2008

Pre-operative procedure. Xylocaine Adrenaline® 3 x 1.8 ml. Marginal incision from the distal aspect of tooth 47 to the mesial aspect tooth 43. Vertical releasing incision at the mesial aspect tooth 43. Elevation of mucoperiostal flap. Removal of cyst like tissue (Ø 12 mm) on the buccal aspect of the mesial root of tooth 46. Biopsy. After removal of tissue, the entire mesial root was exposed and a fracture line was evident in a bucco-lingual direction. The tooth was diagnosed with vertical root fracture. Methylene blue was used for staining the root. Patient was informed of the vertical root fracture and the treatment alternatives (hemisection or extraction). Extraction of the tooth was performed. Suturing with 4-0 Supramid®. Post-operative instructions. Patient given six tablets of 400 mg Ibuprofen to take one tablet every fourth hour the first day after surgery.

Figure 8: Cystic tissue on the buccal aspect of tooth 46

Figure 9: No bone covering the mesial root of tooth 46

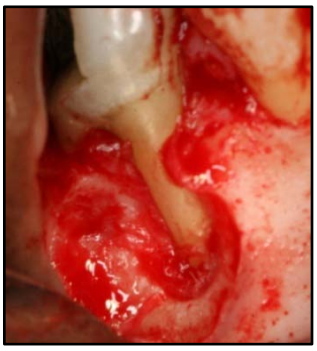

Figure 10: Vertical root fracture of the mesial root tooth 46

Figure 11: Methylene blue staining of vertical root fracture

Figure 12: Suturing of flap

10 June 2008

Suture removal. Some secondary wound healing evident. Patient without symptoms.

Biopsy diagnosed the lesion as a cyst.

Figure 13: Wound healing after suture removal

Result

Tooth extracted

Follow-up examination

9 December 2008 (six months after surgical extraction of tooth 46)

Patient is without discomfort after extraction of tooth 46.

Figure 14: Lateral view at follow-up examination

Discussion

Vertical root fractures (VRF) are according to the American Association of Endodontists "a longitudinal orientated fracture of the root that originate the apex and propagates to the coronal part".[1] From the horizontal aspect, the fracture initiates in the root canal wall and extends to the root surface, involving either the one side (incomplete) or both sides (complete fracture).[2] Often the definitive diagnosis is made years after extensive treatment of the tooth. VRF occur mostly in endodontically treated and restored teeth. Some root canal procedures, such as excessive removal of dentin during canal preparation[3] and post space preparation and post placement,[4] have been identified as causes of VRF. The most susceptible roots to fracture are those in which the mesiodistal diameter is narrow compared to the buccolingual dimension.[5] Examples of such teeth are maxillary and mandibular premolars, mesial roots of mandibular molars, and mandibular incisors.[6] Tamse et al.[7] found that these were the most frequently fractured roots and teeth (79%).

Gher et al.[8] showed a low incidence (2.3%) of VRF. However, the percentage of extracted teeth with VRF can be much higher, between 10 and 20%.[9, 10]

The constant ingress of bacteria into VRFs provides an open pathway from the oral cavity to the supporting periodontal and alveolar tissues. Various treatment modalities have been suggested to save vertically fractured roots, but all of them have proved to be ineffective in the long run.[11]

In this case a deep periodontal pocket was not found at the clinical examination. A deep periodontal pocket is often a sign of VRF.

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Maxillary Lateral Tooth with Apical Abscess

Introduction

24 year old white Northern European male

Figure 1: Frontal view

Chief complaint

3 April 2008

Pain from the maxillary left lateral incisor. He has had periodic elevations of the left anterior palate.

Medical history

Non-contributory

Dental history

March 2007: Acute dental consultation at his general dentist, because of pain and swelling from tooth 22. He was prescribed Apocillin 4 x 660mg/7 days for acute apical periodontitis tooth 22. Referred to the Department of Endodontics, UiO, for examination and treatment of tooth 22.

Clinical findings

30 January 2008

Figure 2: Frontal view

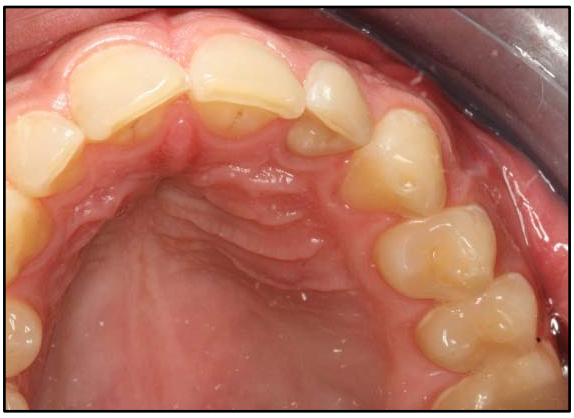

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	21	22	23
Cold	Yes	No	Yes
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD(mm)	2	2	2
Restoration	None	Comp. (P)	None

Table 1: Clinical findings

Soft tissue: General gingival bleeding on probing. Periodontal pockets within normal limits. No sinus tract. Fluctuating elevation of the palate mucosa in the area of teeth 21, 22 and 23.

Dental:

Tooth 21: within normal limits
Tooth 22: composite restoration on the palatinal aspect
Tooth 23: within normal limits

Radiographic findings

3 April 2008

Tooth 21: Normal lamina dura, no apical radiolucency. PAI 1.

Tooth 22: Discontinued lamina dura. Large circumscribed apical radiolucency (Ø 15 mm). PAI 4. Wide root canal. Radiographic findings in the coronal part of the root can be diagnosed as dens invaginatus. Small radiopaque material in the crown.

Tooth 23: No widening of the lamina dura and no apical radiolucency. PAI 1. Small radiopaque material in the crown. Root is in near proximity to the radiolucency.

Figure 4: Periapical radiograph

Diagnosis

Tooth 22:

Pulpal: Necrotic (K04.1)
Apical: Apical abscess without sinus tract (K04.7)
Marginal: Within normal limits

Problem list

Wide root canal
Large apical lesion

Treatment plan

Orthograde endodontic treatment of non-vital pulp tooth 22
Apicoectomy with retrograde filling tooth 22

Treatment

3 April 2008

Clinical examination. Tooth diagnosed with apical abscess without sinus tract. 1.8 ml Septocaine®. Rubber dam. Preparation of access cavity and localization of a wide root canal. The canal was filled with excudate. A microbiological sample of the canal content was taken. Root canal length was determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically with Hedstroms files to size:

One canal: R90/20 mm/incisal edge
Irrisafe® used for further cleaning of the canal. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

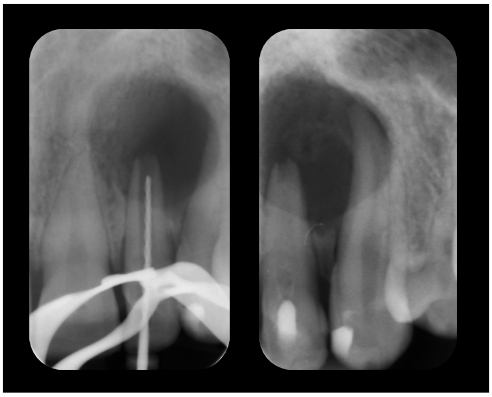

Figure 5: Working length radiograph

Figure 6: $Ca(OH)_2$ intra-canal dressing

8 April 2008

The patient sought emergency consultation because of severe pain and swelling from tooth 22. Diagnosed as acute apical abscess tooth 22. Prescription of Dalacin® (clindamycin) 3 x 500 mg/7 days.

14 April 2008

The microbiological sample showed:

Treponema denticola
Porphyromonas gingivalis
Eubacterium saburreum
Streptococcus intermedius
Prevontella nigrescens
Fusobacterium nucleatum subsp vincentii
Treponema socranskii sunsp socranskii
Parvimonas micra
Actinomyces viscosus
Actinomyces gerencseriae
Actinomyces israelii
Aggregatibacter actinomycetencomitans
Tannerella forsythia

Treponema denticola was dominant. DNA probing was used.

29 May 2008

The patient was asymptomatic from tooth 22. The tooth was still sensitive to percussion. 1.8 ml Septocaine®. Rubber dam. Removal of temporary filling. Root canal disinfection was done with Irrisafe® with 1% NaOCl, 2% CHX and 17% EDTA. A long-term intra-canal dressing with $Ca(OH)_2$ was placed, and IRM was applied as a temporary filling.

Figure 7: Access cavity

14 October 2008

The patient had been asymptomatic from tooth 22 since the last treatment on May 29th. The tooth was still sensitive to percussion. It was decided that the tooth should be root filled, and an appointment for apicoectomy tooth 22 was made.
1.8 ml Septocaine®. Rubber dam using the split dam technique. OralSeal® was used to achieve a dry operational area. Removal of temporary filling. Root canal disinfection was done with 1% NaOCl, 2% CHX and 17% EDTA. The root canal was filled with white MTA (ProRoot-MTA®) in a length of 8 mm. A cotton pellet with saline water was applied over the MTA. On top of the cotton pellet, a temporary filling with IRM was placed.

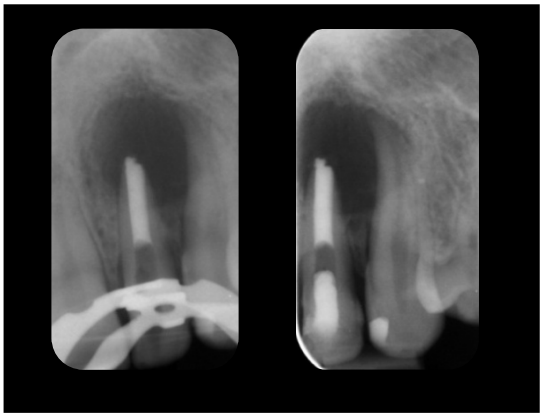

Figure 8: MTA in the canal

Figure 9: MTA, cotton pellet and IRM

Figure 10: White MTA in the canal

23 October 2008

Pre-operative procedure. Septocaine® 3 x 1.8 ml. Marginal incision from the mesial aspect of tooth 21 and to the distal aspect of tooth 23. Vertical releasing incisions of a length of 5 mm at the mesial aspect tooth 21 and a length of 10 mm at the distal aspect tooth 23. A 3CK micro blade was used for the incisions. Elevation of mucoperiostal flap. A pathological fenestration

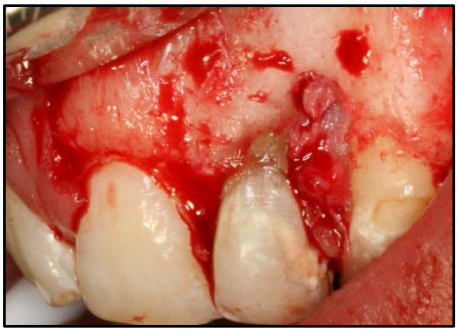

Figure 11: Elevation of surgical flap

of the cortical buccal bone was evident approximately 3 mm from the marginal bone crest between teeth 22 and 23. Osteotomy. Curettage of lesion. Biopsy of the lesion. The palatinal cortical bone had also a pathological perforation. Root-end resection of 3 mm of the root. The root-end was inspected through the SOM, and no fracture was found. The adaptation of the white MTA to the root canal walls was judged as good. The operation site was inspected and rinsed with sterile saline. Suturing with five 6-0 silk sutures. Post-operative instructions given and the patient informed about the prognosis of the tooth. Patient given six tablets of 400 mg Ibuprofen to take one tablet every fourth hour the first day after surgery. A prescription of Apocillin® (phenoxymethylpenicillin) 4 x 660 mg/7 days was also given.

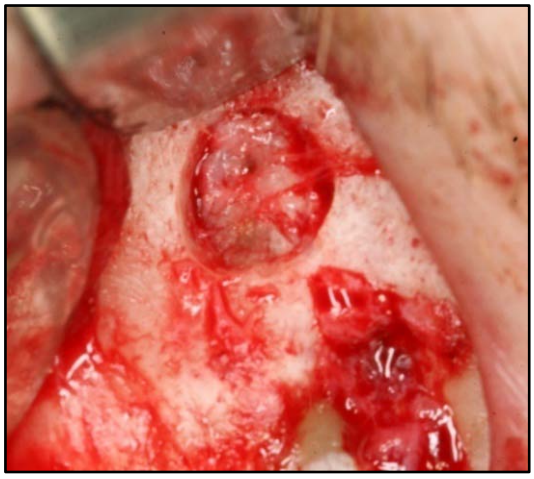

Figure 12: Granulation tissue after osteotomy

Figure 13: Granulation tissue removed and root resection performed

Figure 14: Flap sutured with 6-0 silk sutures

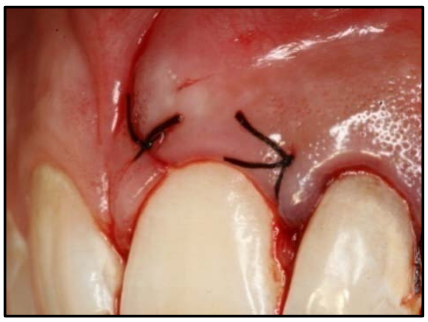

Figure 15: Suturing at the junction between the mesial vertical releasing incision and the horizontal marginal incision

30 October 2008

Suture removal. Evidence of good soft tissue healing. The patient was with no discomfort from the surgical site.

Figure 16: Wound healing before removal of sutures

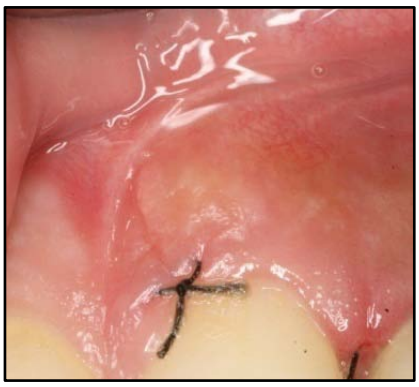

Figure 17: Wound healing at the junction between the mesial vertical releasing incision and the horizontal marginal incision before removal of sutures

Figure 18: Wound healing after removal of sutures

Figure 19: Occlusal view after removal of sutures

Figure 20: Composite filling on the palatinal aspect of tooth 22

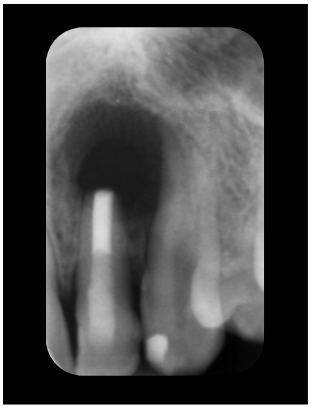

Figure 21: Post-operative periapical radiograph

Rubber dam. Temporary filling and cotton pellet were removed, and replaced by a composite restoration (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Flow (A3) in the apical part, Filtek™ Supreme (A3D and A3B) in the coronal part). Teeth 21 and 22 were sensitive to ice-test.

The histological examination of the lesion showed a partial epithelium lined cystic wall with intense chronic to acute inflammation, consistent with a radicular cyst.

Result

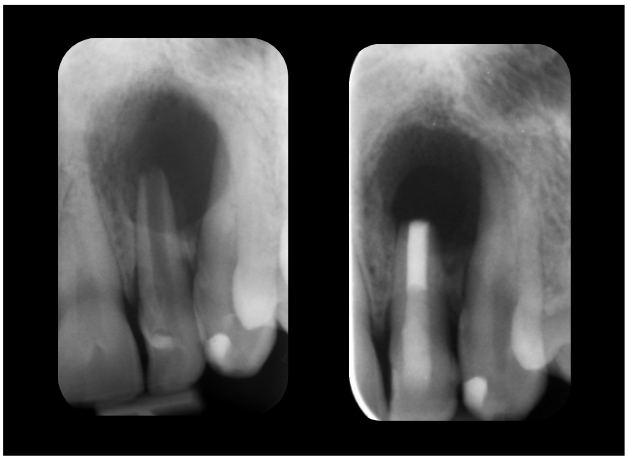

Figure 22: Pre- and post operative periapical radiographs

Evaluation

No complications during treatment. The root filling appeared dense and good.

Prognosis

Endodontic: uncertain – because of thin root canal walls

Tooth: uncertain - because of thin root canal walls and a higher risk of fracture

Follow-up examination

17 April 2009 (six months after apicoectomy)

The patient was asymptomatic. No sensitivity from percussion or palpation test. Teeth 21 and 23 were sensitive to ice-test.

Figure 23: Frontal view at follow-up examination

Figure 24: Occlusal view at follow-up examination

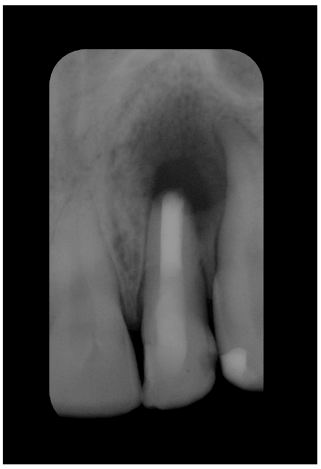

Figure 25: Periapical radiograph at follow-up examination

The radiograph showed evidence of healing (Fig. 25).

Discussion

Within infected root canals, the inner layer of dentine next to the pulp space contains a large number of microorganisms.[1,2] One aim of root canal instrumentation is to remove the inner layer of dentine together with the bacteria.[3] However, in many cases bacteria have penetrated deeply into the dentinal tubules to such an extent that they cannot be removed mechanically.[1, 4, 5] No technique presently available is able to remove the entire inner layer of infected dentine from a root canal.[6, 7, 8, 9] Consequently, bacteria are likely to remain in dentinal tubules after instrumentation.[10, 11]

The antimicrobial effect of calcium hydroxide, the most popular intra-canal medicament, is related to the release of hydroxyl ions in an aqueous environment; however, the free radical rarely diffuses away from the bulk of the material.[12] In addition, dentine has an inherent buffering capacity to reduce the pH of calcium hydroxide pastes.[13] Thus, calcium hydroxide will have a limited lethal effect on bacteria within dentinal tubules and other inaccessible areas such as apical canal ramifications and isthmuses and it remains to be seen if other medicaments, for example, calcium hydroxide combined with chlorhexidine, are more potent.[14, 15]

It has been shown that microorganisms from the root canal of the tooth can invade periapical endodontic lesions of asymptomatic teeth and establish an infectious disease process extraradicular.[16, 17, 18, 19] The infection is usually polymicrobial, comprising anaerobic and facultative. In most instances, endodontic infections respond well to conventional root canal therapy. When the root canal is properly instrumented, disinfected, and obturated, follow-up studies show a success rate of teeth with apical periodontitis of 80% to 90%.[20, 21] Still, this means that 10% to 20% of periapical lesions do not respond to local treatment of the tooth. It is not known whether the lack of response of refractory periapical lesions is due to the inaccessibility of the extraradicular microorganisms or to the presence of a microbiota, which is different from that normally found in endodontic infections. It has been shown that extraradicular bacteria may form colonies or aggregates where they are surrounded by extracellular material.[22] Sometimes the bacterial aggregates have the form of granules with diameters up to 3 to 4 mm. These granules often have a bright, yellow color, and because of this, in older literature are referred to as sulfur granules. There are also indications that the flora of refractory lesions may be atypical. Thus, the root canal flora of root-filled teeth, where the treatment has failed, has been shown to differ markedly from the flora of infected root canals of untreated teeth.[23, 24]

It appears to be important to prevent pulpal infection because it is difficult to eliminate bacteria and biofilms from the root canal system, especially from the most apical portion of the root canal and apical ramifications.[25, 26] Furthermore, when the apical portion of the root has been infected, bacterial biofilms may occasionally be present on the external surface of the root tip.[27, 28] It is therefore

preferable to perform root canal treatment in cases where the apical portion of the root has not been infected using a technique that prevents apical spread of microorganisms.

When non-surgical root canal treatment is unsuccessful, surgical root canal treatment is often performed. Following root-end resection and ultrasonic root-end preparation, a root-end filling material is usually used to seal the root.

The microbiological sample in this case conformed that the canal harbored bacteria before the endodontic treatment. This was of course in accordance with Sundquist's findings (1976) that 18 out of 19 teeth with apical periodontitis had positive growth of bacteria from the canal.[29]

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Resurgery of Apical Periodontitis

Introduction

49 year old Latin American female

Figure 1: Frontal view

Chief complaint

30 January 2008

Pain from left side of maxilla. The patient describes the pain as intense and that she has "stabbing" pain when she eats.

Medical history

The patient diagnosed with fibromyalgia in 2006.

The patient cannot communicate in Norwegian or English. Her husband translates from Spanish.

Dental history

Pain from the maxillary left quadrant for the last two years.

Tooth 23: Root canal treatment and porcelain metal fused crown treatment 15 years ago.

Tooth 24: Root canal treatment in 2004.

Tooth 25: Root canal treatment in 2004. Apicoectomy with retrograde filling in June 2007.

Tooth 27: Root canal treatment started in December 2007. Tooth with a $Ca(OH)_2$ intra-canal dressing.

Clinical findings

30 January 2008

Figure 2: Lateral view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	22	23	24	25	26	27
Cold	Yes	No	No	No	Yes	No
Percussion	No	No	Yes (+)	Yes (+++)	No	Yes (+)
Palpation	No	No	Yes	Yes	No	No
Mobility	No	No	No	No	No	No
PPD (mm)	4	4	6	6	5	5
Restoration	Comp. (MB)	Crown	Comp. (MODP)	Comp. (MODP)	Comp.(MO) Am. (ODP)	IRM (MO)

Table 1: Clinical findings

Soft tissue: Bleeding from gingiva on probing and increased periodontal probing depths.

Dental:

Tooth 22: composite restoration on the mesial and buccal aspects of the crown
Tooth 23: porcelain fused to metal crown
Tooth 24: composite restoration on the mesial, occlusal, distal and palatinal aspects of the crown
Tooth 25: composite restoration on the mesial, occlusal, distal and palatinal aspects of the crown
Tooth 26: composite restoration on the mesial and occlusal aspects of the crown, amalgam restoration on the occlusal, distal and palatinal aspects of the crown
Tooth 27: IRM restoration on the occlusal aspect of the crown

Radiographic findings

30 January 2008

Tooth 22: Normal lamina dura. PAI 1. Reduced marginal bone level. Calculus on the root surface.

Tooth 23: No widening of the lamina dura. No apical radiolucency. PAI 1. Crown with short post. The quality of the root canal filling appears very poor. Reduced marginal bone level.

Tooth 24: No widening of the lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the mesial, occlusal, and distal aspects of the crown. Two root canals. The quality of the root canal filling appears dense and good. Reduced marginal bone level.

Figure 4: Periapical radiograph of teeth 22, 23 and 24

Tooth 25: Widening of the lamina dura. Apical radiolucency (Ø 4mm). PAI 3. Radiopaque material on the mesial, occlusal and distal aspects of the crown. One root. The quality of the root canal filling appears dense and good, but the quality of the retrograde filling appears poor. Reduced marginal bone level.

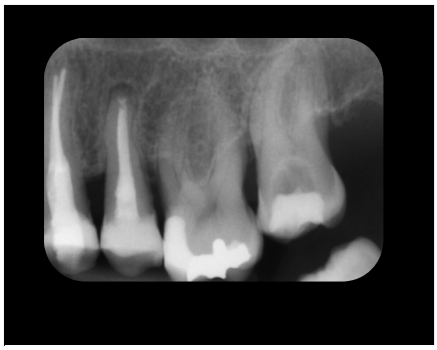

Figure 5: Periapical radiograph of teeth 25, 26 and 27

Tooth 26: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the mesial, occlusal and distal aspects of the crown. Reduced marginal bone level.

Tooth 27: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the occlusal aspect of the crown. Reduced marginal bone level.

Diagnosis

Tooth 23:
- Pulpal: Root filled (K04.19)
- Apical: Within normal limits
- Marginal: Chronic marginal periodontitis (K05.3)

Tooth 24
- Pulpal: Root filled (K04.19)
- Apical: Within normal limits
- Marginal: Chronic marginal periodontitis (K05.3)

Tooth 25:
- Pulpal: Root filled (K04.19)
- Apical: Acute apical periodontitis (K04.4)
- Marginal: Chronic marginal periodontitis (K05.3)

Tooth 26:
- Pulpal: Within normal limits
- Apical: Within normal limits
- Marginal: Chronic marginal periodontitis (K05.3)

Tooth 27:
- Pulpal: Necrotic (K04.1), but under root canal treatment
- Apical: Within normal limits
- Marginal: Chronic marginal periodontitis (K05.3)

Diagnose acute apical periodontitis tooth 25 was based on the dental examination and the patient description of the pain. An important clinical finding was an intense reaction from tooth 25 on the percussion test. An alternative diagnose was peripheral neuropathy. It was decided that cautious treatment of the patient was important, and to not give her extensive dental treatment at once because neuropathy was an alternative diagnosis. The patient was also advised to seek periodontal treatment for the marginal periodontitis.

Problem list

Prior apical surgery
The possibility of a vertical root fracture
The pain can be caused by neuropathy
The patient cannot communicate in Norwegian or English

Treatment plan

Apicoectomy with retrograde filling tooth 25
Observation and possible endodontic retreatment of tooth 23, because of poor quality of the root filling.

Treatment

27 February 2008

Pre-operative procedure. Xylocaine Adrenaline® 3 x 1.8 ml. Marginal incision from the mesial aspect of tooth 23 to the distal aspect of tooth 27. Vertical releasing incision on the mesial aspect of tooth 23. Elevation of mucoperiostal flap. A pathological fenestration of the buccal cortical bone was observed. Osteotomy. Curettage of granulation tissue. Root-end resection. Two root canals with an isthmus were found and prepared with diamond coated ultrasonic tip. Stryphnon gauze and ferric sulfate were used for hemorrhage control. White MTA (ProRoot® MTA) was applied as retrograde filling material. The operation site was inspected and carefully rinsed with sterile saline. Suturing with six 4-0 silk sutures. Post-operative instructions. Patient given six tablets of 400 mg Ibuprofen to take one tablet every fourth hour the first day after surgery.

Figure 6: Pathological fenestration of the cortical bone

Figure 7: Apical part of root before root-end resection

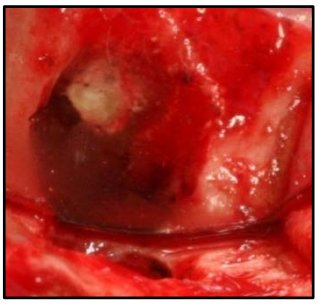

Figure 8: Retrograde filling (seen through mirror)

Figure 9: Flap sutured

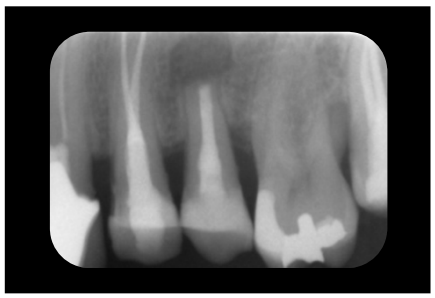

Figure 10: Periapical radiograph after retrograde filling

5 March 2008

Suture removal. Some secondary healing evident. Poor patient compliance with regard to post operative oral hygiene. Patient presented with less symptoms than before the surgery.

Figure 11: Wound healing one week after surgery

Figure 12: After suture removal

12 March 2008

The patient contacts for an emergency consultation because of severe pain from the site of surgery. She had been in pain for three days.
Clinical examination: multiple small (Ø1-2 mm) erosive ulcerations on the mucosa of the maxillary buccal fold from right canine to left second molar. The ulcerations were diagnosed as Aphthae herpitiformis. The patient was advised to discontinue the use of Corsodyl® mouth rinse, use a tooth paste not containing sodium lauryl sulfate and apply Aftamed® on the lesions.

Figure 13: Aphthae herpitiformis on the buccal mucosa

Figure 14: Aphthae herpitiformis on the mucosa

3 April 2008

The patient had no lesions on the oral mucosa. There was evidence of good healing of the mucosa. She had experienced less pain the last two weeks. Tooth 25 was sensitive to percussion.

Figure 15: Three weeks after aphthae herpitiformis was diagnosed

Result

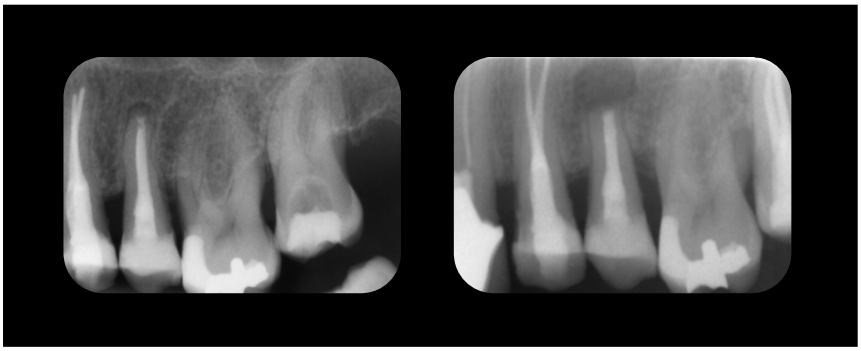

Figure 16: Pre- and post-operative periapical radiographs

Evaluation

The retrograde filling appears dense and good.

Prognosis

Endodontic: good
Tooth: good

Follow-up examination

11 November 2008 (10 months after apicoectomy with retrograde filling)

Asymptomatic, no sensitivity from percussion test tooth 25. The patient has undergone periodontal treatment. Root canal retreatment tooth 23 is planned.

Intra-oral examination:

	22	23	24	25	26	27
Cold	Yes	No	No	No	Yes	No
Percussion	No	No	No	No	No	Yes
Palpation	No	No	No	No	No	No
Mobility	No	No	No	No	No	No
Pocket (mm)	4	4	4	4	5	5
Restoration	Comp. (MB)	Crown	Comp. (MODP)	Comp. (MODP)	Comp(MO) Am. (ODP)	Comp. (MO)

Table 2: Clinical findings at follow-up examination

The radiograph showed good evidence of healing of tooth 25. Tooth 23 showed a widened lamina dura, with a PAI-score of 2.

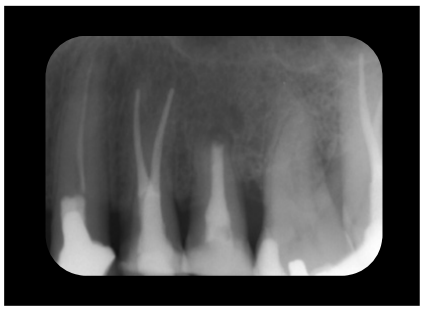

Figure 17: Periapical radiograph at recall

Discussion

Recurrent aphthous ulceration (RAU) is an inflammatory condition of unknown aetiology characterized by painful recurrent, single or multiple ulcerations of the oral mucosa.[1] Recurrent aphthous ulceration has three different variants—minor aphthous ulcers, major aphthous ulcers and herpetiform ulcers, according to the classification described by Stanley.[2] Minor RAU is the common variety, affecting about 80% of RAU patients.[3] It is characterized by painful round or oval shallow ulcers, regular in outline, less than 10 mm in diameter, with a grey-white pseudo membrane surrounded by a thin erythematous halo. Minor RAU usually occurs on non-keratinized mucosa such as labial mucosa, buccal mucosa and the floor of the mouth, and it is uncommon on the keratinized gingiva, palate, or dorsum of the tongue. The lesions recur at varying frequencies (from every few years to almost constantly) and heal within 10-14 days without scarring.[3] Major RAU occurs in approximately 10% of RAU patients.[4] The lesions are similar in appearance to those of minor RAU, but they are larger than 10 mm in diameter, single or multiple and very painful. Major RAU has a predilection for the lips, soft palate, and fauces, but can affect any site.[5] The ulcers persist for up to 6 weeks or longer and often heal with scarring. The third and least common variety of RAU is herpetiform. This form is characterized by multiple recurrent crops of small, painful ulcers that are widely distributed throughout the oral cavity. As many as 100 ulcers may be present at a given time, each measuring 2–3 mm in diameter, although they tend to fuse, producing large irregular ulcers. They usually heal without scar formation, the healing time of an individual lesion being 7 to 10 days. The condition occurs more often in women.[6]

It has been estimated that 20% of the general population will suffer from RAU at some time in their lives.[7] Possibly more than 40% of patients may have a familial history of RAU.[8]

Most patients with RAU need no treatment because of the mild nature of the disease. Some manage with maintenance of good oral hygiene and toothpaste without sodium lauryl sulfate[9] and occasional palliative therapy for pain. Patients should avoid irritating agents, such as acid, crusty/hard, spicy and salty foods and alcoholic beverages. Topical anesthetics such as 2% viscous lidocain hydrochloride (Xylocain, Astra) are widely used to palliate the pain.[10] Local steroid treatment can be the use of Flutide®nasal spray, Kenacort-T® 0,1%, Synalar® 0,025% or Clobetasol© dental gel. In severe cases can systemic steroid treatment be administrated.

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Three Root Canals in a Maxillary First Premolar

Introduction

89 year old white Northern European female

Figure 1: Frontal view

Chief complaint

27 March 2008

Referred from the dental student clinic, UiO, to the Department of Endodontics, UiO, for examination and treatment of apical periodontitis teeth 24 and 25. The patient experienced no discomfort from teeth.

Medical history

Non-contributory

Dental history

Attends routine dental examinations and treatments at dental student clinic, UiO.

Clinical findings

27 March 2008

Figure 2: Frontal view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	23	24	25	26
Cold	Yes	No	No	No
Percussion	No	Yes	Yes	No
Palpation	No	Yes	No	No
Mobility	No	No	No	No
PPD(mm)	2	2	2	4
Restoration	Porcelain fused to metal crown	Comp. (MODBP)	Porcelain fused to metal crown & Comp. (O)	Porcelain fused to metal crown

Table 1: Clinical findings

Soft tissue: within normal limits

Dental:

23: porcelain fused to metal crown

24: composite filling on the mesial, occlusal, distal, buccal and palatinal aspects of the crown

25: porcelain fused to metal crown, and composite filling on the occlusal aspect of the crown

26: porcelain fused to metal crown

Radiographic findings

27 March 2008

Tooth 23:

Normal lamina dura. No apical radiolucency. PAI 1. Metal crown. Normal marginal bone level.

Tooth 24:

Discontinued lamina dura apically. Apical radiolucency (Ø 2mm) PAI 3. Radiopaque material on the mesial, occlusal, distal and buccal/paltinal aspects of the crown. Normal marginal bone level.

Figure 4: Periapical radiograph

Tooth 25:

Discontinued lamina dura apically. Apical radiolucency (Ø 8mm) PAI 4. 3 mm separated endodontic file in the apical segment of the root. Metal crown. Normal marginal bone level.

Tooth 26:

Normal lamina dura. No apical radiolucency. Root filled. PAI 1. Metal crown with post. Normal marginal bone level.

Diagnosis

Tooth 24:

Pulpal: Necrosis (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Tooth 25:

Pulpal: Necrosis (K04.1)
Apical: Chronic apical periodontitis (K04.5)
Marginal: Within normal limits

Problem list

Separated endodontic file in the apical segment of tooth 25

Treatment plan

Orthograde endodontic treatment of non-vital pulp tooth 24
Apicoectomy with retrograde tooth 25

Treatment

24 April 2008

Clinical examination. Tooth 24 diagnosed with chronic apical periodontitis.1.8 ml Septocaine®. Access cavity preparation. Rubber dam applied. Two root canals located. Working lengths were determined by apex locator (Root ZX®) and a periapical radiograph. Root canal disinfection was done mechanically with Gates-Glidden-burs, K- and NiTi hand files in conjunction with PreRace® to sizes:
B: R45/16 mm/buccal cusp
P: R45/17 mm/palatinal cusp
1% NaOCl and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-canal dressing. IRM was applied as a temporary filling.

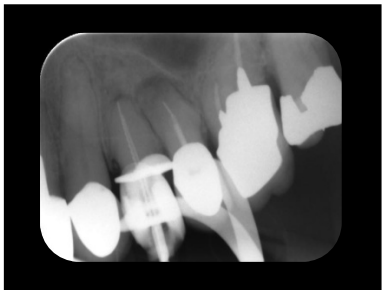
Figure 5: Working lengths radiograph

28 May 2008

Tooth 24 was sensitive to percussion and palpation tests. 1.8 ml Septocaine®. Rubber dam applied. 1% NaOCl and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an long-term intra-canal dressing. IRM was applied as a temporary filling.

10 September 2008

The patient had no percussion or palpation sensitivity from the area of tooth 24. 1.8 ml Septocaine®. Rubber dam applied. 1% NaOCl and 17% EDTA were used for cleaning of the canals. Gutta-percha and AH Plus were used as root filling materials. IRM was applied as a temporary filling.

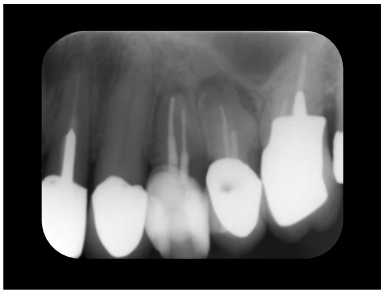
Figure 6: Post-treatment radiograph

25 March 2009

Pre-operative procedure. Septocaine® 3 x 1.8 ml.
Marginal incision from the mesial aspect tooth 23 to the distal aspect tooth 26. Vertical

releasing incision at the mesial aspect tooth 23. Elevation of mucoperiostal flap. Pathological perforation of the buccal bone plate tooth 25 present. Osteotomy. Removal of granulation tissue around the apical part of tooth 25. The lesion extended to the apical part of tooth 24. Removal of lesion around the apical part of tooth 24. Root-end resection of approximately 3 mm of teeth 24 and 25. A groove was present on the buccal surface of the buccal root of tooth 24. Methylene blue staining showed an unfilled buccal root canal, which was distally placed to the root filled buccal canal of tooth 24. The palatinal root of tooth 24 was separate to the buccal root. Ultrasonic retrograde preparation of buccal and palatinal canals and isthmus tooth 25 (with removal of separated endodontic file in the palatinal canal), and the palatinal root canal and the two buccal root canals and isthmus between the two buccal canals tooth 24. Stryphnon gauze and ferric sulfate for hemorrhage control. White MTA (Angelus, Brazil) was used as retrograde filling material in tooth 25. Grey MTA (Angelus, Brazil) was used as retrograde filling material tooth 24. The operation site was inspected and carefully rinsed with sterile saline. Suturing with seven 4-0 Supramid® sutures. Post-operative instructions and the patient was informed about the prognosis of the tooth. Patient given six tablets of 400 mg Ibuprofen to take every fourth hour the first day after surgery. Prescription of 30 tablets Apocillin® (phenoxymethylpenicillin) (four tablets pr day for 7 days).

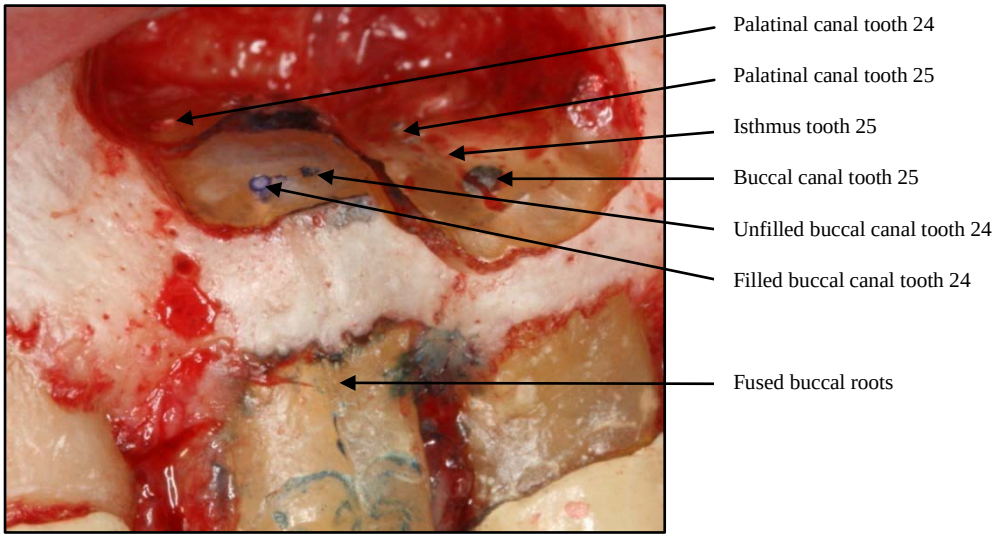

Figure 7: Tooth 24 and 25 root-ends resected and stained with methylene blue

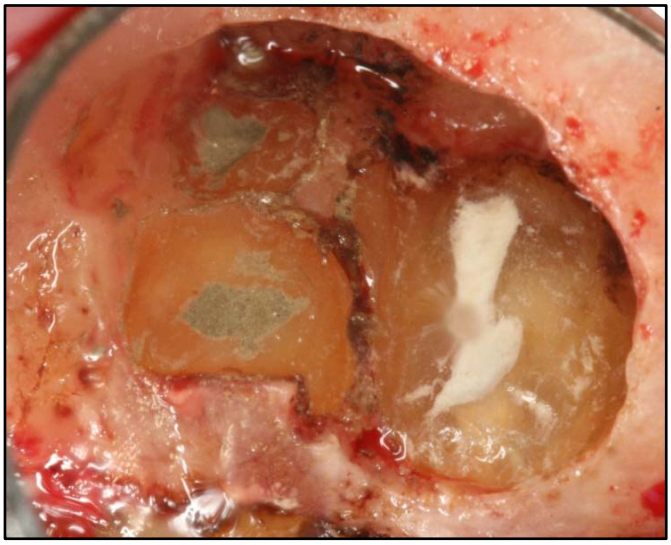

Figure 8: Retrograde fillings teeth 24 and 25

Figure 9: Suturing of the surgical flap

Figure 10: Post-operative periapical radiograph

1 April 2009

Suture removal. Good soft tissue wound healing. Patient had experienced no discomfort after the surgery.

Figure 11: Before removal of sutures

Figure 12: After removal of sutures

Result

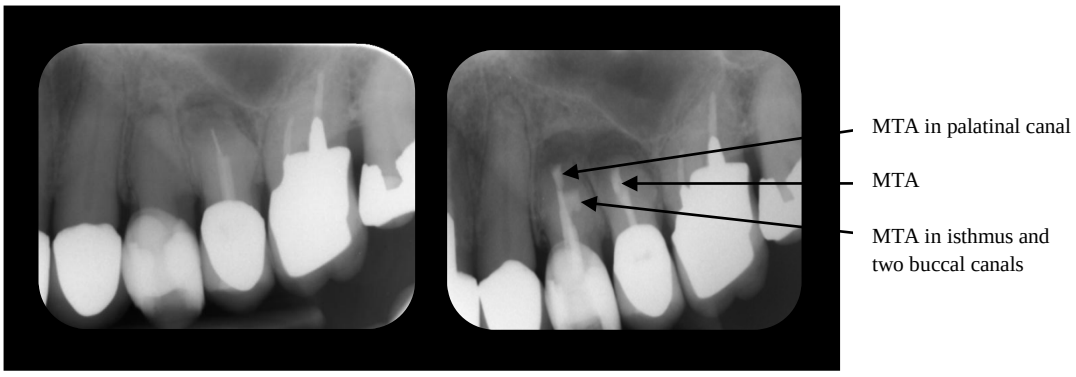

Figure 13: Pre- and post-treatment periapical radiographs

Evaluation

Tooth 24: The retrograde root fillings appear dense and good. At least one of the buccal root canals is infected, but the bacteria and their by-products are hopefully entombed.
Tooth 25: The retrograde root fillings appear dense and good.

Prognosis

Tooth 24:

Endodontic: uncertain - because of one of the canals is not orthograde root filled

Tooth: good

Tooth 25:

Endodontic: good

Tooth: good

Follow-up examination

No follow-up examination because surgery performed in March 2009.

Discussion

The root anatomy of the maxillary first molar can vary depending on whether one, two, or three roots are present. The overall length of the maxillary first premolar is 22.5 mm with an average crown length of 8.5 mm and an average root length of 14 mm.[1] Prominent root concavities are present on both the mesial and distal surfaces of the root. The mesial root concavity is more prominent and extends onto the cervical third of the crown.[1, 2, 3] The root is therefore broad buccolingually and narrow mesiodistally with a kidney shape when viewed in cross section at the cementoenamel junction.[1] The palatinal aspect of the buccal root tip of the two-rooted maxillary first premolars usually has a deep longitudinal depression along its length.[4] Joseph et al. found an incidence of buccal furcation groove in 62% of teeth with bifurcated roots.[5]

The majority of anatomical studies have reported that the most common form of the maxillary first is the two-rooted form (table 2).

Author (Year)	One Root (%)	Two Roots (%)	Three Roots (%)
Ingle (1965)	43.0	55.0	2.0
Carns and Skidmore (1973)	22.0	72.0	6.0
Vertucci and Gegauff (1978)	26.0	70.0	4.0
Pecora et al. (1991)	55.8	41.7	2.5
Loh (1996)	49.4	50.6	0
Kartal et al. (1998)	37.3	61.3	1.3
Chaparro et. al (1999)	40.0	56.7	3.3

Table 2: Percentage of roots in the maxillary first premolar.

The majority of studies reporting that the two-rooted form of the maxillary first premolar were the most common had a Caucasian cohort. In studies of the Asian population[6, 7] single-rooted maxillary premolars are the dominant form, and three-rooted forms are rare.[6, 7]

The majority of maxillary first premolars have to canals, irrespective of whether the tooth has a single or double root (table 3).

AUTHORS (YEAR)	ONE CANAL(%)	TWO CANALS (BUCCAL AND PALATAL) (%)	THREE CANALS (TWO BUCCAL, ONE PALATAL) (%)
Vertucci (1984)	26	69	5
Pineda and Kuttler (1972)	50.1	49.4	0.5
Caliskan et al (1995)	9.8	90.2	-
Carns & Skidmore (1973)	22	72	6
Walker (1987)	36	64	-
Kartal et al (1998)	9.7	88.6	1.7
Pecora et al (1991)	17.1	80.4	2.5

Table 3: Studies of apical canal configurations for the maxillary first premolar

In this case the tooth 24 had two buccal canals and one palatinal canal. This configuration has a prevalence of 0.5 to 5% according to studies (table 3).

Reference list

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6. Akoi K. [Morphology studies on the roots of maxillary premolars in Japanese]. Shikwa Gakuho 1990;90:181-199.
7. Walker RT. Root form and canal anatomy of maxillary first premolars in a southern Chinese population. Endod Dent Traumatol 1987;3:130-134.

Apicoectomy with Retrograde Filling - without Prior Root Canal Filling

Introduction

39 year old white Northern European female

Figure 1: Frontal view

Chief complaint

21 May 2008

Some lingering pain from maxillary left premolar.
Wish to postpone implant maxillary left premolar.

Medical history

Bulimia nervosa from the age of 12 to 16 years

Dental history

General dental erosion because of bulimia nervosa.
Tooth 25 was extracted at age 13.
Tooth 46 was replaced with an implant at age 35.

Clinical findings

21 May 2008

Figure 2: Frontal view

Figure 3: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	23	24	25	26
Cold	Yes	No	-	Yes
Percussion	No	Yes	-	Yes
Palpation	No	Yes	-	Yes
Mobility	No	I	-	No
PPD (mm)	2	4	-	3
Restoration	No	Comp. (OP)	-	Comp.(OD)

Table 1: Clinical findings

Soft tissue: within normal limits

Dental: generalized dental erosion

23: healthy

24: composite filling on the distal and palatinal aspects of the crown

25: extracted

26: composite filling on the occlusal and distal aspects of the crown

Radiographic findings

21 May 2008

Tooth 24: Discontinued lamina dura at the apical and distal aspects of the roots. Apical radiolucency (Ø 4 mm). PAI 4. Two roots. Small ratio crown-root length. Radiopaque restoration in close proximity to the marginal alveolar crest. Resorption of the marginal bone distally.

Figure 4: Periapical radiograph

Tooth 26: Normal lamina dura. PAI 1.Restoration on the distal and occlusal aspects of the crown. Some reduced marginal bone level.

Tooth 27: Restoration on the mesial and occlusal aspects of the crown. Normal lamina dura. PAI 1. Some reduced marginal bone level.

Bite-wing radiographs taken to examine for possible cervical resorptions – no cervical resorption found.

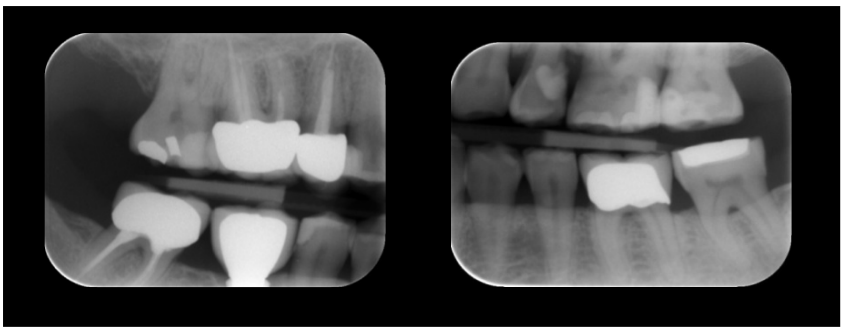


Figure 5: Radiographic bite-wings

Diagnosis

Tooth 24:

Pulpal: Necrosis (K04.1)

Apical: Chronic apical periodontitis (K04.5)

Marginal: Chronic periodontitis simplex (K05.3)

Problem list

Obliteration of root canals

Treatment plan

Treatment of non-vital pulp tooth 24

Treatment

21 May 2008

Clinical examination. Tooth 24 diagnosed with chronic apical periodontitis. 1.8 ml Septocaine®. Access cavity preparation. Rubber dam. No root canals located with the use of LN-bur (no. 10) and diamond coated ultrasonic tips. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. $Ca(OH)_2$ was placed as an intra-root dressing. IRM was applied as a temporary filling.

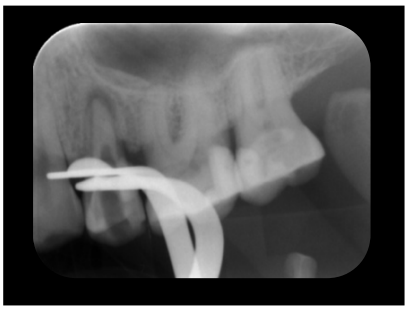


Figure 6: Periapical radiograph (no root canals located)

20 August 2008

The patient presented with no symptoms from tooth 24. Clinical examination showed no percussion and palpation sensitivity from the tooth. 1.8 ml Septocaine®. Rubber dam. No root canals found at the second attempt to locate the canals. LN-bur (no.10) and diamond coated ultrasonic tips were used for this purpose. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. The apical part of the preparation was filled with IRM. A composite restoration was applied in the coronal part of the tooth (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Supreme (A3B)). The tooth was scheduled for apicoectomy with retrograde filling.

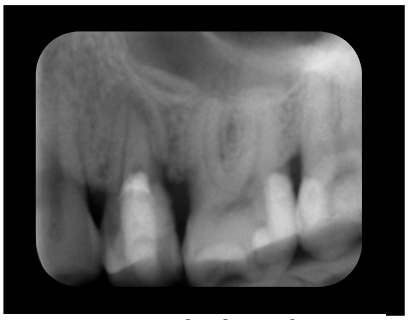


Figure 7: Periapical radiograph (composite build up of the crown)

Problem list

Obliterated root canals

Small ratio crown-root length

Revised treatment plan

Apicoectomy with retrograde IRM filling tooth 24

Treatment
4 June 2008

Pre-operative procedure. Septocaine® 3 x 1.8 ml. Marginal incision from the mesial aspect of tooth 23 to the distal aspect of tooth 26. Vertical releasing incision at the mesial aspect tooth 23. A CK3 micro blade was used for the incisions. Elevation of muco-periostal flap. Osteotomy. Removal of granulation tissue. Root-end resection and ultrasonic retrograde preparation of the buccal root. Stryphnon gauze for hemorrhage control. IRM retrograde filling was applied because of better moisture tolerance than MTA. After finishing the buccal root, the palatinal root underwent root-end resection, ultrasonic retrograde preparation and retrograde filling with IRM. To achieve hemorrhage control stryphnon gauze and ferric sulfate was used. The root ends were then polished with a fissure bur. The operation site was inspected and rinsed with sterile saline. Suturing with four 6-0 silk sutures. Post-operative instructions and the patient was informed about the prognosis of the tooth. Patient given six tablets of 400 mg Ibuprofen to take one tablet every fourth hour the first day after surgery. A prescription of Apocillin® (phenoxymethylpenicillin) 4 x 660 mg/7 days was also given.

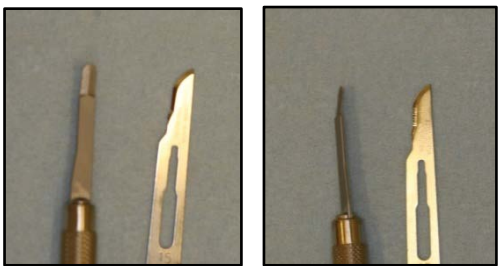
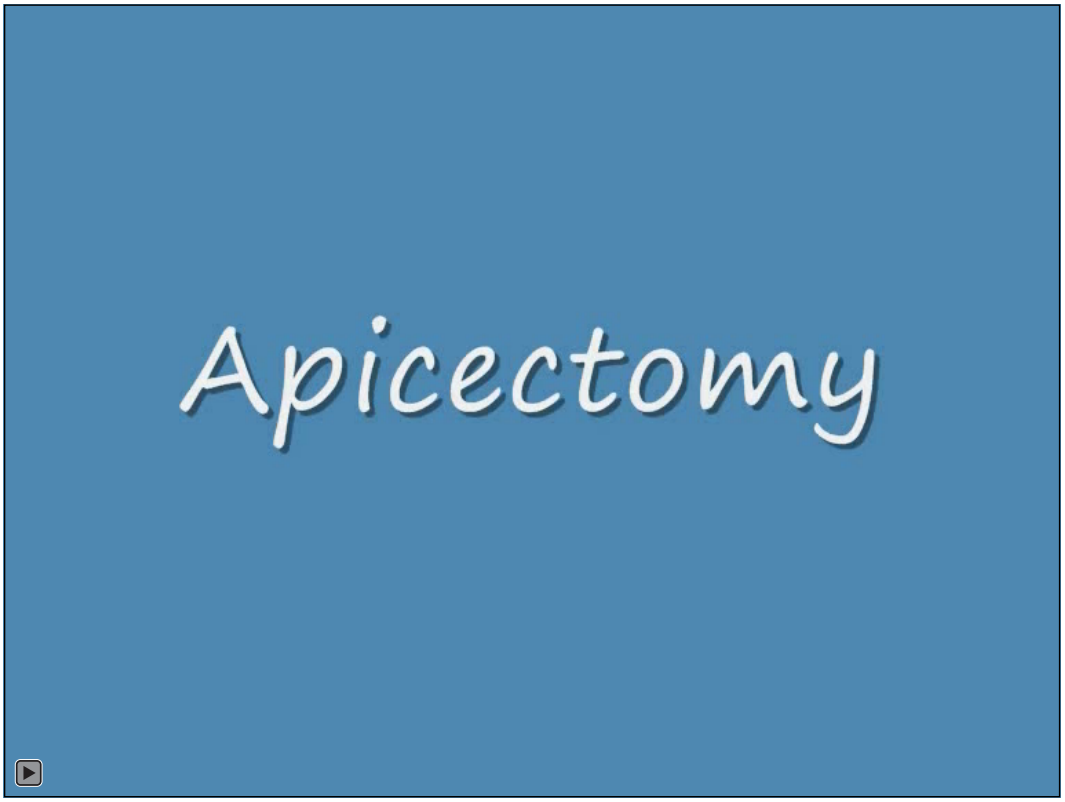


Figure 8 a and b: CK3 micro blade (right) and 15 blade (left)

Video presentation (Adobe® Reader® version 9 or above is required for viewing)



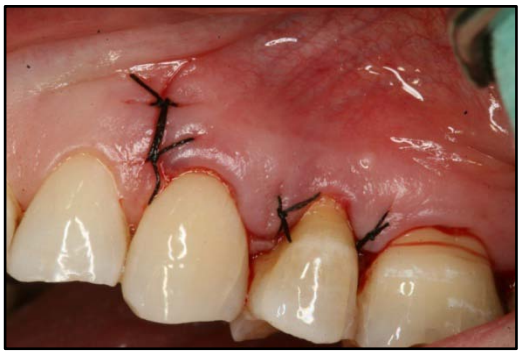


Figure 9: Suturing of the surgical flap

Figure 10: Post-operative periapical radiograph

9 October 2008

Suture removal. Good soft tissue healing evident. Patient had experienced no discomfort after the surgery.

Figure 11: Before removal of sutures

Figure 12: After removal of sutures

Figure 13: Occlusal view after removal of sutures

Result

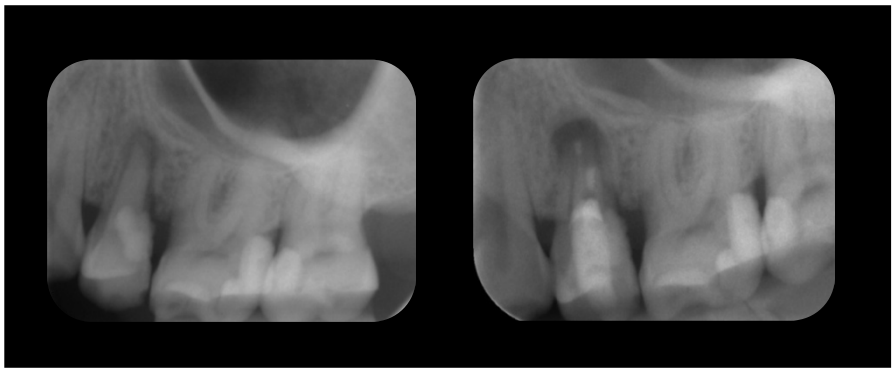


Figure 14: Pre- and post-treatment periapical radiographs

Evaluation

No root canals found during the orthograde root canal treatment. The retrograde root fillings appear dense and good. The root canals are infected, but the bacteria and their by-products are hopefully entombed.

Prognosis

Endodontic: uncertain - because the canals are not orthograde root filled
Tooth: uncertain - because of thin root canal walls and a higher risk of tooth fracture

Follow-up examination

12 March 2009 (five months after apicoectomy with retrograde filling)

No symptoms. Extra-oral examination: within normal limits
Intra-oral examination:

	23	24	25	26
Cold	Yes	No	-	Yes
Percussion	No	Yes	-	Yes
Palpation	No	No	-	Yes
Mobility	No	No	-	No
Pocket (mm)	2	4 (DP), 2 (B)	-	3
Restoration	No	Comp. (O and OP)	-	Comp. (OD)

Table 2: Clinical findings at recall

The periapical radiograph showed evidence of healing.

Figure 15: Periapical radiograph at recall

Figure 16: Lateral view at recall

Figure 17: 2 mm periodontal probing depth on the buccal aspect of tooth 24 at recall

Figure 18: 2 mm periodontal probing depth on the buccal aspect of tooth 24 at recall

Discussion

In this case the canals are not root filled, and the canals are definitely infected. Sundqvist[1], in 1976, used modern anaerobic techniques to evaluate the bacteriology of pulps of human intact teeth that became devitalized after trauma. He found that necrotic teeth without apical periodontitis lesions were aseptic, but those showing periradicular bone destruction were almost always infected (Fig. 19). Anaerobic bacteria predominated, comprising 90% of the isolates. Sundqvist's findings also served to demonstrate that necrotic pulp tissue itself and stagnant tissue fluid in the root canal cannot induce and maintain a periradicular inflammatory disease.

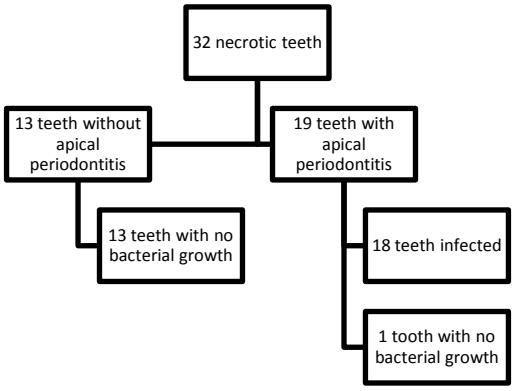


Figure 19: Sundqvist 1976

There is no study that looks at treatment outcome for humans on teeth that have undergone apicoectomy without root filled canals. An in vivo simulation model was developed by Friedman et al.[2] (Fig. 20). In this model they have tested the outcome of root-end filling materials on teeth that not have been root filled. This is to be curtain that the teeth are infected. Variations of this model have been used in several studies[3, 4, 5, 6, 7, 8] with better consistency of the results than in the in vitro studies. In these animal studies, IRM[3, 4], Super-EBA[5, 7], MTA[6], and Diaket[8] have performed better than other materials

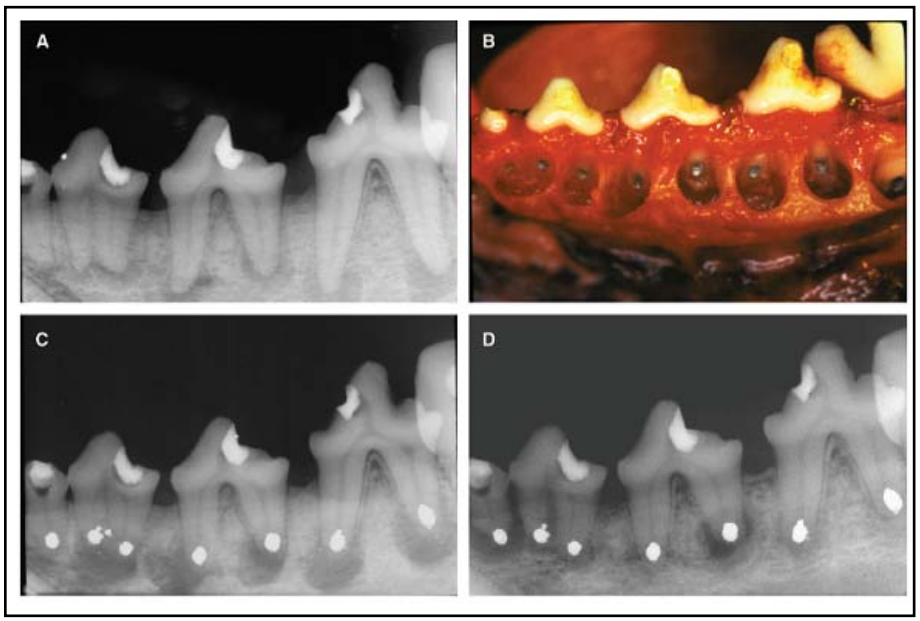


Figure 20: Animal model for assessing the efficacy of root-end filling materials. (A) A dog's mandibular premolars with apical periodontitis induced by inoculation of the canals with plaque. (B) Clinical view of the crypts and root-end fillings with amalgam and varnish in all the canals of the four premolars. (C) Completed surgery. (D) After 6 months, some of the lesions are healed and others are not. Healing is the measure of the sealing efficacy of the root-end fillings.

Chong and Pitt Ford[9] compared the success rate of IRM and MTA as root-end filling material in a randomized in vivo prospective study. They followed 108 patients (47 in IRM group, 61 in MTA group) for 2 years. The highest number of teeth with complete healing at both times was observed when MTA was used. When the numbers of teeth with complete and incomplete (scar) healing, and those with uncertain and unsatisfactory healing were combined, the success rate for MTA was higher (84% after 12 months, 92% after 24 months) compared with IRM (76% after 12 months, 87% after 24 months). Statistical analysis showed no significant difference in success between materials ($P > 0.05$) at 24 months.

In this case the root canals are infected. Healing of the apical periodontitis is dependent of the sealing ability of the retrograde IRM fillings.

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8. Witherspoon DE,Gutmann JL. Analysis of the healing response to gutta-percha and Diaket when used as root-end filling materials in periradicular surgery. Int Endod J 2000:33:37–45.
9. Chong BS, Pitt Ford TR, Hudson MB. A prospective clinical study of Mineral Trioxide Aggregate and IRM when used as root-end filling materials in endodontic surgery. International Endodontic Journal 36**(**8):203:520-526.

Root Resection

Introduction

44 year old white Northern European female

Figure 1: Frontal view

Chief complaint

6 September 2007

Some tenderness from maxillary left first molar. Referred from private dental office to the Department of Endodontics, UiO, for examination and treatment of 26.

Medical history

Non-contributory

Dental history

Tooth 26:

Root canal treatment performed approximately 15 years ago.

Apicoectomy with retrograde filling mesiobuccal root 10 years ago

Clinical findings

6 September 2007

Extra-oral examination: within normal limits

Figure 2: Lateral view

Figure 3: Occlusal view

Intra-oral examination:

	25	26	27
Cold	Yes	No	Yes
Electrical test (0-80)	32	No	38
Percussion	No	Yes	No
Palpation	No	Yes	No
Mobility	No	No	No
PPD (mm)	2	2	3
Furcation involvement	No	No	No
Restoration	Comp. (MODP)	Comp. (MODP)	Am. (MOD)

Table 1: Clinical findings

Soft tissue: Sinus tract buccally tooth 26.

Dental:

Tooth 25: composite restoration on the mesial, occlusal, distal and palatinal aspects of the crown

Tooth 26: composite restoration on the mesial, occlusal, distal and palatinal aspects of the crown

Tooth 27: amalgam restoration on the mesial, occlusal and distal aspects of the crown

Radiographic findings

6 September 2008

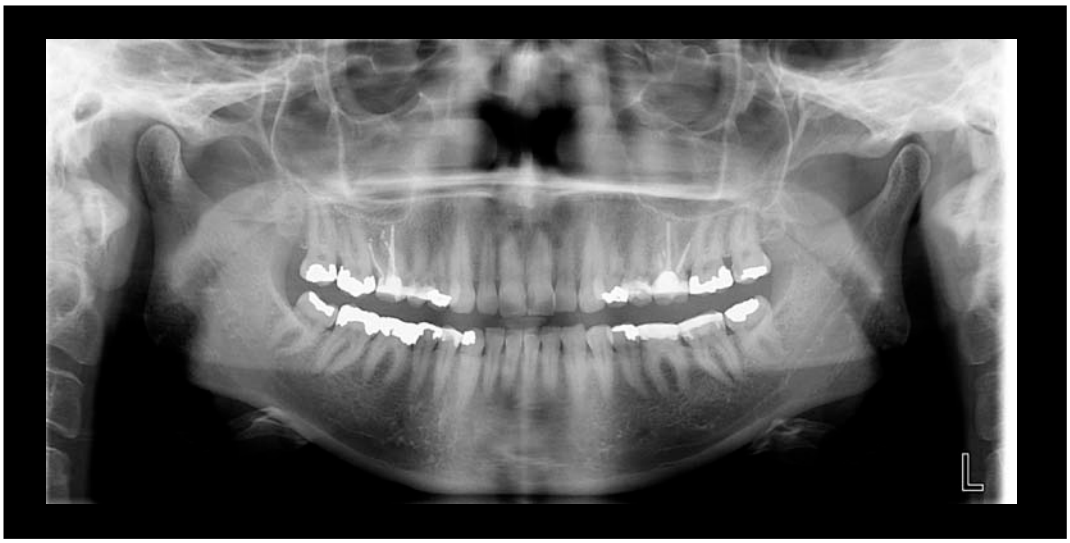

Figure 4: OPG

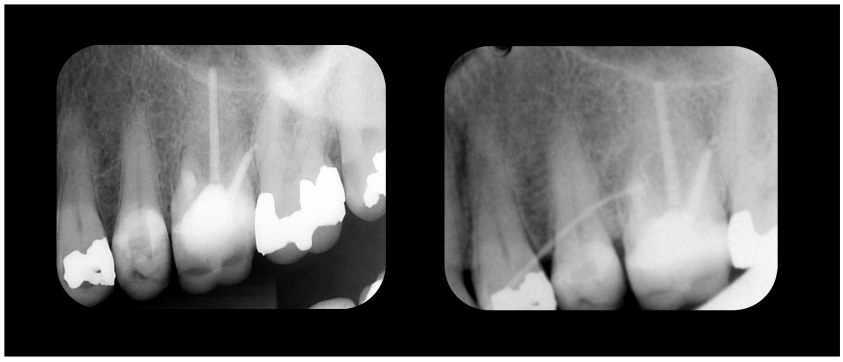

Figure 5: Periapical radiograph

Figure 6: Periapical radiograph with gutta-percha cone for tracing of sinus tract

Tooth 25: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the mesial, occlusal and distal aspects of the crown. Normal marginal bone level.

Tooth 26: Broken lamina dura. Diffuse apical radiolucency (Ø 6 mm). PAI 4. Radiopaque material on the mesial, occlusal and distal aspects of the crown. Gutta-percha cone tracing to the mesiobuccal root. Normal marginal bone level

Tooth 27: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the mesial, occlusal and distal aspects of the crown. Normal marginal bone level.

Tooth 28: Normal lamina dura. No apical radiolucency. PAI 1. Radiopaque material on the occlusal aspect of the crown. Caries on the mesial aspect of the crown. Normal marginal bone level.

NOTE: OPG shows apical over-extrusion of root filling material tooth 16.

Diagnosis

Tooth 26

Pulpal: Root filled (K04.19)
Apical: Periapical abscess with sinus tract (K04.71)
Marginal: Within normal limits

Problem list

Possible root fracture of the mesiobuccal root
Bone attachment level of the mesiobuccal root
Prior apicoectomy with retrograde filling of the mesiobuccal root

Treatment plan

Root resection of the mesiobuccal root tooth 26.

Treatment

24 October 2007

Pre-operative procedure. Xylocaine Adrenaline® 3 x 1.8 ml. Marginal incision from the distal aspect tooth 28 to the mesial aspect tooth 24. Vertical releasing incision at the mesial aspect tooth 24. Elevation of mucoperiostal flap. Osteotomy. A lesion was also present at the apical part of the distobuccal root. Curettage of lesions. Root resection of the mesiobuccal root and 3 mm root-end resection of the distobuccal root.

Ultrasonic preparation of retrograde cavity distobuccal root. Homeostasis with Stryphnon gauze and ferric sulfate. Filling of retrograde cavity with grey MTA (Angelus, Brazil). The mesiobuccal preparation was in level with the intra-coronal composite filling; no filling necessary on the remaining mesiobuccal root. Suturing of marginal incision with four 4-0 silk sutures, and vertical realizing incision with 3 4-0 silk sutures. Post-operative instructions. Patient given six tablets of 400 mg Ibuprofen, to take one tablet every fourth hour the first day after surgery.

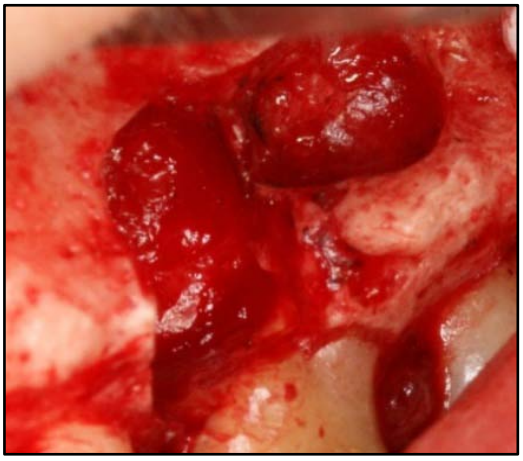

Figure 7: Root resection of the entire mesiobuccal root and 3 mm of the distobuccal root

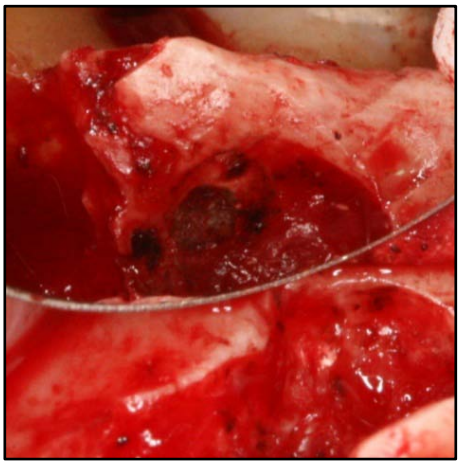

Figure 8: Root-end filling with MTA in the distobuccal root (photo through mirror)

Figure 9: Sutured flap

Figure 10: Post-operative radiograph

31 October 2007

Suture removal. Patient without symptoms. (No clinical photos available.)

Result

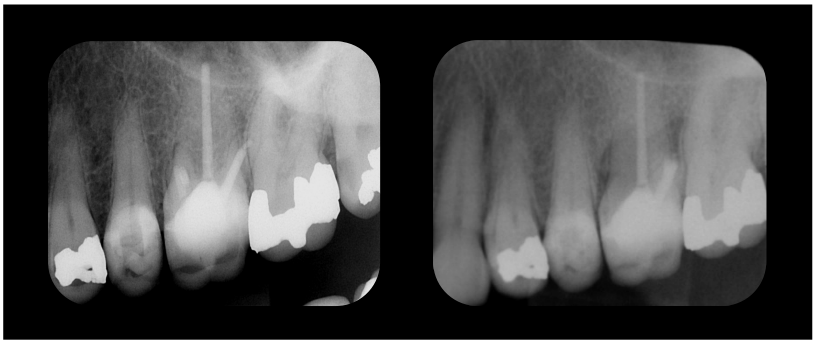

Figure 11: Pre- and post-operative radiographs

Prognosis

Endodontic: good

Tooth: uncertain because of reduced attachment surface of the roots

Follow-up examination

29 August 2008 (10 months after endodontic surgery)

No symptoms, no sinus tract.

Intra-oral examination:

	25	26	27
Cold	Yes	No	Yes
Electrical test (0-80)	37	No	33
Percussion	No	No	No
Palpation	No	No	No
Mobility	No	No	No
PPD (mm)	2	2	2
Furcation involvement	-	I	No
Restoration	Comp. (MODP)	Comp. (MODP)	Am. (MOD)

Table 2: Clinical findings at follow-up examination

Figure 12: Lateral view

Figure 13: Occlusal view

Figure 14: Periapical radiograph at follow-up examination

The periapical radiograph showed evidence of healing.

Discussion

Root resection is the removal of a root with accompanying odontoplatsy, before or preferably after endodontic treatment.[1] Formerly, it was used when root canal therapy was considered too difficult, but now its indications are restricted to multirooted teeth in which one or more roots cannot be saved. The indications for root resection often include root fracture, perforation, root caries, dehiscence, fenestration, external root resorption involving one root, impaired endodontic treatment of a particular root, severe periodontitis affecting only one root, and severe Grad II and III furcation involvement. Root resection requires a careful diagnostic process for selection of those teeth that would be likely successful candidate. Factors such as occlusal forces, tooth restorability, and the value of the remaining roots must be examined before treatment.[2] Proper reshaping of the occlusal table and restoration of the clinical crown are essential, and the root surface must be recontoured to remove the root stump, thus preventing formation of potential food trap.[3] Retrospective longitudinal studies have observed the fate of sectioned teeth for time frames from 3 to 12 years and have reported success rates between 62% to 100%,[1, 4, 5, 6, 7, 8, 9] with a low incidence of periodontal breakdown. In most long-term studies the major cause of failure of resection procedures resides in failure of the endodontic treatment and restorative components. Unique anatomic features, such as root length, curvature, shape, size, position of adjacent teeth, and bone density, may influence the end result.

In this case resection of the mesiobuccal root of tooth 26 was performed because of prior apicoectomy and too little bone support for a second apicoectomy.

Reference list

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Cervical Root Resorption

Introduction

40 year old white Northern European male

Figure 1: Frontal view

Chief complaint

30 August 2007

The patient had a pink spot on the maxillary right central incisor.

Medical history

Non-contributory

Dental history

1980's: The patient went through orthodontic treatment at the Department of Orthodontics, Faculty of Dentistry, UiO.

Referred from specialist in endodontics for examination and treatment of cervical root resorption teeth 11 and 16.

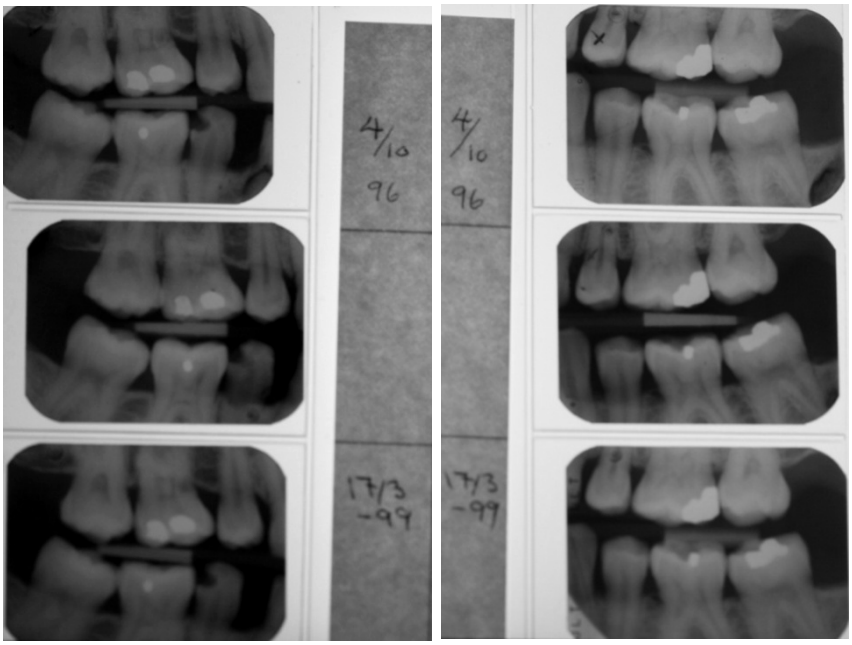

Figure 2: Bite-wing radiographs 1996-1999

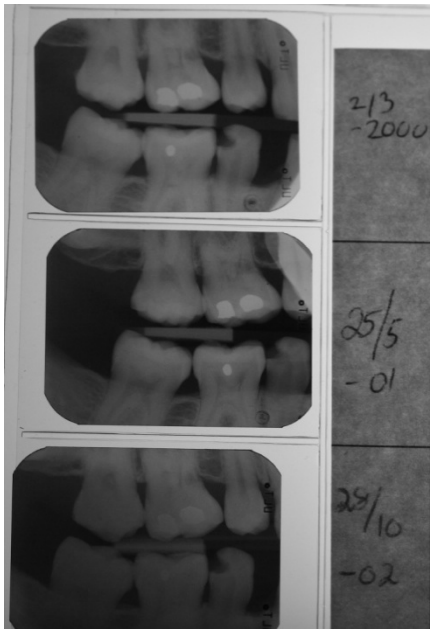

Figure 3: Bite-wing radiographs 2000-2002


Figure 4: Periapical radiograph (from referring endodontic specialist)

Clinical findings

30 August 2007


Figure 5: Lateral view


Figure 6: Occlusal view

Extra-oral examination: within normal limits

Intra-oral examination:

	17	16	15	14	13	12	11
Cold	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Percussion	No	No	No	No	No	No	No
Palpation	No	No	No	No	No	No	No
Mobility	No	No	No	No	No	No	No
PPD (mm)	2	3	2	2	2	2	3
Restoration	Amalgam (O)	Amalgam (O)	No	No	No	No	No

Table 1: Clinical findings

	21	22	23	24	25	26	27
Cold	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Percussion	No	No	No	No	No	No	No
Palpation	No	No	No	No	No	No	No
Mobility	No	No	No	No	No	No	No
PPD (mm)	2	2	2	2	2	2	3
Restoration	No	No	No	No	No	Amalgam (OD)	No

Table 2: Clinical findings

Soft tissue: Periodontal pockets within normal limits. No visible “pink spot” tooth 11. No communications from the oral cavity to cervical root resorptions teeth 16 and 26. Good oral hygiene.

Radiographic findings

30 August 2007

Figure 7: OPG

Figure 8: Axial CT-image in the coronal parts of maxillary teeth

Figure 9: Axial CT-image 0.7 mm apically to Fig. 8

Figure 10: Axial CT-image 0.7 mm apically to Fig.9

Figure 11: Axial CT-image 0.7 mm apically to Fig.10

Figure 12: Axial CT-image 0.7 mm apically of Fig.11

Figure 13: Axial CT-image 0.7 mm apically to Fig.12

Figure 14: Axial CT-image 0.7 mm apically to Fig.13

Figure 15: Axial CT-image 0.7 mm apically to Fig.14

Figure 16: Axial CT-image 0.7 mm apically to Fig.15

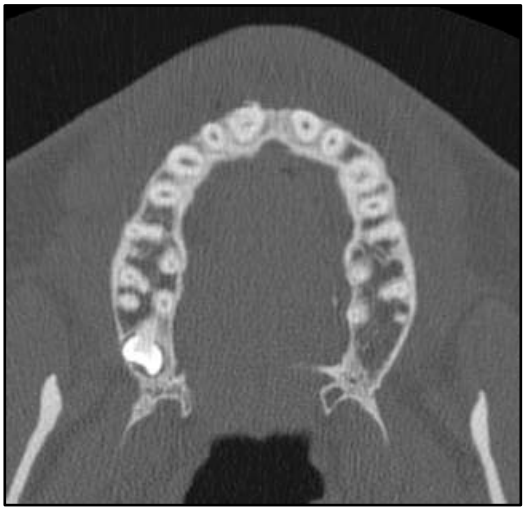

Figure 17: Axial CT-image 0.7 mm apically to Fig.16

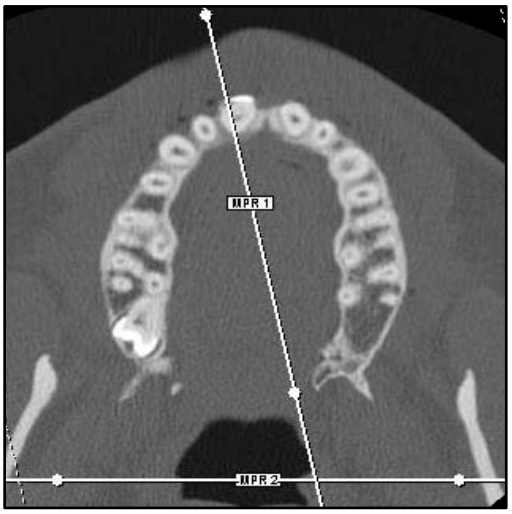

Figure 18: Axial CT-image in the CEJ parts of maxillary teeth with the direction for the sagittal image (Fig.11)

Figure 19: Saggital CT-image of tooth 11

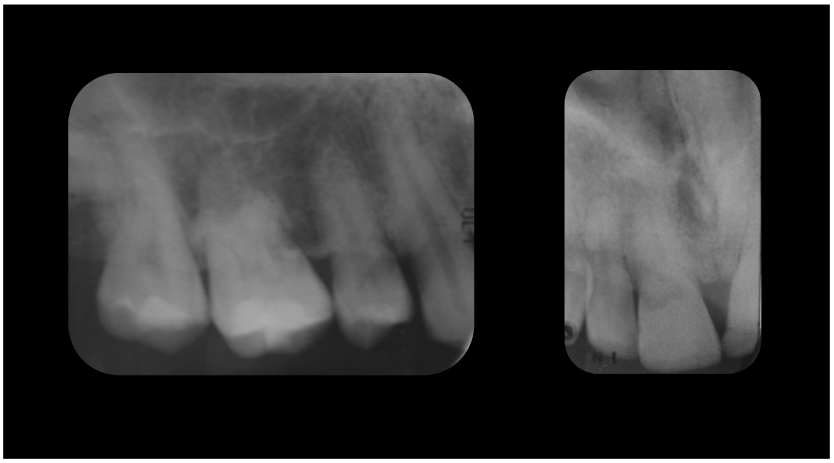

Figure 20: Periapical radiographs

Svarrapport:

Tilsendt 2 intraorale bilder fra 30.08.07, 4 intraorale og OPG fra 30.08.07 og CT maxilla og mandibula (axial spiral 0.625 mm) fra 14.09.07:

Det sees cervicale rotdefekter på tennene 11, 16 og 26.

Defekten i tann 11 strekker seg langs hele buccalflaten like apikalt for emalje-sementgrensen og ca. halvveis gjennom dentinet mot pulpa på det dypeste.

På den mesiopalatinale del av tann 16 sees en mindre ekstern cervical rotdefekt. I tillegg sees en intern oppklaring fra mesiopalatinale del av pulpakavum, som strekker seg mot den mesiobuccale roten. Denne ser ikke ut til å ha sammenheng med den eksterne defekten.

Det sees en mindre cervical defekt mesiopalatinalt på tann 26.

Bifunn: Retinert 18 ligger i horisontalplanet med apex tett mot den palatinale roten til 17 og kronen i distobuccal retning i tuber maxillaris. Det kan ikke påvises resorpsjon på den palatinale roten til 17. Apex til den palatinale roten til 17 står i sinuscortex

R: Ekstern cervical rotresorpsjon 11, 16 og 26. 26 har også en intern defekt som vruderes enten som pulpaanomali eller intern rotresorpsjon. Konf. beskrivelse.

Figure 21: Answer from specialist in oral radiology (in Norwegian)

Translation of answer from CT-scan:

Six intra-oral radiographs, OPG and CT maxilla and mandible:

It is shown cervical root resorptions on teeth 11, 16, and 26.

The lesion in tooth 11 extends over the entire of the buccal surface just apically for the enamel-cement junction and at its depth is about halfway through the dentin towards the pulp.

On the mesiopalatinal part of tooth 16 it is shown a smaller external cervical root lesion. In addition it is shown an internal radiolucency from the mesiopalatinal part of the pulp cavity, which extends towards the mesiobuccal root. It appears not to be in relationship with the external lesion.

It is shown a small cervical lesion mesiopalatinally on tooth 26

R: External cervical root resorption teeth 11, 16 and 26. Tooth 16 has also an internal lesion which is considered as either pulp anomaly or internal root resorption.

Diagnosis

Tooth 11:

Tooth: Cervical root resorption (K03.3)
Pulpal: Within normal limits
Apical: Within normal limits
Marginal: Within normal limits

Tooth 16:

Tooth: Cervical root resorption (K03.3), and internal root resorption (K03.3) or toot anomaly (K00.2)
Pulpal: Within normal limits
Apical: Within normal limits
Marginal: Within normal limits

Tooth 21:

Tooth: Cervical root resorption (K03.3)
Pulpal: Within normal limits
Apical: Within normal limits
Marginal: Within normal limits

Problem list

Tooth 11: Cervical and root resorptions
Tooth 16: Cervical root resorption and internal root resorption/toot anomaly are large.If the lesions are treated, a small part of the toot will still be in function.
Tooth 26: Cervical root resorption

Treatment plan

Tooth 11: Surgical treatment of cervical root resorption
Tooth 16: Observation of cervical root resorption and internal root resorption/toot anomaly
Tooth 26: Observation of cervical root resorption
The decision to observe tooth 16 was based on the likelihood that the tooth would be severely compromised if treated. There was also no communication between the oral cavity and the resorption, and the tooth was asymptomatic. Observation of tooth 26 was based on the fact that there was no communication between the oral cavity and the resorption, and the tooth was asymptomatic.

Treatment

13 November 2007

Treatment of cervical root resorption tooth 11. Pre-operative procedure. 2 x 1.8 ml Xylocaine Adrenaline®. Marginal incision from the distal aspect of tooth 12 to the distal aspect tooth 21. Vertical releasing incision at the distal aspect tooth 12. Elevation of mucoperiostal flap. Osteotomy. Removal of cervical lesion on the buccal surface of tooth 11. No communication with the pulp. Stryphnon gauze and ferric sulfate for hemorrhage control. A composite filling was applied. (35% phosphoric acid, Adper™ Scotchbond™, Filtek™ Z250 (A3,5B)). The filling was polished. The operation site was inspected and rinsed with sterile saline. Suturing with five 4-0 silk sutures. Post-operative instructions and the patient was informed about the prognosis of the tooth. Patient given six tablets of 400 mg Ibuprofen to take every fourth hour the first day after surgery.

Figure 22: Resorption defect (after removal of lesion)

Figure 23: Composite filling

Figure 24: Post-operative radiograph

Figure 25: Flap sutured

20 November 2007

Suture removal. No patient discomfort after surgery. Good soft tissue healing. Positive ice-test tooth 11. (No clinical photos available.)

Result

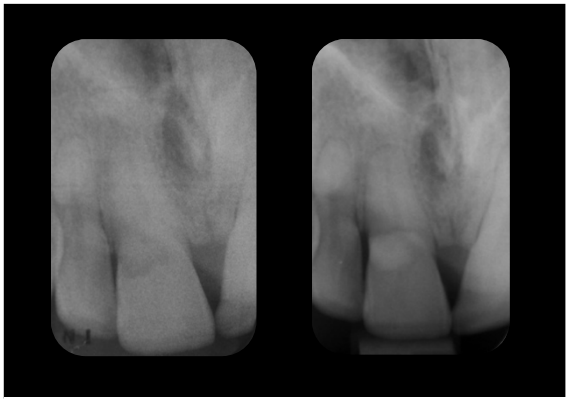

Figure 26: Pre- and post-treatment periapical radiographs

Evaluation

Cervical composite filling appears satisfying. No complications during treatment.

Prognosis

Endodontic: uncertain

Tooth: uncertain

Follow-up examination

31 January 2008 (two months after surgery)

No patient discomfort. Positive ice-test teeth 11, 16 and 26. Periodontal probing depth of 3 mm on the buccal surface of tooth 11.

Figure 27: Frontal view (January 2008)

9 December 2008 (12 months after surgery)

The patient had experienced sensitivity from tooth 11 when drinking cold and hot drinks the last two months.

Figure 28: Frontal view at follow-up examination (12 months after surgery)

Figure 29: 2 mm periodontal probing depth

Figure 30: 2 mm periodontal probing depth

Intra-oral examination:

	17	16	15	14	13	12	11
Cold	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Percussion	No	No	No	No	No	No	No
Palpation	No	No	No	No	No	No	No
Mobility	No	No	No	No	No	No	No
PPD (mm)	2	2	2	2	2	2	2
Restoration	Amalgam (O)	Amalgam (O)	No	No	No	No	Comp. (B)

Table 3: Clinical findings at one year recall

	21	22	23	24	25	26	27
Cold	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Percussion	No	No	No	No	No	No	No
Palpation	No	No	No	No	No	No	No
Mobility	No	No	No	No	No	No	No
PPD (mm)	2	2	2	2	2	2	3
Restoration	No	No	No	No	No	Amalgam (OD)	No

Table 4: Clinical findings at one year recall

No periodontal probing depths over 3 mm. No communication between the oral cavity and the cervical resorptions teeth 11, 16 and 26.

Radiographic findings

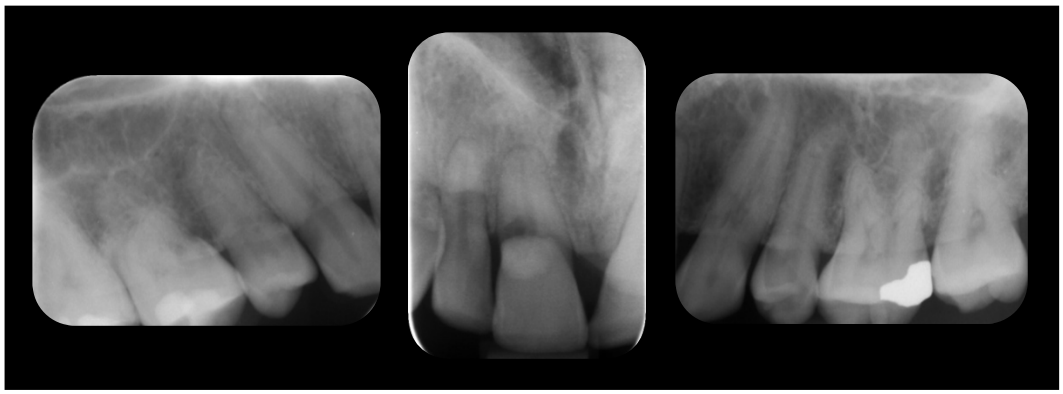

Figure 31: Periapical radiographs at one year recall

Tooth 11: Radiolucency (3 x 5 mm) apically to the cervical composite filling. Normal lamina dura. No apical radiolucency. PAI 2. Reduced marginal bone level.

Tooth 16: No change since examination 30th of August 2007.

Tooth 26: No change since examination 30th of August 2007.

Tooth 13: Diffuse radiolucency on the mesial aspect of the coronal segment of the root. No further radiographic findings.

Tooth 23: Diffuse radiolucency on the coronal segment of the root. No further radiographic findings.

Diagnose

Tooth 11:

Tooth: Cervical root resorption (K03.3)
Pulpal: Acute pulpitis (K04.01)
Apical: Within normal limits
Marginal: Within normal limits

Problem list

Tooth 11: Large cervical root resorption. Previously surgical treated.

Teeth 13 and 23: Possible cervical root resorption

Treatment plan

Tooth 11: Orthograde initial endodontic treatment and intra-canal filing in resorption, because of sensitivity and to postpone extraction of tooth.

Teeth 13 and 23: Referral to the Department of Oral and Facial Radiology, for further examination of possible cervical root resorptions.

Treatment

13 January 2009

Toot 11 diagnosed with chronic pulpitis (K03.03) and cervical root resorption (K03.3). 1.8 ml mepivacaine. Rubber dam applied. Access cavity preparation. Vital pulp tissue. Root canal length was determined by apex locator (Root ZX®) and a peri apical

radiograph. Root canal disinfection was done mechanically with K-files and ProTaper® to size:
One canal: R60/20 mm/incisal edge.
There was no communication from the canal to the resorption. 1% NaOCl, 2% CHX and 17% EDTA were used for chemical root canal disinfection. The canal was filled with AH Plus and gutta-percha. The gutta-percha was removed to 2 mm under the apical extent of the radiolucent area. A temporary IRM filling was applied over the gutta-percha. With the use of LN-bur and diamond coated ultrasonic tips the resorptive tissue was located and removed. 1% NaOCl and 17% EDTA were used for chemical disinfection. $Ca(OH)_2$ was placed as a dressing in the area of the lesion. IRM was applied as a temporary filling.

Figure 32: Working length radiograph

Figure 33: Master point radiograph

Figure 34: Root filled and $Ca(OH)_2$ in resorption

17 February 2009

The patient presented with no symptoms from tooth 11. Clinical examination showed no percussion or palpation sensitivity from the tooth. Rubber dam applied. The resorption defect was irrigated with 1% NaOCl. Grey Mineral Trioxide Aggregate (Angelus, Brazil) was applied with MAP-system® in the resorption. A wet cotton pellet was placed over the MTA. Temporary IRM filling applied.

Figure 35: Post-treatment periapical radiograph

Result

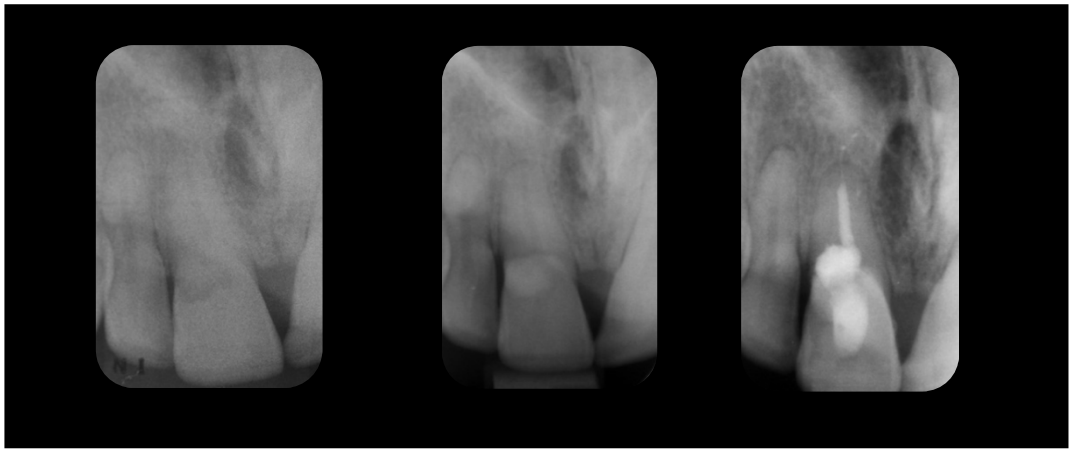

Figure 36: Pre-, post-surgical-, and post-treatment periapical radiographs

Evaluation

Cervical root resorption progressed after surgical treatment. Internal treatment attempted.

Prognosis

Endodontic: poor
Tooth: poor

Follow-up examination

No further follow-up examination because treatment ended in February 2009.

April 2009: awaiting examination at the Department of Oral Radiology, UiO.

Discussion

Tooth resorption is either a physiologic or a pathologic process resulting in a loss of dentin or cementum.[1] It is a common sequel to injuries, or to irritation of, the periodontal ligament or the tooth pulp. Tooth resorption is commonly subdivided into internal and external resorption. External resorption can be classified into three categories by clinical and histological features, namely external surface resorption, external inflammatory root resorption and replacement resorption. Invasive cervical resorption is a type of external inflammatory root resorption. [2]

Cervical root resorption is a localized resorptive process that commences on the surface of the root below the epithelial attachment and the coronal aspect of the supporting alveolar process, namely the zone of the connecting tissue attachment.[3] It has been defined in the literature as internal replacement[4], asymmetric internal[5], progressive intradental[6], peripheral cervical[7], cervical external[8] and extra-canal invasive resorption[9, 10].

Heithersay[11] classified cervical resorptions into four categories according to the depth and extent of the lesion, ranging from Class 1, denoting a small resorptive lesion near the cervical area with shallow penetration into dentin, to Class 4, where a larger resorptive process has extended apically beyond the coronal third of the root (Fig. 37).

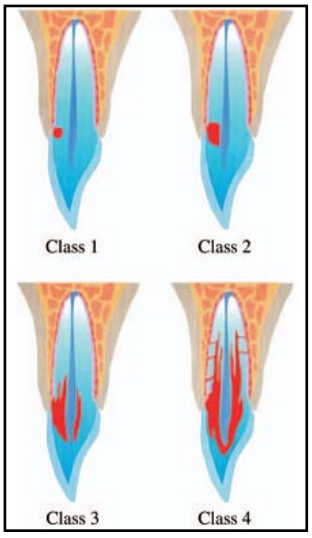

Figure 37: Classes and extent of cervical root resorption according to Heithersay (Heithersay et al.[11])

Cervical root resorption is asymptomatic as long as the pulp is not involved. Sensitivity tests are therefore within normal limits. The resorption starts on the root surface just below the epithelial attachment. When it approaches the pulp it spreads laterally, embracing the pulp. The resorptive process continues in an apical and coronal direction making tunnels in dentine, but leaves the root canal intact in most cases. Granulation tissue replacing tooth structure can be seen undermining the enamel of the crown, giving the tooth a pinkish appearance. This “pink spot” has often been used to describe the pathognomonic clinical picture of internal root resorption, which has resulted in cervical root resorption cases being misdiagnosed and treated as internal root resorptions.[12]

The radiographic appearance of cervical root resorption can be quite variable depending on the root surface affected. The resorption expands coronally and apically in the dentine and surrounds the pulp leaving a radiopaque line bordering the pulp space, the newly formed dentine. The pulp is normally not affected until later in the process. This image may mimic dental caries but differs in that the outline is slightly more irregular and that the lesion may not be probed because the starting point is below the epithelial attachment.

If the resorption is located buccally or palatally/lingually, the radiographic picture is dependent on the extent of the process. It is seen as an irregular radiolucency extending from the cervical area into the tooth crown/root and projected over the root canal outline and shows an irregular mottled, or ‘moth-eaten’ image in the main lesion area. The outline of the root canal can be seen as a radiopaque line demarcating the root canal from the adjacent irregular radiolucency, the latter being indicative of resorbing tissue.

Correct radiographic interpretation is critical to diagnosis and treatment of invasive cervical resorption. There is often confusion between the diagnosis of external cervical root resorption and internal resorption. It is important to separate these two diagnoses because of the different treatment strategies and prognoses involved. In cervical root resorptions the lesion is located at the periphery of the root, it will move on angulated X-rays, and the root canal outline is undistorted and can be visualized “through” the resorptive defect on radiographs. There is often a crestal bone defect situated in the bone right outside the resorption. Internal root resorptions present with a necrotic pulp coronally and a vital pulp apically. Internal resorptions can occur at any location along the root canal and the lesion always includes the root canal, in any X-rays irrespective of the angulation.[13]

The aetiology of cervical root resorption is unknown. For the resorption to be initiated, it seems that the normally protective cementum-cementoid layer must be deficient or damaged. In study by Heithersay[11] a group of 222 patients with a total of 257 teeth displaying variable degrees of cervical root resorption were analyzed for potential predisposing factores (Fig. 38). The most common single factor was orthodontic treatment. 24.1% of the teeth affected with cervical root resorption had undergone orthodontic toot movement.

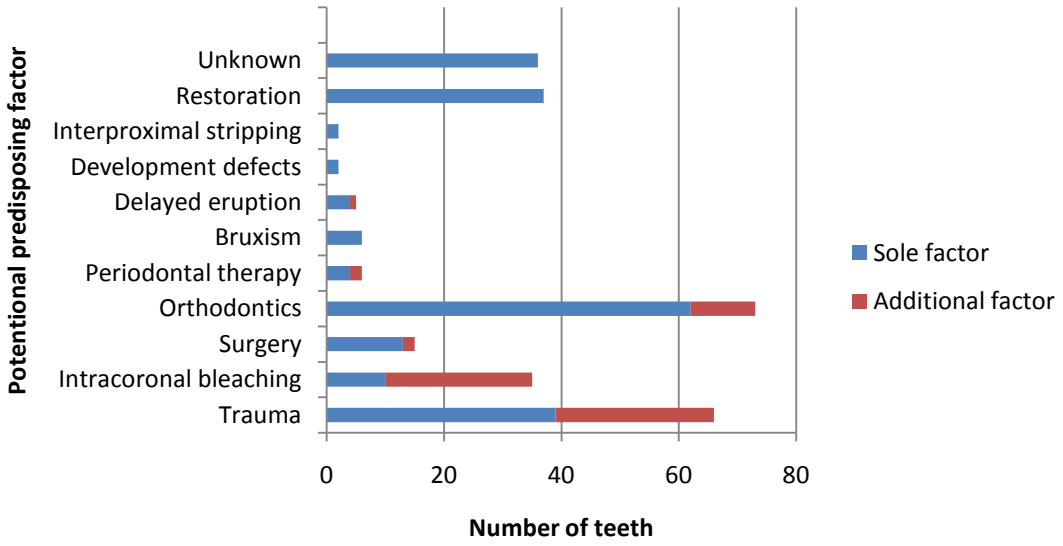

Figure 38: Invasive cervical resorption: Distribution of potential predisposing factors for patients. (Data from Heithersay et al.[11])

In many instances no known general or local history explain the condition.

Two different hypotheses exist that try to explain this invasion. In one, microorganisms in the sulcus are the activating factor. They may reach a damaged root surface when the tooth erupts or if gingival recession takes place, and initiate an inflammatory reaction.[14] Arguments against this view are that there are cases in the literature which show no sign of inflammation and that the lesions might be secondarily invaded by microorganisms. In another, a non-bacterial explanation to the process has been proposed. Here, the epithelial cell rests of Malassez exert some kind of protective function. Research on clastic cell activity in an aseptic root resorptive model provides support for this view.[15, 16, 17] For invasion by clastic cells to occur, a defect in the cementum/cementoid layer is likely a prerequisite. This may be of developmental origin in a small zone near the cervical area, or the result of physical or chemical trauma.

The literature search on the prognosis of cervical root resorption is very limited. Heithersay[18] followed 101 teeth in 94 patients over 3 to 12 years and had a success rate of 100% in Class 1 and 2, 78% in class 3 and only 12% in Class 4. Other articles are case rapports only with just a few teeth and with short follow-up periods.[19, 20, 21]

Multiple resorptions can occur, particularly when there has been a history of orthodontic treatment. A genetic influence is supported by reports of external root resorption of no apparent cause has been found in members of the same family. Hormonal disturbances have also been shown to be associated with resorptions of the roots.[22] There is not much research done on multiple cervical resorptions, and we rely mostly on case reports. [23, 24, 25, 26]

In this case tooth 11, 16 and 26 were diagnosed with cervical root resorption. Tooth 11 was Class 2, tooth 16 Class 3, and tooth 26 Class 2 according to Heithersay. It was decided to observe tooth 16 and 26. Tooth 11 was initially treated surgically, but the resorption progressed and the tooth needed root filling and internal filling of resorption. In this case it was not used 90% aqueous solution of trichloracetic acid. The prognosis of tooth 11 is poor, and the tooth must be regarded as temporary retained, and replacement of tooth with a dental implant is likely.

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