UNIVERSITY OF OSLO
DENTAL FACULTY

Department of Endodontics

Postgraduate program in **Endodontics**

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Casebook

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Spring Semester 2013

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Endodontic Treatment Guidelines

The description of procedures below spans the treatment of a normal spectrum of cases. Deviations from this may occur in select cases, and will be described in detail for those.

Treatment of teeth without pulp space infection

The pulp space is aseptically enlarged, cleaned and obturated, preferably in a single visit.

Preoperative radiograph
Anaesthesia
Removal of plaque, caries and substandard fillings
Tooth build-up as required
Access cavity preparation aiming for straight-line access to canal systems, as conservative as possible
Localization of canal orifices
Application of rubber dam before or after access
Disinfection of the working area with 0.5% chlorhexidine tincture Measurement of working length, using electronic apex locator and working length radiograph, to 0.5-1mm short of the major apical constriction
Instrumentation to desired apical length and size with frequent irrigation using 27G cannula and 1% buffered sodium hypochlorite (NaOCl).
Final irrigation with 17% ethylenediaminetetraacetic acid (EDTA)
The canals are dried with sterile paper points
Uncontrollable bleeding, iatrogenic perforations or available time may necessitate a second visit. The tooth is then closed off in the same manner as described for treatment of infected pulp spaces.
Adaptation of disinfected master point and a subsequent radiograph
Obturation with cold lateral or warm vertical compaction
Gutta-percha or Resilon core material is used with epoxyamine (Ah plus®) or methacrylate (RealSeal®) sealers, respectively
Cleaning of the access cavity and sealing with a temporary filling material, extending at least 2mm down in each canal. Reinforced ZOE (IRM®) or calciumsulphate-based (Cavit®) materials are used. Final radiograph(s) demonstrating void-less obturated preparations.

Treatment of teeth with pulp space infection with or without apical periodontitis

The pulp space is aseptically enlarged, disinfected and medicated for 7 or more days. Subsequently the canal space is further cleaned, disinfected and obturated.

First Visit

Anaesthesia and pre-treatment of tooth as required, like caries removal, disassembly of restoratives, rebuilding a rubber-dam facilitative tooth. Access preparation and localization of canal orifices as above, before or after rubber dam placement.
Rubber dam placement and disinfection of the working area with 0.5% chlorhexidine tincture

Unobturated canal space

Measurement of working length, using electronic apex locator and working length radiograph, to 0.5-1mm short of the major apical constriction
Instrumentation to desired apical length and size with frequent irrigation using 27G cannula and 1% buffered sodium hypochlorite (NaOCl). Ultrasonic agitation of the irrigation fluid is done for 30-60s, using a dulled endodontic needle of ISO20 size in a ultrasonic device, on a low power setting.
Final irrigation with 17% ethylenediaminetetraacetic acid (EDTA)
The canals are dried with sterile paper points and filled with water-based calcium hydroxide paste. A temporary filling is placed, using reinforced ZOE or calcium-sulphate based materials of at least 4mm thickness. A sandwich combination of Cavit-G® and IRM® is the standard choice.

Obturated canal space

Complete removal of the obturation material is sought for. The obturation material dictates the method of removal. Gutta-percha based obturation is the most common; the removal technique for this is described. This is done by initial gross removal of gutta-percha using rotary Gates-Glidden and NiTi files at around 1000 rpm. The remainder of obturation material is meticulously removed with the aid of solvent (chloroform), hand files, paper points and ultrasonic-powered instruments.
Measurement of working length is then performed as above.
Instrumentation to desired apical length and size with frequent irrigation using 27G cannula

and 1% buffered sodium hypochlorite (NaOCl). Ultrasonic agitation of the irrigation fluid is done for 30-60s, using a dulled endodontic needle of ISO20 size in a ultrasonic device, on a low power setting. Secondly irrigation with 17% ethylenediaminetetraacetic acid (EDTA) ultimately followed by 2% chlorhexidine irrigation.
The pulp space is dressed and temporized as above.

Second visit

Symptom resolution allowing, the canal space is obturated. Rubber dam is placed, gross removal of temporary filling and working field disinfection is done using 0,5% chlorhexidine tincture. The remainder of temporary filling and calcium hydroxide paste is removed. To aid this, the same irrigation regimen as above is used, excluding 2%chlorhexidine.
Obturation and temporization is done as described for uninfected pulp spaces, ending with radiographic control of the root filling.

Emergency Treatment

Acute Pulpitis

Pain relief without detriment to future treatment is the goal.
Preoperative radiograph, anaesthesia. Pulpotomy is the standard recommended treatment. Caries removal. Access cavity preparation and removal of coronal inflamed pulp tissue. A small cotton pellet soaked in eugenol is placed in the pulp chamber, which is thereafter sealed using reinforced ZOE or calcium-sulphate based materials like IRM® or Cavit®. Pharmacological treatment is instigated as needed. The standard analgesic prescribed is ibuprofen, 400mgx4 q.d. for 2-3 days.

Acute apical periodontitis

Pain relief and infection control without detriment to future treatment is the goal.
Preoperative radiograph, anaesthesia. Pulpotomy is the standard recommended treatment. Caries removal. Access cavity preparation permits drainage of pus from the canal system. A small cotton pellet soaked in eugenol is placed in the pulp chamber, which is thereafter sealed using reinforced ZOE or calcium-sulphate based materials like IRM® or Cavit®. If a palpable apical abscess is present, incision and drainage is recommended. A small incision is done in the periphery of the abscess. A sterile, blunt instrument is inserted to facilitate pus drainage. A butterfly rubber drain may be placed, dictated by the severity and location of the swelling. Pharmacological treatment is instigated as needed. An analgesic is considered most important, antibiotics only if indicated. In short, signs of the infection disseminating into neighbouring orofacial structures and signs of a systemic infection response indicate treatment. The standard analgesic prescribed is ibuprofen, 400mgx4 q.d. for 2-3 days. The standard antibiotic prescribed is penicillin V, 600mgx4 q.d. for 6 days, with a re-evaluation after 2-3 days use.

Endodontic Surgery

This is an elective procedure. At least one orthoradially angulated periapical x-ray showing the tooth to be treated and its neighbouring structures is kept at hand. Supplementary views and other modalities may be needed. The amount of intraoral structures shown when smiling or laughing should be documented, when related to the area to be treated. A preoperative photograph is standard. The patient performs a 1-minute mouthrinse with chlorhexidine gluconate 2mg/ml (Corsodyl®).
Local anaesthesia is administered; standard is lidocaine 20mg/ml+adrenaline 12,5μg/ml (Xylocaine Dental Adrenalin®). Dosage is discretionary.
The patient, operator with assistant and instrument area is draped and prepared. A dental nurse is dedicated to serve as needed throughout the procedure. An endodontic surgical tray with accessories is laid out in the sterile area. Surgical operatory microscope (SOM), ultrasonic unit, X-ray tube, dental surgical handpiece is also prepared and draped for use.

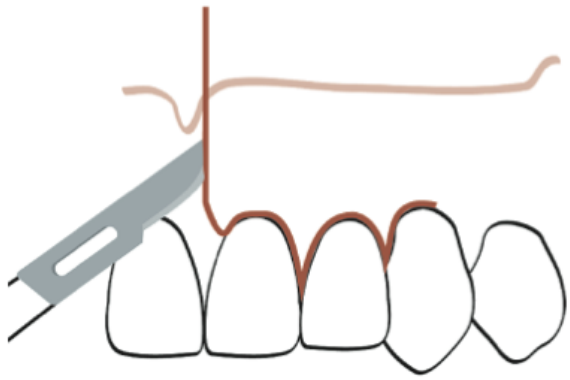

Figure 0-1: Marginal incision and vertical incision

An incision type according to case is done; subsequently a full-thickness mucoperiosteal flap is reflected using a periosteal elevator.
Incision types:

1. Marginal incision, creating an envelope flap
2. Marginal incision with one vertical releasing incision, creating a triangular flap
3. Marginal incision with two releasing incisions, creating a rectangular flap
4. Submarginal flap, always a rectangular flap, requiring a broad zone of attached gingiva

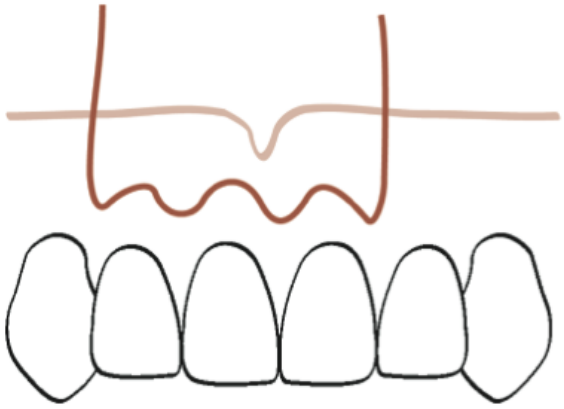

Figure 0-2: Submarginal incision with two vertical incisions

Decisive factors in incision selection are judged on a case basis. Easy wound retraction providing good view and minimal bleeding, safe handling of the mental nerve, optimal wound closure, as little gingival retraction and scarring as possible is among the factors deciding incision type.

Osteotomy with round carbide burs under saline irrigation is done to create access to the pathologic process and the roots to be treated. In the standard condition of treating an apical periodontitis, 3-4mm of the apical root(s) should be exposed and laid free to facilitate further treatment. A fissure bur is selected, and the apical 3 mm of the root is resected perpendicular to the root, under saline irrigation.

Surgical curettage of the pathologic process is performed until visibly clean borders to neighbouring structures.

Biopsy is performed when indicated. In general, biopsy is done to verify a clinical diagnosis.

Inspection of the resected root using SOM and a surface-reflective micromirror, after staining with methylene blue, should reveal cracks, canals or isthmi. If the root is judged untreatable, because of a previously undiagnosed condition, the tooth may or may not be extracted at this point and the wound closed. If close inspection reveals a sound root, the root-end should be sealed with a suitable filling.

Ultrasonic, diamond-coated retrograde tips is used at medium power to prepare a 3mm deep cavity in the gutta-percha obturated prepared canal, and possibly in discovered isthmus areas and untreated canals. Saline irrigation is done continuously. The SOM is used during preparation to guide and to verify a clean retrograde cavity.

The prepared and curetted bony crypt is packed with adrenaline-soaked sterile gas, and blotted with a cotton pellet soaked in ferric sulfate to achieve haemostasis. The retrograde cavity is dried using paper points.

Standard retrograde filling material is mineral trioxide aggregate (MTA-Angelus®). Ancillary equipment: sterile mixing slab and spatula, Dr. Lee MTA pellet forming block and its associated carver. The cavity is obturated under dry conditions and the void-free fill is verified radiographically.

All gauze packing strips is removed from the wound. All ferric sulfate remnants is washed and scraped away, along with surplus MTA. Saline irrigation is done continuously.

The wound edges is re-approximated and sutured, using simple interrupted sutures. Standard suture is a pseudomonofilamentuous 4-0 and 5-0 thread and a reverse-cutting 3/8 needle. (Supramid® 4-0 and 5-0)

The operator gently compresses the wound for a few minutes. The patient is given a cold pack and is urged to press it against the skin overlying the surgical site for 15-20 minutes.

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 and postoperative control is scheduled 3-7 days after surgery.

Case 1: Pulpectomy and a retained endodontic instrument

Introduction

The patient is a 30-year-old Norwegian female. She is referred from undergraduate clinic. She attends to continue the treatment of her mandibular right second premolar (35), that was started earlier by another postgraduate candidate. Patient record number is 0950183. This was my first treated case.

Chief complaint

She has no symptoms. She is anxious, but complies with the treatment plan.

Medical history

General

Known epilepsy, uniparous, appendectomy in 2009.
An unknown antiepileptic drug
Smoker, 5-7 cigarettes/day

Figure 1-1:Dental attrition and treatment area

Dental

She attends the university dental clinic for several other problems, including removal of third molars and restorative therapy. She is aware of that she grinds her teeth. She is anxious to dental treatment, especially invasive treatment. Today she believed that removal of 48 was to happen, and had medicated herself with an unknown dose of Valium®, a well known anxiolytic.
The treatment of the tooth was started by another postgraduate student, now a specialist. A separated instrument was present apically, the apex had a slight curvature. The student attempted to bypass the fragment, but this resulted in deviation from the main canal. Because of little available time, the treatment could not be finished, the patient had to wait for a new student to finish the treatment after the summer.

Examination

Clinical

There is obvious attrition to dentin in several teeth. A remnant of the mandibular right first molar is found, but this is of no importance to the patient at this time. Healthy and normal soft tissue.
Mandibular left first molar: occlusal temporary filling, occlusal attrition.
Mandibular left second premolar: occlusal temporary filling, occlusal attrition.
Mandibular left first premolar: Nonrestored. Occlusal attrition to dentin, but not severe.

	46	45	44
EPT	ND	ND	ND
Cold	ND	ND	ND
Palpation	-	-	-
Percussion	-	-	-
Mobility	-	-	-
CAL	<2mm	<2mm	<2mm
PPD	<2mm	<2mm	<2mm
Furcation inv.	-	N/A	N/A
Biting/chewing	-	-	-

Table 1-1: Dental diagnostic data

Radiographic

46: Radioopaque filling material in the crown and pulp space, apical

radiolucencies on both roots, traces of radioopaque material in the coronal parts of each root.
45: Radioopaque filling material in the crown and pulp space. The canal space appears unfilled. A radiodense, thin, 3mm long object is lodged apically in the root canal. Normal periradicular conditions. Earlier radiographs show a widened periodontal space apically
44: Normal appearance.

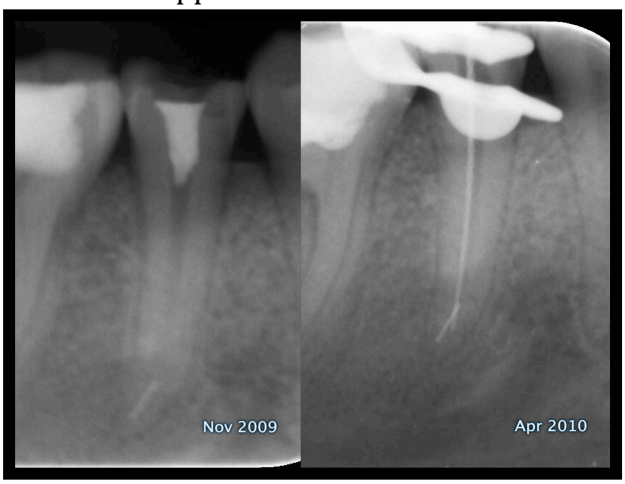

Figure 1-2: Pre-treatment radiographs

Diagnosis

Tooth 45:
Pulpal: necrosis of pulp, K04.1. Unfinished earlier treatment.
Periapical: healthy conditions

Treatment plan

It was decided to obturate tooth 45, and not remove the fragment.
Tooth 46: Leave to others
A decision was made earlier to leave the fragment. When the condition is as good as now, this decision was not questioned. Alternate treatments would be to perform an apicoectomy after obturation. This could be done to rule out late complications stemming from the file fragment. This was not recommended, as complications and late failures can also occur with apicoectomy. It may be performed later if needed. Orthograde removal was decided against, because of the apical location of the fragment. It was expected that removal would also weaken the tooth.

Treatment

02. Sept. 2010: Obturation
Rubber dam was placed, the field disinfected. The canal was irrigated according to protocol, and the apical size above the fragment was assessed. The canal was dried. A root filling was made using the standard protocol, Ah plus and gutta-percha (2%taper) and accessory points with a cold lateral condensation technique. Gutta-percha was removed 3mm below the bone crest and a plug of IRM was placed in the canal to ensure a tight coronal seal. IRM was also placed in the access cavity. Cone fit and end-result radiographs were obtained.

Figure 1-3: Left: Masterpoint; Right: Postoperative

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

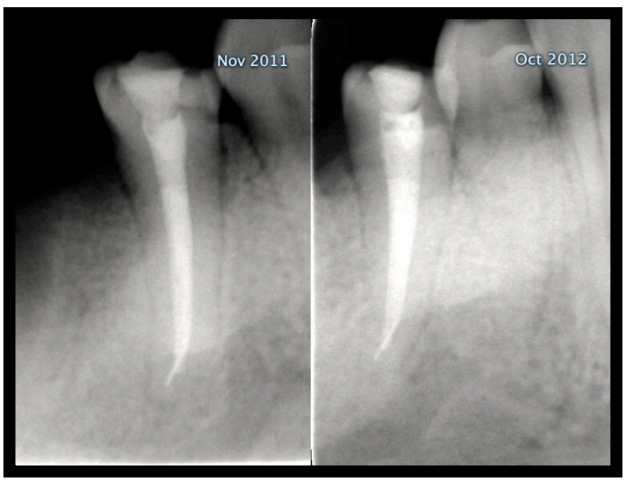

Figure 1-4: Follow-up, left: 10. Nov. 2011; Right: 01. Oct. 2012 (2y)

Evaluation

Follow-up displayed no pathologic developement. PAI was 1 at both times.
If an apical periodontitis seem to develop, surgical retreatment with fragment removal is the recommendation. Photographs of the dentition were taken, to document the severity of the attrition. This had not been done earlier, and is important to secure the patient's rights in the HELFO benefit system.

Discussion

Tests for assessing the resistance to separation of endodontic files are standardized trials, from the International Organization for Standardization (ISO) and from the American National Standards Institute by the American Dental Association (ANSI/ADA). Simple mechanistic properties of instruments are measured; dimensions, flexibility and resistance to torsional fracture. Other methods of testing instruments have been developed, an important test was developed initially researchers in the USA. (1) The torsional fatigue test has since been refined, and is often used to measure a new instrument's proposed superiority.
An endodontic instrument may separate both as overloading of its initial properties, or resulting from mechanical fatigue, with prolonged use. Several researchers have measured this occurrence. A prerequisite has been a landmark study that analysed the fracture surface of separated instruments, and classified the fracture pattern. (2) Pattern analysis revealed if an instrument had been subjected to torsional overload or so-called flexural fatigue fracture. Many different terms is regrettably used on these two fracture modes, creating possible confusion. Instrument separation frequencies are obtained either as database queries (3), or by collecting and analysing discarded instruments for defects and fractures. (4) These and other investigations in general report separation frequencies of around 1-2%. Both fracture modes occur. It may be inferred that if too great axial and rotational force is applied to an instrument rotating in a canal with a large contact surface or a bend, torsional overload fracture will happen. If instruments are re-used, especially in bent canals, flexural fatigue will degrade the mechanical properties, disposing the instrument to fracture with unexpectedly low applied force. Careful use and sound routines for reprocessing instruments is therefore advocated. The recent trend of asymmetrical reciprocation has shown promise in increasing an instruments resistance to flexural fatigue, as opposed to continuous rotational use. (5) Single-use, at least of smaller diameter instruments, may further reduce the problem of instrument separation.
An instrument left in the canal may hinder the proper disinfection of an infected canal, or it may harbour necrotic, sterile pulp remnants that may be infected later, if exposed to bacteria. As instrument separation is an uncommon occurrence, this problem is often studied with a case-control study design. Not many have been done, but a systematic review with meta-analysis identified two studies of 199 cases that could be included in the review. (6) The conclusion was that the retaining of a separated instrument did not affect the prognosis, both for cases with apical periodontitis and without.
Clinical judgement would commend operators to try to remove a separated instrument situated at the cervical or middle level of the root. In such cases, large proportions of canal space would remain untreated if left in situ. Techniques for instrument removal have been reviewed. Many ingenious methods exist. (7) The use of a modified Gates Glidden drill and small ultrasonic instruments is a widely used technique for removal. Reported success rates are around 70-80%. Some authors obviously are very skilled, and have removal rates of 95%, including apical fragments in molars. (8) Other reports may be more generalizable, reporting 100% removal success for coronal fragments, 45% for middle root fragments and 38% for apical fragments. (9)
Micro-computed tomography studies reveal that a large amount of dentin is removed when using the Gates

Glidden/ultrasonic instrument removal technique for apical fragments. (10) Other laboratory studies report that removal attempts result in lower resistance to fracture. Perforation may occur. Taken together with the good results for treated teeth with retained instruments, the clinician must judge when it is recommended to remove a separated instrument from a root.

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Case 2: A conventional treatment of pulpitis

Introduction

A Norwegian female, aged 31, is referred from her private general practitioner to the postgraduate education for treatment of a carious pulp exposure in the maxillary left second molar. Patient record number is 1162852.

Chief complaint

The patient wishes to comply with the recommendations of the referring dentist, and treat the involved tooth. There is no pain or other problems associated with the tooth at present.

Medical history

General

No known medical problems, no known allergies. Patient uses an oral contraceptive.

Figure 2-1: Dentition overview

Dental

An unspecified restoration of the maxillary left second molar is planned. No pain since pulpotomy and temporization with eugenol-soaked cotton pellet and IRM filling.

Examination

Clinical

The clinical examination revealed normal conditions. A temporary restoration was in an occluso-mesial cavity of the maxillary left second molar, and in an occluso-distal cavity of the maxillary left first molar. The premolars in the quadrant had intact tooth-coloured restorations, and no carious cavities.

Figure 2-2: Clinical situation, temporary restoration removed

	27	26
EPT	ND	ND
Cold	+	+
Palpation	-	-
Percussion	-	-
Mobility	-	-
CAL	<2mm	<2mm
PPD	<2mm	<2mm
Furcation inv.	-	-
Biting/chewing	-	-

Table 2-1: Dental diagnostic data

Radiographic

There was inadequate diagnostic quality in the apical region, due to the superimposition of the zygmatic buttress. This occurred in several projections. The

height of the patient's palatal vault may be causative of this.

Figure 2-3: Above:Orthoradial, Below:Distoangulated

Maxillary left second molar - Radioopaque restoration with excess margins, overlying a large access cavity, normal lamina dura where traceable.
Maxillary left first molar - Radioopaque restoration with excess margins and close proximity to the pulp space. A normal lamina dura where traceable.
Maxillary left second premolar - Radioopaque restoration with good marginal adaptation. Normal lamina dura
Normal apperance of alveolar cancellous bone, as well as the marginal bone level. The clinical findings did not prompt further radiographic investigations, because it would most probably not alter the suggested treatment.

Diagnosis

Maxillary left second molar:
Pulp: K04.0 Irreversible pulpitis
Periapical: normal conditions
Maxillary left first molar:
Pulp: normal conditions
Periapical: normal conditions

Treatment plan

Maxillary left second molar: Pulpectomy in a single visit.
Maxillary left first molar: No treatment.
Radiographic working length measurement could pose a problem. Therefore, the reliance on the electronic apical length-measuring device would be important.

Treatment

15. March 2012: Pulpectomy
2x1,7ml articaine 4%, 1:200k epinephrine (Septocaine®) local infiltration anaesthesia were injected medial and lateral to the maxillary left second molar. Temporary filling and cotton pellet was removed, 4 bleeding root canal orifices were identified.

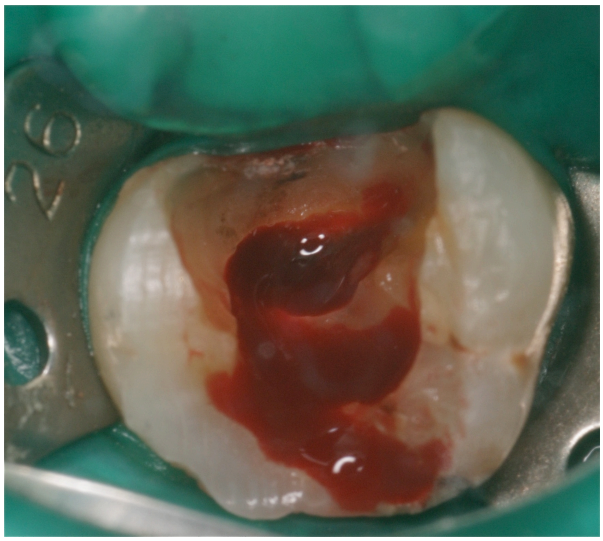

Figure 2-4: Bleeding pulp, all canals vital

Rubber dam was applied using a no. 26 clamp, and disinfected. Working length was established using electronic apex locator and radiograph. The root canal system was negotiated and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. Bio-RaCe® instruments BR5 was used as last file to working length, preparing a 4% tapered apical box of ISO 40 in the mesio-buccal, mesio-palatinal and disto-buccal canals, all 15mm. The palatinal canal was prepared using BR7, giving a shape of 2% taper and an apical size of ISO 60, 16mm long. The canals were dried, and a masterpoint radiograph was taken. No bleeding was visible on the paper point. The canals were all obturated with gutta-

percha and Ah plus sealer, in a cold lateral condensation technique. 3mm long orifice plugs of IRM® was placed, in continuum with a temporary restoration. A final radiograph was taken.

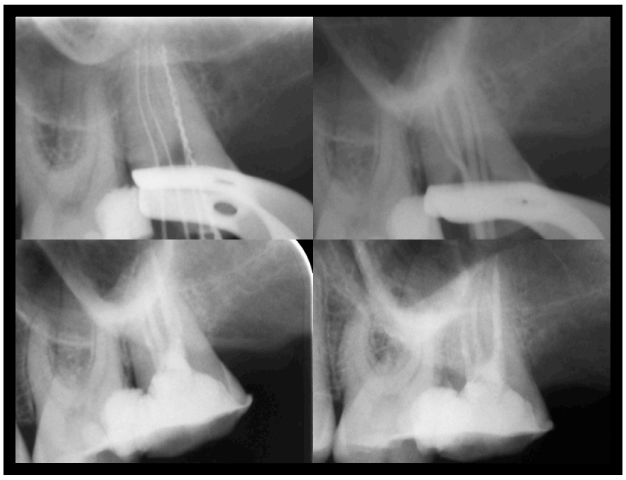

Figure 2-5: Treatment radiographs, 15. Mar. 2012

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

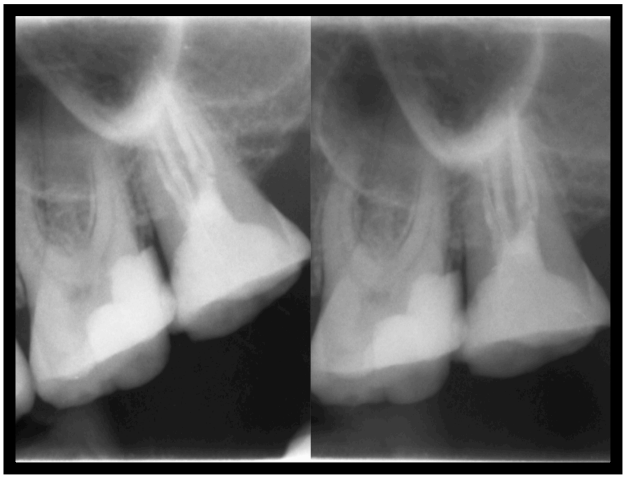

Figure 2-6: Follow-up, 10. Apr 2013 (1y 1m)

Evaluation

In this case, the most difficult part was visualizing the root morphology, determining the correct working length and evaluating the filling density. The zygomatic buttress projected over the apical area in several different radiographic projections. Although CBCT is a better diagnostic tool in this situation, using this modality might not alter the diagnosis and prognosis of the treatment. Cost-effectiveness and radioprotective guidelines weighed against its use here.

At one-year follow-up PAI is 1, with no symptoms.

Discussion

Vital pulpectomy is the removal of the dental pulp proper, excepting lateral canals, isthmus-residing tissue remnants and the main canal tissue apical to the working length, if it should be inside the root, as aimed for. The pulp may or may not be superficially infected, but the apical part of the canal system is still infection-free. Animal models of pulp exposure have shown that although the pulp tissue is not necrotic, an osteolytic reaction may be seen after 7 days. (1) The influx of innate immunocompetent cells, notably the macrophages, is seen in the first 0-3 days after an experimental pulp exposure. The osteolytic reaction is induced by the host immune system reaction to microorganisms. Food, saliva and other foreign matter do not elicit strong inflammatory reactions, shown in the classic study on germ-free animals. (2) The amputated pulp heals if the conditions are aseptic. The mode of healing is like other wounds, with formation of connective tissue. The nerve fibres undergo changes like those for amputations elsewhere in the body, with formation of microneuromas and lateral sprouting of axons. (3) Inflammatory cells may be seen histologically some time after the procedure. Some animal experiments conclude that obturation of the canal system is ineffective in maintaining a inflammation-free periapical area. (4, 5) Explanations for this may be break in asepsis, leakage of microorganisms, even the old hollow tube theory is mentioned as a reason. (6) One may wish or expect that the periapical area should be uninflamed after a period of wound healing. Other animal studies have shown better effect; it may not be a coincidence that a strong focus on microbiology gives more consistent result. (7) Clinical studies have reported good results when periapical healing is assessed on radiographs. Overall healing in teeth initially diagnosed with a vital pulp, range from 90,5-96%. (8-10)

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Case 3: Retreatment of a mandibular first molar

Introduction

The patient, a Norwegian female, aged 17, is referred from the public dental health service in Oslo. Patient record number is 1056838.

Chief complaint

None. She complies with the referral.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diagnosed diseases. No fear or compliance problems with treatment

Dental

The referral asked a retreatment of tooth 46. She has had sporadic tenderness in this tooth, but asymptomatic at the moment.

Examination

Clinical

Examination reveals normal conditions: Healthy mucosa and intact teeth save for tooth 46, which has a class 1 composite restoration.

Figure 3-1: Dental overview

	47	46	45
El. Pulp test	-	-	-
Cold sens.	+	-	+
Percussion - ax	-	+	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD	<2mm	<2mm	<2mm
Mobility	-	-	-

Table 3-1: Diagnostic dental data

Radiographic

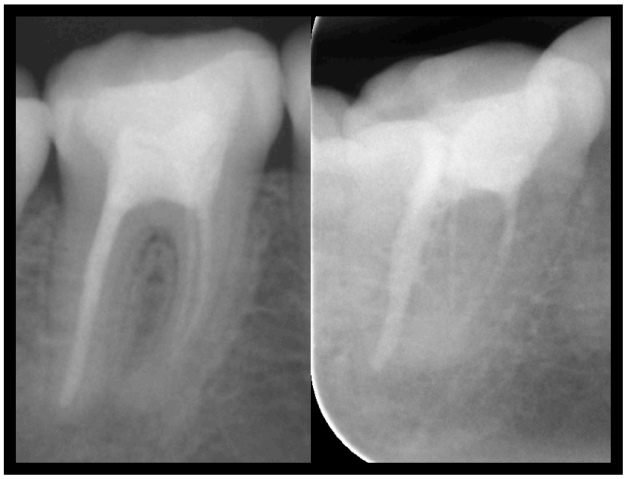

Figure 3-2: Pretreatment radiographs; right: mesioangulated

Tooth 47 and 45: Normal dental morphology, lamina dura and surrounding alveolar bone.
Tooth 46: A radioopaque filling is seen in the crown. In the root, there is a radioopaque obturation material that has adequate dimensions in the distal roots, but is thin and short of the apex in the mesial root. Apically, the lamina dura is discontinued and there is a radiolucent circular zone of 3mm diameter. An extra, mesioangulated radiograph reveals voids in the distal root as well as the possibility of the two mesial canals to join apically.

Diagnosis

Pulpal

K04.1 Necrosis of pulp
Previously root-canal treated

Periapical

K04.5 Chronic apical periodontitis
PAI 4

Treatment plan

The inadequate root filling was considered a risk factor for the chronic apical periodontitis in this case. Non-surgical retreatment in two visits was considered the best option, as removal of the restoration could be done with no harm to the tooth. Alternate treatments were to refrain from treatment, surgical retreatment or extraction. The patient agreed to the recommended treatment.

Treatment

15. December 2010: Re-access

The composite filling was removed. Rubber dam was applied and the field was disinfected.

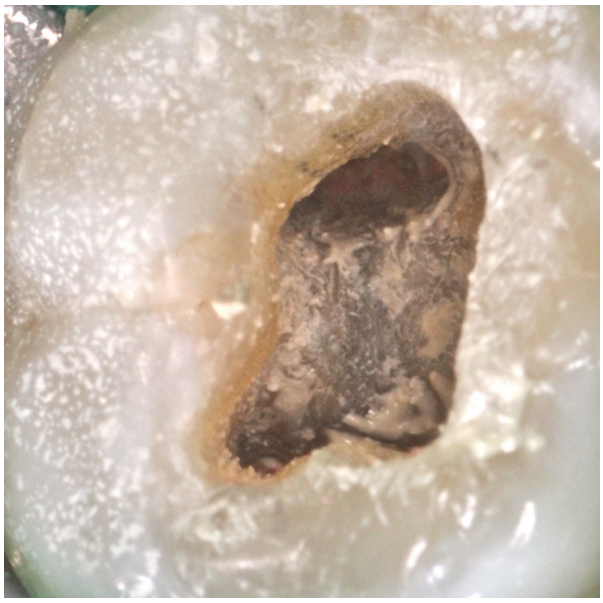

Figure 3-3: Access cavity

The gutta-percha root filling was mechanically removed using rotary nickel-titanium files in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm. Hand instruments removed the apical remnants, and working length was established radiographically. Two mesial and one distal canal was found and cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. Chlorhexidine gluconate 2% soaked the canals for 5 minutes. The final dimensions were: distal root - 16mm/ISO 60/2% taper, mesial roots - 17,5mm/ISO40/4% taper, both canals. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

04. January 2011: Obturation

The patient's tooth was asymptomatic. Rubber dam was applied and the field was disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha and Ah plus® sealer, in the cold lateral condensation technique. 3mm thick orifice plugs of IRM® were placed in each canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling.

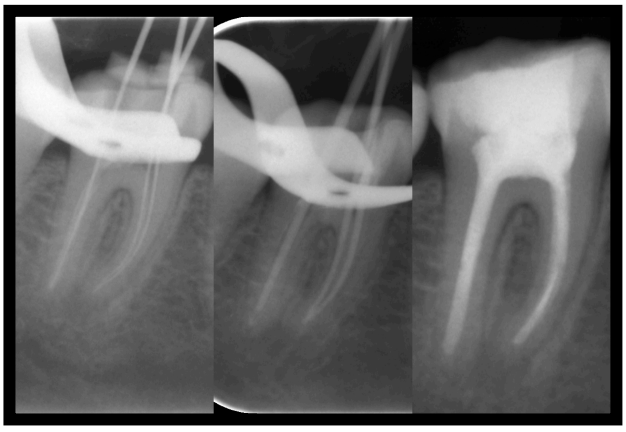

Figure 3-4: Treatment radiographs

Prognosis

Endodontic: good
Periodontal: good
Restorative: good

Evaluation

For this young and healthy patient, with no particular oral healthproblems, this tooth might have a good longevity-potential if treatment is optimized. One major risk

factor is present; persistent or secondary chronic apical periodontitis. This would affect the prognosis negatively. Otherwise, there was not found other risk factors. Therefore, the recommendation to do a orthograde retreatment would be a strong recommendation. This was carried through with no complications, hopefully to the patient's long-term benefit. PAI was set to 1 at the one-year follow-up, with no symptoms.

Figure 3-5: Follow-up, 25. Jan 2012 (1y 1m)

Discussion

A persistent or secondary infection is used as a term to describe the nature of the infection present in teeth that are earlier root-canal treated, and failing. Their treatment has proved less successful than the treatment of primary infections. (1) Early in the endodontic era of research, the idea grew that certain microorganisms were responsible for persistent canal infections. (2) The idea was that targeted treatment, like antibiotic therapy or vaccination might lead to better results. (3, 4) Although these early attempts to optimize treatment did not succeed, large efforts have been made to characterize the microbiota in persisting infections. *Enterococcus faecalis* and the fungi *Candida* was a frequent finding. (5-8) The interpretation was that these organisms had the ability to survive our treatments, commonly using mechanical debridement, sodium hypochlorite and calcium hydroxide. Therefore, modifications like the addition of chlorhexidine were tried out. Laboratory and clinical data supported its use, although the data was few and based on analysis of secondary variables. (9) In the last decade, molecular microbiological techniques has so far shown mixed data that indicate that the predominance of *Enterococcus faecalis* may have been influenced by the earlier culture methods. In one study, no association of *E. faecalis with* treatment failure was made, and a prevalence in persisting infections of 12%. (10) Other data using molecular microbiologic techniques present prevalence figures of 77%. (11) Well-designed studies that use radiographic follow-up analysis are lacking to show the effect of different treatment protocols. Furthermore, microbiologic investigations that analyze the whole microbiome in the root canal in an unbiased way are also warranted. Published data on single-visit retreatment with sodium hypochlorite as the disinfection medicament give alluringly high success rates, 84%, for cases with preoperative lesions. (12) These observational, uncontrolled clinical data questions the importance of the use of chlorhexidine.

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Case 4: Post removal and retreatment in a mandibular first molar

Introduction

The patient, a white Norwegian male, aged 48, was referred from the undergraduate clinic, to retreat tooth 46. Patient record number is 0950779.

Chief complaint

None. The patient complies with the referral.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 4-1: Dentition overview

Dental

No symptoms from tooth 46 at present, occasional tenderness in the tooth. The tooth was diagnosed with chronic apical periodontitis, and an attempt to retreat had been done and discontinued, because of posts present in the canals.

Examination

Clinical

The patient´s lower right quadrant is currently undergoing restorative treatment in the undergraduate clinic. The mucosa is uninflamed, the marginal probing depths is within acceptable normal limits.

Figure 4-2: Treatment area

Tooth 48 has a class 1 and 47 a class 2 amalgam restoration. Tooth 46 is restored with a metal-ceramic crown, with an occlusal temporary filling. Tooth 45 has lost large parts of its coronal substance, and has a temporary filling. Tooth 44 has two small class I amalgam restorations. Diagnostic dental tests were done, see table 1.

	47	46	45
El. Pulp test	43	-	-
Cold sens.	+	-	-
Percussion - ax	-	+	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD			
Mobility	-	-	-

Table 4-1: Dental diagnostic data

Radiographic

Tooth 47 has a radioopaque filling with adequate dimensions and margins. There is a small radiolucency on the distal approximal surface, limited to the outer 1/3 of the dentin, constituting a small carious lesion. Otherwise, there is normal root morphology and surrounding bone.

Tooth 46 has a radioopaque crown restoration with well-fitting margins, obturation materials with different radioopacity in 4 canals, suggesting some type of fibre post in the distal two roots.

Figure 4-3: Pretreatment radiograph, 10. Sept. 2010

Both roots has a well-defined apical circular radiolucency and broken lamina dura apically. Interradicular and marginal bone is intact. There is some sign of bony sclerosis inferior to the radiolucencies.
Tooth 45 has substantial loss of coronal dentin, and a small sliver of radioopaque obturation material is seen in the canal space. The root has a slightly distended periodontal ligament space apically, but otherwise normal bone supporting structure.
A small radiolucent circular area 5-6mm below the root of tooth 45 is consistent with the mental foramen.

Diagnosis

47 - Dentinal caries, K02.1
46 - Chronic apical periodontitis, K04.5, Pulp necrosis, K04.1. Endodontically treated earlier. Periapical index score: 4.
44 - Pulp necrosis, K04.1

Treatment plan

Non-surgical retreatment of tooth 46 as wanted in the referral is recommended. Other less recommended options would be surgical retreatment with restoration of the access cavity with a composite filling, or extraction. Leaving a chronic periapical inflammation that is symptomatic at times has a poor prognosis and is not recommended. Non-surgical retreatment has several benefits to surgical retreatment: The access cavity has already destroyed the retentive effect of the posts and composite core. If the retention of the crown is lost, a new post might be needed. The removal of fibre posts is presumed easy and safe. The long-term prognosis of surgical retreatment is not better than non-surgical retreatment. The patient chose to follow our recommendation, although extraction, also of tooth 45, was discussed. The undergraduate treatment plan encompasses his other dental problems.

Treatment

26. October 2010: Post removal and re-access

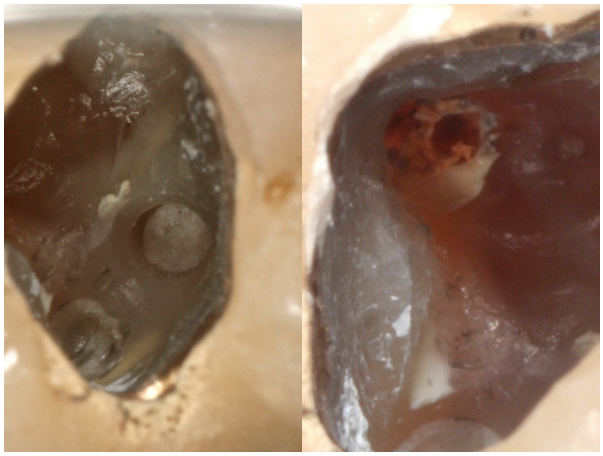

Figure 4-4: Left, pretreatment fiber post in distal root; Right, intiating removal, distal root

The temporary filling was removed and inspection with an operating microscope revealed two remnants of quarts- or glass fibre posts in two distal canals. They were removed using diamond-coated ultrasonic tips. The removal was done in a dry field, but intermittently, and with no local anaesthesia, to control for excessive heat build-up in the root. Then, rubber dam was placed and the field disinfected. The gutta-percha root filling was mechanically removed using rotary nickel-titanium files in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm. Hand instruments removed the apical remnants, and working length was established radiographically. Two mesial and two distal canals was found and cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%.

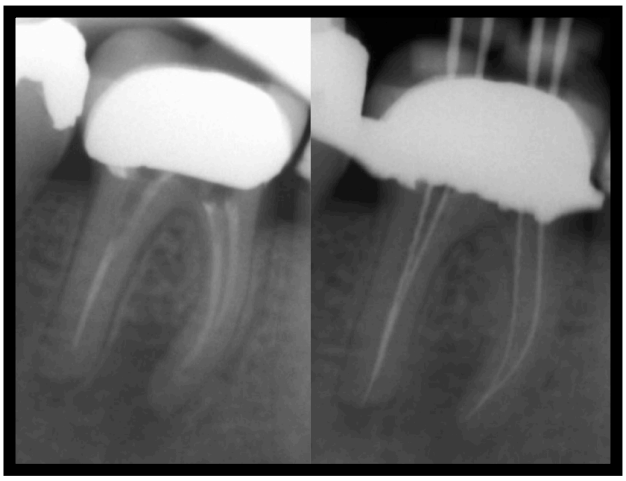

Figure 4-5: Left, post removal; Right, working length

Chlorhexidine gluconate 2% soaked the canals for 5 minutes. The final dimensions were:
Distobuccal root - 17,5mm/ISO 55/2% taper
Distolingual root - 17mm/ISO55/2%taper
Mesial roots - 18mm/ISO45/2% taper, both canals.
The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

16. November 2010: Obturation
The patient was still free of symptoms. Rubber dam was placed and the field disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. A masterpoint radiograph was taken. The canals were dried and obturated with Resilon points and Epiphany® sealer, in the cold lateral condensation technique. Three mm deep orifice plugs of IRM® were placed in each canal. The tooth was permanently restored with composite, using Scotchbond Multipurpose® bonding and Tetric EVOCeram® restorative. A final radiograph was taken, showing adequate dimensions of the root filling. A void-like discrepancy between the composite and the root is due to pooling of bonding fluid in the pulp chamber. This was attributed to the operator's inexperience with the material.

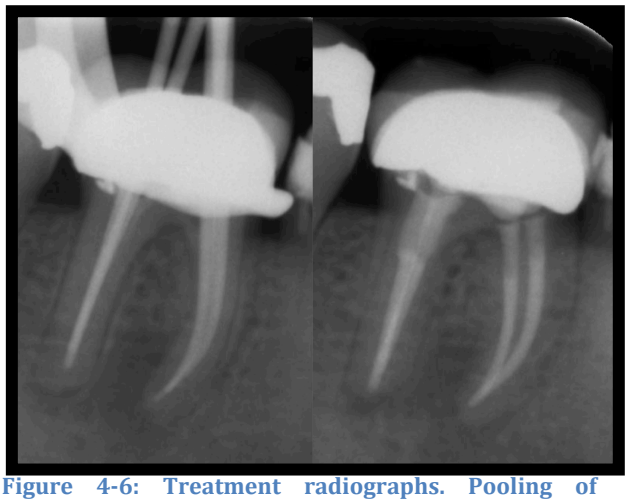

Figure 4-6: Treatment radiographs. Pooling of bonding resin visible to the right

Prognosis

Endodontic: good.
Periodontal: good
Restorative: uncertain

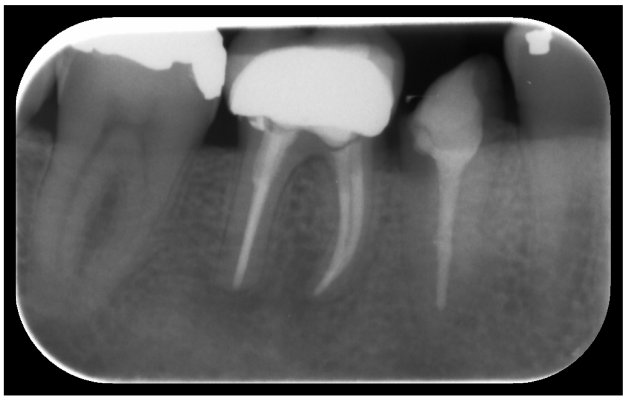

Figure 4-7: Follow up, 26. April 2012 (1y 5m)

Evaluation

The treatment went according to plan. There is uncertainty to the remaining retention of the crown, after removal of both the posts and the core, and then a new, intracoronal bonded core. Even when using an operating microscope, one must expect better conditions for creating a good bond between the dentin and the composite core if the crown had been removed and made anew afterwards. In the patient's economic interest, an attempt at keeping the crown was done, of course with a guarded prognosis for its retention. He was informed of this, and agreed. PAI was set to 1 at the follow-up, with no symptoms.

Discussion

If orthograde retreatment is called for, posts need to be removed. Different methods may be used for different posts. In this case, fibre posts was removed. The fibre post, introduced by Reynaud at Recherches Techniques Dentaires (RDT), started as the carbon-fibre based Composipost in 1988, and has since been repeated by a plethora of manufacturers and in different variations. Posts made of metal, either cast or prefabricated, may induce damage to the tooth when removed. (1) Cracks and loss of tooth structure may be induced by pulling or drilling out a post. Post-pullers that grab and pull the post (Eggler device) or machine threads and lever up the post (Gonon, PRS, Meitrac), even wedging devices (WAM-X) may be used for removal. Ultrasonic vibration applied to the head of the post may vibrate loose the cement. Data from select laboratory studies do not support that the post alloy, cement type or even the use of ultrasonic vibration applied to the post head affect the pull-out force. (2, 3) It is speculated that the reason for the clinical experience that ultrasonic vibration may loosen a post, may be because of poor adaptation of the post or a weak cement film. Troughing out the post with small-diameter burs, thin ultrasonic instruments or even trephines like the Masseran kit may be used, with the risk of removing dentin in the process and weakening the tooth.

A proposed benefit of the fibre post is its ease of removal. This way, the clinician has more of a choice between non-surgical and surgical retreatment of teeth with a dowel. Proposed methods of removal for fibre posts are conventional burs, removal bur kits and ultrasonic instruments. Post-pulling devices may not be well suited for fibre posts. The fibre post is made of cured resin that infiltrates axially oriented fibres. This is taken advantage of during removal by cutting a centrally oriented guide hole in the post. Thereafter, end-cutting drills are pushed into this pilot hole, enlarging it and progressing axially partially guided by the fibre orientation. If done with water spray or intermittently, heat build-up is not a problem. The process is said to be fast, at least in laboratory studies. (4, 5) These same studies note that some enlargement of the canal space occur, caused by bur deviation. So caution and precision may be advised during removal. Ultrasonic instruments disintegrate the resin matrix and are effective in removing fibre posts as well, albeit slower. In cases were restricted access and visibility is a factor, it may give the operator added control, when aided by the operating microscope.

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Case 5: Post removal and retreatment in a maxillary lateral incisor

Introduction

The patient was referred to the postgraduate endodontic clinic from a private dental practice in Oslo. She is a 49-year-old female, who has immigrated to Norway from Serbia. Patient record number is 0069890.

Chief complaint

The patient wants a more aesthetic maxillary left lateral incisor (22). She is referred for retreatment of this tooth, so that a new post and crown can be made.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.
She is fluent in Norwegian.

Figure 5-1: Dental overview

Dental

Most of her dental treatment is done here in Oslo. Tooth 22 is discoloured. It has been discoloured for many years, since it initially received a root canal treatment in Serbia, for reasons not remembered. It recently broke at the gingival level, and was temporarily repaired by her dentist. She has no problems or symptoms associated with 22 other than the discolouration. She is anxious that the temporary repair may not hold for a long time.

Examination

Clinical

The patient has a well-restored dentition and good oral hygiene.
21 - distal class IV composite restoration
22 - discoloured, crown fragment is re-attached to the root with a fibre post and composite restorative material. The repair looks very well performed, with perfect margins and gingival health. The post has a transparent appearance, it may be seen on the palatal surface. This is typical for quartz- or glass fibre posts, and rules out carbon fibre or zirconium post materials.
23 - distal class IV composite restoration

	21	22	23
El. Pulp test	No result!	-	26
Cold sens.	+	-	+
Percussion - ax	-	-	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD	<2mm	<2mm	<2mm
Mobility	-	-	-

Table 5-1: Dental diagnostic data

Radiographic

21 and 23 - normal root morphology, intact lamina dura, normal appearance of surrounding bone
22 - A radioopaque material fills out about half of the crown. There is a radiolucent dental post joining the coronal fragment to the root. Apical to the post, there is a radioopaque root filling material that terminates 5mm short of the apex. The root filling material has a radioopacity normal to gutta-percha, in contrast with the appearance of resorcinol-based material that is sometimes used in parts of Eastern Europe. There is a discontinued lamina dura apically, in conjunction with a radiolucent circular zone 3-4mm in diameter.

Figure 5-2: Pretreatment radiograph

Diagnosis

Pulpal - necrosis of pulp, K04.1. Complicated crown fracture, S02.52. Previously endodontically treated.
Periapical - chronic apical periodontitis, K04.5. PAI 4

Treatment plan

Removal of post and orthograde retreatment in two visits was recommended and planned. A preoperative partial impression would be used to fabricate a temporary crown in a chairside material, retained with a temporary post in the canal. The option of no treatment was discussed but quickly discarded; the patient wanted a better-looking tooth with optimal strength. Surgical retreatment with the benefit of not needing to remove the post was considered, but not recommended. It was considered easy and safe to remove this type of fibre post, and the high likelihood of a persisting intracanal infection causing the chronic apical periodontitis lowered the recommendation for the surgical approach. The patient also preferred not to have a surgical procedure if a non-surgical treatment would have a similar prognosis. The root was considered restorable, so extraction and single-tooth implant restoration was not considered.

Treatment

2. September 2010: Post removal

A thorough discussion of the scope and course of treatment was done, as outlined above. A sectional index in polyether impression material (Impregum®) was taken. The coronal fragment and composite material was removed with a bur. The post was removed using a removal bur kit for fibre posts (D.T. Post Removal® kit from VdW). A radiograph was taken to verify removal. A small piece of metal wire was adapted as a temporary post. A small pellet of Cavit-G® was placed in the bottom of the now empty post space. The post was inserted on top. The sectional impression was filled with a bis-acrylic provisional material (Luxatemp®), left to cure, removed and finished. The provisional post-crown was cemented in place with TempBond NE®.

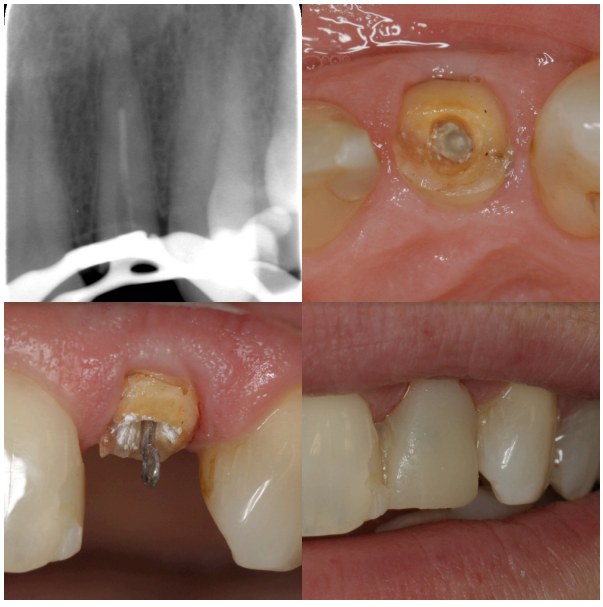

Figure 5-3: Post removal, temporization

14. September 2010: Retreatment, 1st visit

The temporary crown was removed, and rubber dam applied. The field was disinfected. The obturation material proved to be conventional gutta-percha. It

was mechanically removed, and optimal working length was reached. This was

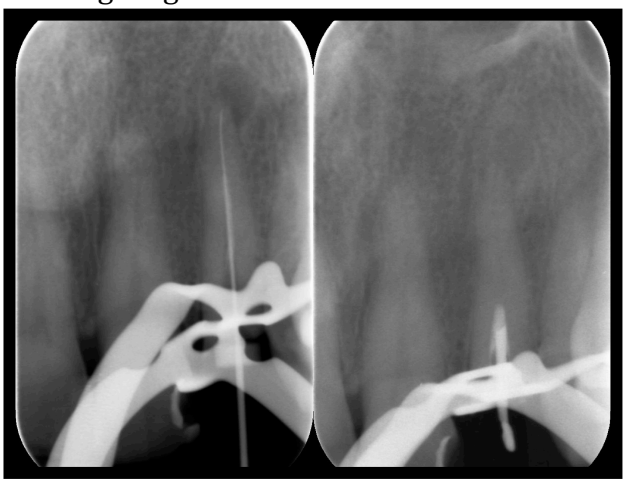

Figure 5-4: Working length and temporization post

confirmed radiographically. Small lateral remnants of fibre post material were removed with a diamond-coated ultrasonic instrument. The canal was shaped and cleaned, using Bio-Race® rotary instruments and sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. Chlorhexidine gluconate 2% soaked the canals for 5 minutes. The final dimensions were 17mm/ISO40/4% taper. The canal were dried and calcium hydroxide paste was spun down with a lentulo spiral, sealed with a plug of Cavit-G® inferior to the temporary crown, which was cemented as before.

21. September 2010: Retreatment, 2nd visit

The patient did not have any symptoms, nor did she at the two other appointments.

Figure 5-5: Masterpoint and final radiograph

The temporary crown was removed, and rubber dam applied. The field was disinfected. The canal was cleaned and irrigated as above, including the use of passive ultrasonic activation. The canal was dried, a conefit radiograph taken. The root was obturated with Resilon® master cone and Epiphany® primer and sealer. The filling was cut back to facilitate cementation of the temporary restoration and a separating plug of Cavit-G®. This was mentioned in the discharge summary.

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Figure 5-6: Follow-up, 20. Sep. 2011 (1y)

Evaluation

The procedure went according to plan. The thickness of the interrim sealing plug was a bit short, 3-4mm would be preferrable. A lighter shade of provisional material would have been better, only shade A3 was

available. Follow-up at 1 year show clear signs of healing, PAI is 3.

Discussion

Using a combination of a sealer and a core material dominates over other techniques to create a hermetic seal of the canal after disinfection procedures. Gutta-percha has been the most used core material; in the cement area there are more variations. Unfortunately, coronal leakage of microorganisms may lead to treatment failure. Resilon and its associated sealer aim to improve the sealing properties. Curiously, there is no world-wide accepted method to rely on when testing for sealing ability, not in the laboratory or in the clinic. This certainly poses a problem when one wish to determine which is the better sealing filling material.

Early attempts to test for leakage measured the ability for small particles to penetrate along the filling. One method was to immerse the root-filled tooth in a solution containing radioactive particles, and then grinding the tooth in half along it axis, placing it on a film and thus depicting leaky areas filled with radioactive particles. (1) Many attempts at using dyes and inks were also used. In a classic series of experiments, Pelican ink was used to measure the degree of leakage in obturated teeth. After dye immersion, teeth were made transparent and dye penetration was measured, thus giving name to the method: linear dye penetration. The experiments went well initially, with positive and negative control specimens leaking a lot and not at all, respectively. The last experiment, though, was performed on monkeys. Teeth obturated with different sealers were challenged in different ways, to see which was most resistant to leakage. Teeth were removed, exposed to dye, and linear penetration was measured. The positive and negative control teeth leaked no differently from the test teeth. (2-4) This led to the consideration that new laboratory tests must be developed. Small tracer and dye particles were no longer considered a reliable test, this was criticised in two well-known articles published a few years later. (5, 6)

A test that has evolved to contemporary use was the "two-chamber" test for microbial penetration. The sterile, obturated root bridged two chambers, one devoid of and one teeming with microorganisms. Dye indicators mark the passage of organisms from one chamber to the other. The method was used initially to test an early resin-based sealer, Hydron. (7) It evolved to contemporary status when used by Torabinejad, which studies using this model supported the rapid penetration of microorganisms along root-filling exposed to the environment. (8)

Another, parallel approach by the well-known lab of Pashley was the use of pressure, to see if fluid could penetrate through a test specimen. The method was used initially to test restoratives and the leakage of dentin. (9, 10) Later, researchers at ACTA used it to test the leakage of obturated roots. (11) The method has been dubbed the "fluid filtration" method.

Since then, much use of both these methods has been made. The advantage of the "two-chamber" method is that it tests for bacterial penetration. Two years ago, an important criticism of this method was made. Researchers in Zürich used specialized staining and microscopy techniques to discover that in some cases, bacteria did not leak along the root filling, but through the outside of the root, and even in dentinal canals. (12, 13) They advise that this finding be taken into account when using the two-chamber model, and propose that work be done to refine the model.

The search for a good laboratory test method to test the sealing properties of root canal filling materials continues. It is important work, because it allows us to avoid the sacrifice of animals or the troubles of clinical trials. It may even explain why one material is better than another.

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Case 6: Retreatment in a mandibular first molar

Introduction

The patient is a Norwegian male, aged 28. He is married to an undergraduate dental student, who refers him to our department. Patient record number is 0842762.

Chief complaint

His mandibular left first molar (36) is painful at times.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 6-1: Dental overview

Dental

The referral asks retreatment of tooth 36. The patient and referring student believe it to be endodontically treated in 2007, about three years ago. The tooth is tender to percussion and chewing sporadically, but not at the moment. A crown is planned in the future.

Examination

Clinical

Figure 6-2: Treatment area

The tooth has a grey discolouration, and is restored with a MO composite restoration. Neighbouring teeth 35 and 37 are sound. 38 is fully erupted, with a class I composite restoration.

	37	36	35
El. Pulp test	54	80	26
Cold sens.	+	-	+
Percussion - ax	-	(+)	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD	<2mm	<2mm	<2mm
Mobility	-	-	-

Table 6-1: Diagnostic dental tests

Radiographic

Two radiographs were taken, one with a mesio-eccentric angulation.

35 and 37 - normal root morphology, intact lamina dura, normal surrounding bone structure.

36 - In the crown, a radioopaque restoration is seen to fill out most of the coronal toot structure. The roots seem to

Figure 6-3: Pretreatment radiographs

be straight and of normal length. A radioopaque obturation material fills out the root canals in optimal length, width and without voids. The mesio-angulated view indicates a unobturated canal in the distal root partially filled with radioopaque sealer. The lamina dura is broken on both roots; there is also a small circular radiolucent zone on each. A radiograph taken in 2008 was available; it showed the same conditions, but a visible enlargement of the lesion is evident in today's radiograph.

Diagnosis

Tooth 36:

Pulpal - necrosis of pulp, K04.1. Previously endodontically treated

Periapical - Chronic apical periodontitis, K04.5. PAI 4.

Treatment plan

Orthograde retreatment in two visits was recommended and planned. With a worsening chronic apical infection, a missed canal, and a plan for a permanent crown later, the recommendation for orthograde retreatment was strong, and ranking above other treatment options. No treatment and later extraction, or surgical retreatment, was not recommended options for this patient's situation.

Treatment

10. November 2010: Re-access

The composite filling was removed. Rubber dam was applied and the field was disinfected. The gutta-percha root filling was mechanically removed using rotary nickel-titanium files in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm. Hand instruments removed the apical remnants, and working length was established radiographically. Two mesial and two distal canals were found and cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. Chlorhexidine gluconate 2% soaked the canals for 5 minutes. An isthmus in the distal root was cleaned and enlarged with a ultrasonic K-file. The final dimensions were: distobuccal and distolingual canal - 21mm/ISO 45/2% taper. Mesiobuccal canal - 21mm/ISO45/2% taper, mesiolingual canal - 22,5mm/ISO45/2% taper. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

Figure 6-4 Working length, first visit; Masterpoints, second visit

1. December 2010: Obturation

The patient's tooth was asymptomatic. Rubber dam was applied and the field was disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. A masterpoint radiograph was taken. The canals were dried and obturated with Resilon® points and Epiphany® primer and sealer using the cold lateral condensation technique. Three mm deep orifice plugs of IRM® were placed in each

canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling.

Figure 6-5: Postoperative radiograph

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Figure 6-6: Follow-up, 01. Nov. 2011 (9m)

Evaluation

The treatment went as planned. Follow-up radiograph show clear signs of healing, PAI is 3. Given that the tooth receives a permanent restoration, prognosis is optimal. In this case solvents was not used to soften the gutta-percha during removal. Mechanical softening due to friction heat and ultrasonic instruments was sufficient. In general, isthmi are structures that may benefit from chemical solvents, if infected obturation material is lodged within.

Discussion

Resilon® was introduced on the market in 2004. "Resilon" is the brand name for the core material, used in the same way as gutta-percha, in the form of standardized points or thermo-softened pellets. It is a composite material, with glass filler particles in a polycoprolactone matrix. It was intended to be used with the sealer Epiphany®, which is a methacrylate-based sealer capable of fusing to Resilon® and bonding to dentin, inducing a hybrid layer. SybronEndo aquisitioned and now market the system as RealSeal®.

The initial publications on RealSeal were positive. One well-known initial study was a two-chamber microbial leakage test delivering data very much in favour of RealSeal®. (1)

Further initial studies on cytotoxicity and animal implantation tests did not give negative results. (2) Some debate was observed when Pashley's laboratory published data that indicated that the Resilon core material was susceptible to degradation in the root canal, while gutta-percha did not. The basis for this research was that the polymer matrix in Resilon, polycoprolactone, was classified as polyester. Some polyester materials may degrade via hydrolysis, which is the same reaction dissolving sucrose into two monosaccharides. Although not as dissolvable as icing sugar, this susceptibility might leave Resilon open to enzymatic breakdown, by enzymes in tissue fluids or of bacterial origin. Much of the debate centered on the fact that when testing for hydrolytic susceptibility, high concentrations of sodium ethoxide had been used. It is a chemical often used in polymerisation of polyesters, and many felt it was given that it would dissolve Resilon. Pashley's group took the research further in what they called a tiered approach. In a

series of publication Resilon was exposed to different challenges. The data support the notion that Resilon may degrade under the test conditions. (3-7)

A decade after its introduction it is not clear that RealSeal perform better clinically than other materials. Recent unsystematic reviews conclude that too little data is available. (8-10) The few clinical data that is published are based on short follow-up periods, up to two years. The results are not different from success rates normally observed, but direct comparisons between studies may be difficult. (11, 12)

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Case 7: Chronic apical periodontitis, dens evaginatus and lip numbness

Introduction

A 17-year-old Norwegian girl, of Chinese origin, was referred from the public dental health service in Oslo. She is referred for the treatment of her first lower left premolar (35). Patient record number is 0839403.

Chief complaint

The patient has sporadic toothache from her lower left molar region. She has a numb lower lip on the same side as the toothache.

Medical history

General

Her father, a Chinese immigrant, accompanies her. He converses in English language, and some Norwegian. She, being born here in Oslo, is fully fluent in Norwegian. Other than this, the anamnesis was non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 7-1: Dental overview

Dental

The patient reports sporadic tenderness from tooth 35, but at the day of the examination it was asymptomatic. The left half of her lower lip is numb. Some months ago a small filling was placed in 35, the toothache and numbness came afterwards. The same thing, but without numbness, happened on her contralateral side. Here, tooth 45 is now endodontically treated. There was some pain during this procedure, so she and her father are anxious about today's treatment. Furthermore, they are frustrated that this can happen after only a small dental filling.

Examination

Clinical

Figure 7-2: Lower jaw and treatment area

The findings were uncommon to the medical history: small restorations do normally not cause endodontic infections, and endodontic infections do normally not

cause paresthesia. Because of this, thorough examination was done.
Tooth 36, 35 and 34 all had a small class I composite restoration. The oral hygiene was very good, with no sign of gingivitis. The intraoral soft tissue was also healthy. No palpable swelling or lymph nodes was detected. There were no visible carious lesions, and only small restorations in the dentition. The clinical picture is that of a young person with little caries experience.

	36	35	34	33
El. Pulp test	56	80	48	38
Cold sens.	+	-	+	+
Percussion - ax	-	+	-	-
Percussion - hor	-	+	-	-
Palpation	-	+	-	
PPD	<2mm	<2mm	<2mm	<2mm
Mobility	-	-	-	-

Table 7-1: Dental diagnostic tests

Radiographic

Figure 7-3: Pretreatment radiograph

Tooth 36 has a small radioopaque restoration. There is an accessory distal root, possibly radix entomolaris. The lamina dura is traceable with uniform width, and the supporting bone has normal structure. Tooth 35 has a small radioopaque restoration. The coronal pulp is in close proximity to the occlusal surface and the restoration. The root is long; it impinges on the mandibular canal. The lamina dura is broken on the apex; there is a small radiolucency that is continuous with the mandibular canal. Tooth 34 has no visible restorations; the one detected clinically is so small it is not visible. The coronal pulp space is close to the occlusal surface. The root is long, but with a continuous lamina dura. The bone structure surrounding 35 and 34 has normal trabeculation.

Diagnosis

Tooth 35:
Pulpal - necrosis of pulp, K04.1.
Periapical - Chronic apical periodontitis, K04.5†. PAI 4. Other disorders of cranial nerves in other diseases, G53.8*: Paresthesia of left trigeminal nerve, mandibular branch, due to infection.

Treatment plan

Non-surgical root canal treatment in two visits is the recommended treatment. Reassessment if quick recovery does not ensue. An alternative treatment might be extraction of tooth 35, but this is not recommended because of the good prognosis for sensory recovery and retention of the tooth with endodontic treatment.

Treatment

06. January 2011: 1st visit
Rubber dam was applied, the field disinfected. The restoration was removed; no perforation to the pulp was visible in the operating microscope, nor dentin cracks. Access cavity was made into an empty pulp space. Working length was established using electronic apex locator and radiograph.

Figure 7-4: From left to right: Working length (first visit), masterpoint and postoperative radiograph (last visit)

The root canal system was cleaned and enlarged while irrigating with sodium

hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. Hand use NiTi files was used, with ISO 50 as the last size, working length at 23mm. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

01. March 2011: 2nd visit
The patient's tooth was asymptomatic. The lip numbness was gone; there was total sensory recovery. Rubber dam was applied and the field was disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then EDTA 17%. A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha points and Ah plus® sealer, in the cold lateral condensation technique. A 3mm thick orifice plug of IRM® were placed in the canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling.

Prognosis
Endodontic: good.
Periodontal: good
Restorative: good

Figure 7-5: Follow-up, 28. Mar. 2012 (1y)

Evaluation
The paraesthesia was a result of the chronic apical periodontitis, and the close anatomical relationship of the apex of tooth 35 and the inferior alveolar nerve. Peripheral dysfunction in a nerve, in an otherwise healthy individual may have many causes. If resolution of the condition did not occur in this case, it would have needed further investigation. Luckily, it did. PAI at one-year follow-up is set to 1.

Discussion
A high pulp horn in the occlusal surface of a posterior tooth or the lingual surface of an anterior tooth is termed dens evaginatus. A recent review state that it is most commonly found in premolars, and some populations have a higher occurrence of this trait. Chinese, for instance, have between 0,5-4,3% occurrence, higher in females. Co-association with other morphological traits, like showel-shaped incisors, mesiodens and three-rooted mandibular molars are observed. There is a female predilection. (1) The case reported here fits very good in this. The size and location of evaginations, and whether or not they contain pulp tissue, varies. Treatment need often ensues, in the form of pulp infection and apical periodontitis. This may happen at an early age, when the root is not fully developed. Treatments for apical periodontitis that take this into account include apexification with calcium hydroxide or mineral trioxide aggregate and recently pulp regenerative therapies.
Vertucci is a classic author on tooth morphology. There are many ways do evaluate and classify dental morphology, his method were to infuse the pulp space with a dye, and then render the tooth transparent, to visualize the pulp. In his material, the mandibular premolars most of the time had one canal. Mandibular first premolars had one canal 70% of the times, second premolars 97,5% of the times. (2)
Because the crown of the premolar often is tilted slightly lingual, the access need not extend across the central fissure and onto the lingual cusp. It is best kept between the central fissure and slightly shy of the buccal cusp. Because of the mesiodistal width normally found, it is not necessary to use a bigger bur than #4, or 1,4mm in diameter. In adults, a #2, or 1mm bur is enough. The access should be oval, to

account for the oval pulp or dual canal configuration. (3)

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Case 8: Apical periodontitis in a molar with radix entomolaris

Introduction

The patient is a 63-year-old Norwegian male, of Turkish origin. He was referred from the undergraduate clinic for treatment of his lower left third molar (38). Patient record number is 1055481.

Chief complaint

He has a sporadic toothache in the lower left molar region. An older bridge has been removed and the treatment plan is to make a new bridge.

Medical history

Figure 8-1: Dental overview

General

The patient is adequately fluent in Norwegian. Otherwise the general anamnesis is non-contributory: No medications, no tobacco use, no known allergies or current diseases. He was treated for prostate cancer with a surgical procedure 3 years ago, and is, according to himself, fully recovered.

Dental

He has a difficult gag reflex, and it is expected that endodontic treatment of the severely broken-down tooth 38 is to be difficult. 38 has served as a bridge abutment, but the bridge is now sectioned and removed distal to the anterior abutment, tooth 34. The referring student excavated a large carious lesion on the mesiobuccal line angle of 38, thus removing over half of the tooth crown. 38 now has a temporary filling and is asymptomatic. A treatment plan is devised by the student to remake the bridge 38 ^{37} ^{36} ^{35} 34, pending endodontic treatment of 38. The patient's economy is restricted, but he has been granted support for this treatment from the municipal social services (NAV) in Oslo. Both the student and the patient are aware of alternative treatments, e.g. implant-supported prosthetics or a partial prosthesis. A fixed bridge is viewed as the best option, all things considered. The old bridge was made in Turkey several years ago.

Examination

Clinical

There was bleeding on probing on the mesial and buccal side of 38. Soft tissue elsewhere in the region was healthy. There was no palpable swelling. 38 is prepared as an abutment with adequate wall convergence. The occlusal and mesial aspect is restored with IRM®. It is obvious that the abutment needs some measures to provide a good rubber dam seal, because the restoration extends subgingivally. Tooth 34 is restored with a crown, which is the sectioned remnant of the old bridge.

	38
El. Pulp test	N.D.
Cold sens.	-
Percussion - ax	+
Percussion - hor	+
Palpation	-
PPD	<2mm
Mobility	-

Table 8-1: Dental diagnostic tests

Radiographic

Obtaining radiographs is difficult, but not impossible. It poses quite a strain on the patient, and serves as a reminder to both patient and operator on how strenuous endodontic treatment will be. Tooth 38 has a prepared clinical crown, with a large cavity on the mesial aspect. It extends to the pulpal floor. The root canals are visible. An accessory distal root is seen. Statistically, this will most probably be located disto-lingually, but disto-buccally located roots are sometimes seen. The mesial root has a moderate, rounded apical radiolucency, and a discontinued lamina dura. The lamina dura on the distal root is uniform and continuous. The supporting alveolar bone has a normal structure and there is almost no marginal bone loss.

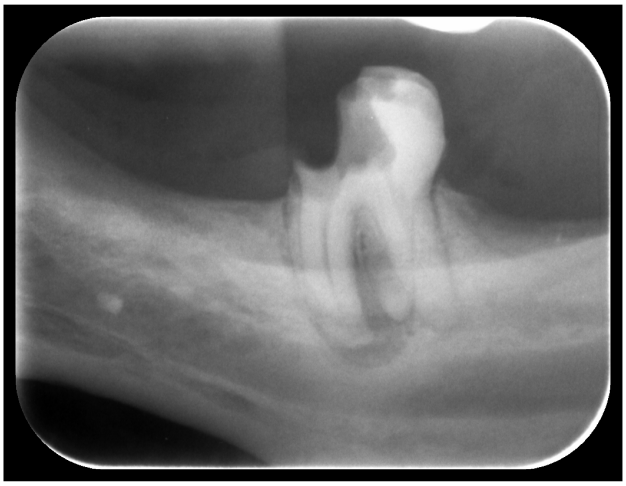

Figure 8-2: Pretreatment radiograph

Diagnosis

Tooth 38:
Pulpal - necrosis of pulp, K04.1
Periapical - chronic apical periodontitis, K04.5. PAI 4.

Treatment plan

A mesiobuccal gingivectomy will give purchase for the rubber dam clamp. Non-surgical root-canal treatment in two visits is planned. The treatment plan may be revised if the gag reflex is a hindrance.

Treatment

13. January 2011: Gingivectomy and chemomecanical debridement

Local anaesthesia, Septocaine®, was administered as an inferior alveolar nerve block. The temporary filling and some residual caries were removed. A small gingivectomy was done with a scalpel, using a no. 15 blade. Haemostasis was achieved by aid of pressure and Ferric Sulfate solution. Rubber dam was applied using an over-bent 211 Aseptico clamp with sharpened beaks. The field were disinfected. Access cavity was refined.

Figure 8-3: Gingivectomy facilitating isolation

An isthmus constituted the canal system in the mesial root, two separate canals was located straight distal and disto-lingual. The two distal roots contained vital, bleeding pulp tissue. Working length was established using electronic apex locator and radiograph. The root canal system was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula.

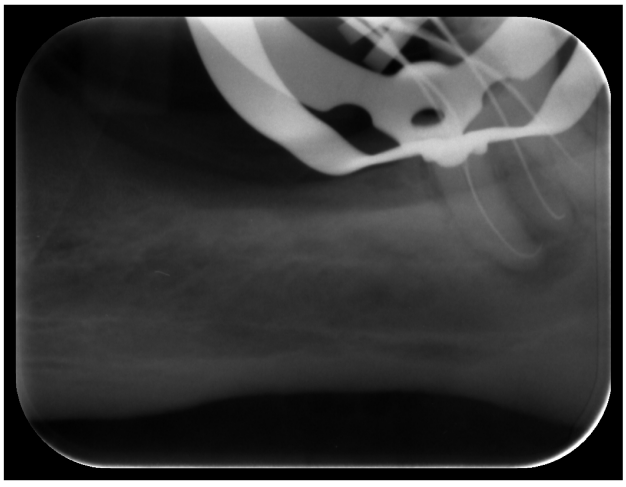

Figure 8-4: Working length

The distolingual root had a sharp curvature in the apical 2/3. The mesial root was debrided with a combination of hand instruments and ultrasonic K-files.

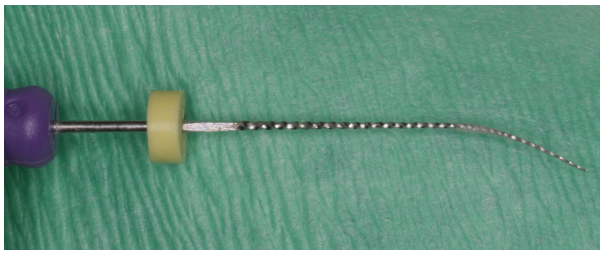

Figure 8-5: K-file just removed from entomolar root, curved, with dentin and deformation at the site of the curvature

Hand use NiTi files was used, with the following final dimensions: Mesio-buccal; 17mm/ISO35
Mesio-lingual; 17mm/ISO35
Disto-buccal; 17,5mm/ISO35
Disto-lingual; 18mm/ISO35
The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

19. January 2011: Obturation

The patient's tooth was asymptomatic. Rubber dam was applied and the field was disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. The dimension of the disto-buccal root was increased to ISO50, same length. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%.

Figure 8-6: Masterpoint and postoperative radiograph

A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha and Ah plus® sealer. The mesial root was obturated using the warm vertical compaction technique, because of the isthmus anatomy. Cold lateral condensation technique was used in the distal roots. A 3mm thick orifice plug of IRM® were placed in the canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling. A small sealer surplus is present.

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Figure 8-7: Follow-up, 14. Apr. 2011 (3m)

Evaluation

The treatment went as planned. Procedural radiographs were very stressful for the patient, but with preparation, a few calm seconds was possible between his retching. Because of our thorough discussion before treatment, the patient was mentally prepared for this. His desire to have a new bridge also helped. Rubber dam was not a problem. Sedation was discussed, but he wished to try without the help of this. Much advice exists for how to alleviate the gag reflex, including the use of topical or local anaesthesia. In our case, there was no difference between the two sittings; the second was performed without regional anaesthesia. One may disagree on the treatment plan, but all involved parts knew that a bridge was inferior in prognosis to

implant-prosthetic treatment. It was considered the best possible solution in this particular situation. If tooth 38 had not been so important, extraction would have been a recommended treatment.
He has no symptoms at follow-up. Adequate radiographs are impossible to obtain, because his gag reflex is very marked today. The radiograph possible to obtain show signs of healing at the mesial root. Panoramic radiograph would be a good alternative, but because of a financially induced delay in his treatment plan, it is decided to obtain such radiographs when he is able to commence treatment again.

Discussion

The archetypal mandibular molar has two roots, one mesial and one distal. Sometimes there may be extra roots, termed accessory roots. When one such is located to the lingual side, it is termed radix entomolaris. When located on the buccal side, it is termed radix paramolaris. Researchers in Copenhagen did a thorough classification of possible variations. They classified lingual third roots in mandibular molars in four groups: A, B, C and AC. Each has two subgroups: fused or separate to the mesial or distal root.
Type A represents molars with a distally located extra root smaller than the main distal root.
Type B is a molar with two distal roots of equal dimensions.
Type C is used in molars that has the accessory root associated with the mesial main root.
Finally, type AC is exiting on the mid-point between the mesial and distal root.
In the Copenhagen material, type A entomolar roots dominated, with more separate roots than fused. (1)
The same researchers also classified variations on the radix paramolaris. They found variations that led them to name two categories, each with two subgroups as above, fused or separate accessory root.
Type A has an acessory root associated with the mesial root.
Type B has an accessory root that exits at the mid-point between the mesial and the distal root. In this material, the type A paramolar root dominated, with more of the subtype that was fused to the mesial root than the one that was separate. (2)
De Moor cites a publication that unfortunately is not available electronically, by authors Ribeiro and Consolaro in the journal Endodoncia, which in 1997 proposed a categorization of the curvatures in accessory mandibular molar roots. (3) The categorization was divided in three. The applicable roots are described as "entomolar", and "distolingual", corresponding to Carlsen's radix entomolaris type A or B, both of the non-fused subtype.
Type I is a straight accessory root.
Type II is curved as it exits the pulp chamber, and straight after that.
Type III has curvatures both at pulp chamber exit and further apically.
The curvatures may lie in different planes, also in the frontal plane not normally visible in radiographs. De Moor advises to expect curved canals, as they are occurring most frequently.
A recent systematic review on the morphology of the mandibular first molar reports that pooled data give a frequency of 13% occurrence of a third molar root. (4) Both in vivo radiographs and computed tomography and ex vivo methods are pooled. A predilection of certain geographical regions exists: Asians, Mongolians and Eskimos. It is worth mentioning that the authors include American Indians in the Mongolian group. A substudy of a German population reports 0,7% occurrence. The review has organized the reports in a world map, so it is easy to know if a patient's origins may be clinically relevant with respect to the occurrence of an entomolar root. The patient treated in this case had his origins in Turkey. No data exist for that region.

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Case 9: Apical peridontitis in a maxillary molar with ledged canals

Introduction

The patient is a Norwegian male aged 52. He is an immigrant from the Middle East, now referred for endodontic treatment of his maxillary left first molar (26). The referral came from the undergraduate clinic. Patient record number is 0521075.

Chief complaint

None. The patient complies with the referral.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 9-1: Dental overview

Dental

The patient was referred for endodontic treatment of tooth 26, because of perceived difficulties for the student treating him. Obliteration was stated as a reason, and that an unsuccessful attempt at negotiating the canals had been made. A crown is planned. Tooth 25 is under retreatment in care of the student. The patient has had sporadic tenderness in this region; he thinks the pain originates from 26. He is asymptomatic at the moment.

Examination

Clinical

The tooth referred for treatment, 26, is the last tooth in the arch. It had a temporary filling in a large access cavity. Tooth 25 was prepared as an abutment, and was also restored with a temporary filling. Tooth 24 was sound. Teeth 37, 36, 35 were well-restored with amalgam. There was subgingival calculus and gingivitis in the dentition.

Figure 9-2: Treatment area, temporary restoration removed

	25	26
El. Pulp test	N.D.	N.D.
Cold sens.	N.D.	N.D.
Percussion - ax	-	-
Percussion - hor	-	-
Palpation	-	-
PPD	<2mm	<2mm
Mobility	-	-

Table 9-1: Dental diagnostic tests

Radiographic

Tooth 26 - A radioopaque filling material obturates the pulp chamber. There appears to be some over-enlargement of the access

cavity to the mesial. The root morphology appears normal; the distal root has a

Figure 9-3: Pretreatment radiographs

moderate curvature. The root canals are hardly visible. The lamina dura appears broken, and there is a small, diffuse radiolucency at the apex of the distobuccal and the mesiobuccal root. There is dense bone superimposed on the roots, which lowers the diagnostic accuracy of the radiograph.

Tooth 25 - A temporary filling fills out a small access cavity in the abutment prepared crown. A radioopaque obturation material is present in two canals, with adequate length, but appears thin. The lamina dura is broken apically, and there is a distinct apical radiolucency.

Tooth 24 - normal tooth morfology and intact lamina dura.

Teeth 24, 25 and 26 all have normal levels of supporting alveolar bone, except for a slightly lowered marginal bone height on the disto-buccal root of 26. This may be associated with the distoversion of the root and with the former loss of tooth 37.

Diagnosis

Tooth 26

Pulpal - Necrosis of pulp, K04.1

Periapical - Chronic apical periodontitis, K04.5. PAI 3

Tooth 25

Pulpal - Necrosis of pulp K04.1

Periapical - Chronic apical periodontitis, K04.5. PAI 4

Treatment plan

Non-surgical root canal treatment in one visit was planned for tooth 26. In the event of non-negotiable canals, a reassessment would have to be done. Extraction or apicoectomy would then have to be considered.

Treatment

27. April 2011: Chemomechanical debridement and obturation

The temporary restoration was removed. The canal orifices of 4 canals were located with a small bur. Some over-enlargement of the access cavity was present from earlier interventions. Rubber dam was applied and disinfected. The Palatal and disto-buccal canal had ledges mid-root.

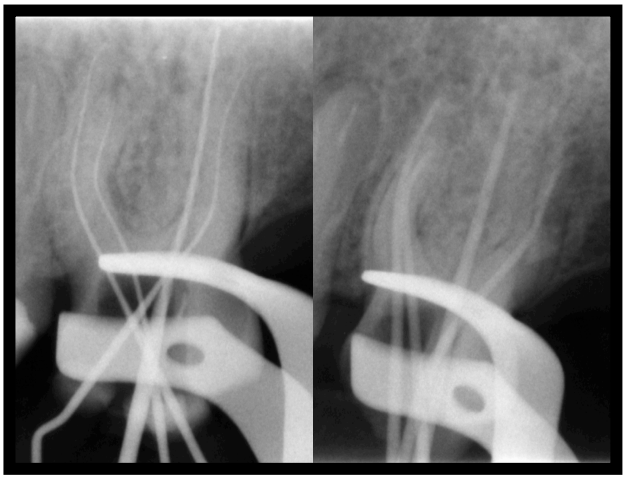

Figure 9-4: Working length and masterpoint radiograph

They were by-passed with pre-bent instruments, and working length was reached. Because of the low level of detail in the measurement radiographs, the electronic apex locator was also used to verify the working length. The root canal system was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula.

Hand use prebent NiTi files was used, initially. Final preparations were performed with Bio-Race® instruments, the final canal dimensions were:
Mesio-buccal - 23mm/ISO40/4%Taper
Mesio-buccal 2 - 19mm/ISO40/4%Taper
Disto-buccal - 22mm/ISO40/4%Taper
Palatal - 22mm/ISO60/2%Taper

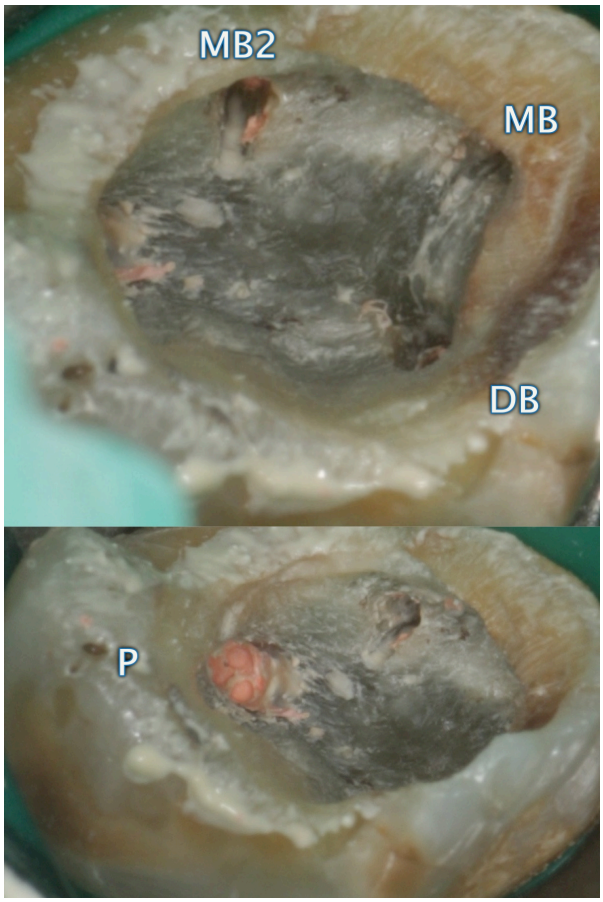

Figure 9-5: Canal orifice locations at obturation

The canals were dried and obturated after a masterpoint radiograph, Ah plus® sealer and gutta-percha were used in the cold lateral condensation technique. Plugs of IRM® were placed over the canal orifices, and the cavity was sealed with more IRM®. A final radiograph was taken.

Figure 9-6: Postoperative radiographs, 27. Apr. 2011, right is distoangulated

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

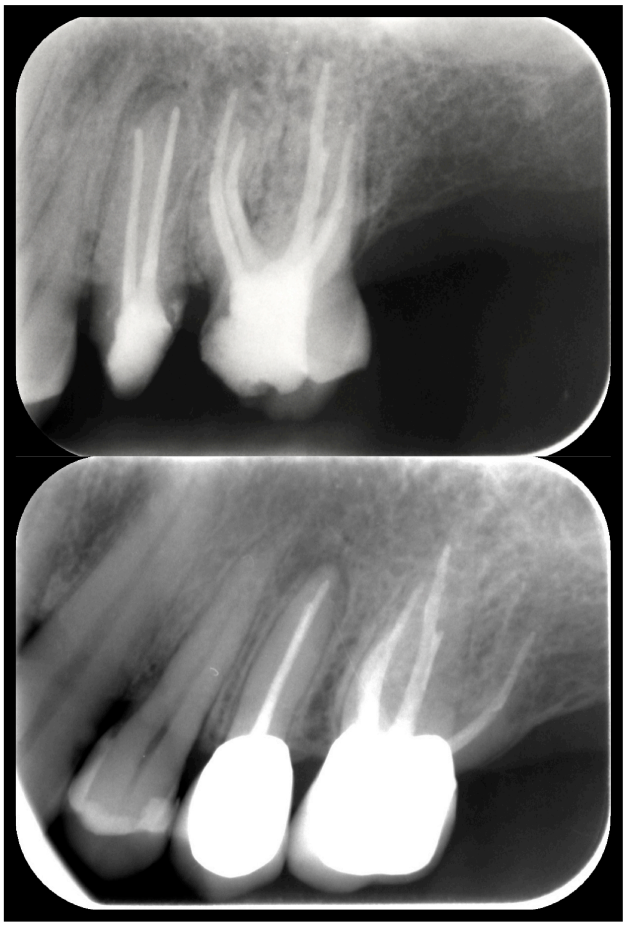

Figure 9-7: Follow-up, top: 03. Jun. 2011; bottom: 11. Apr. 2013 (2y)

Evaluation

The uncovering of the canal orifices was easy in this case. This was not anticipated; therefore canal search was done before rubber dam application. This practice

sacrifices initial asepsis in preference of the added safety of visible anatomical landmarks like root eminences.
PAI is 1 at two-year follow-up, the tooth is restored with a crown.

Discussion

It has been demonstrated repeatedly that apical periodontitis occur as a result of infection in the pulp canal. (1, 2) Irritants from necrotic tissue or endodontic materials may have a small influence, but is not able to cause the histopathologic, radiologic and clinical symptoms of apical periodontitis. (3-5) Various treatments have been used for the treatment of apical periodontitis. Observational studies gave insight in what result a clinician might hope to obtain. (6) Tests of microbial growth from the root canal were used as a measure of the effect of medicaments and procedures. Radiologic assessment years after treatment was and is the primary outcome variable, but microbial tests were faster, and therefore used as a secondary outcome variable. (7-10) The result of these studies was that a combination of mechanical enlargement, irrigation with disinfectants and medication for given time periods with calcium hydroxide paste would predictably reduce the microbial flora of the pulp canal. The reduction was so large that it often was not detectable with paper point sampling. Instrumentation and irrigation alone brought the proportion of sampled canals with negative growth to about 50%. Many studies found a clear association between negative culture sampled from the canal at the time of obturation and radiographic healing at follow-up. (11) This research fit very well with the idea that if bacteria were sufficiently removed from the pulp space, healing would predictably take place. Therefore, there was some surprise when researchers at the ACTA in Netherland published data that failed to find the positive effect of calcium hydroxide medication on growth samples. Canals that sampled positive before obturation, did not show worse results at follow-up radiographic analysis. (12, 13) The discussion around this is also known as the single-visit/multivisit debate. Two recent systematic reviews did not find that long-term radiographic healing differed for teeth treated in a single visit versus teeth treated in multiple visits. One review based itself on data from six trials, the other on data from five trials. (14, 15) Both reviews followed the methodology of the Cochrane collaboration for systematic reviews.
Although these reviews may have their limitations, it is not certain that future reviews will conclude differently. It may reflect that the large reduction of bacteria resulting from mechanical cleansing and irrigation is enough to allow for healing, and that the medication period is also a risk for recontamination through improper temporary seal or other factors.

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Case 10: Conventional retreatment of a mandibular first molar

Introduction

The patient, a Norwegian female aged 69, was referred from the undergraduate clinic for retreatment of her mandibular right first molar (46). Patient record number is 0420172.

Chief complaint

The patient has no problems with this tooth; she complies with the referral.

Medical history

General

The patient has been unfit for work since 2001, because of a psychiatric disorder. She suffers from bipolar disorder; this is well controlled with medications and should not interfere with her dental treatment, according to herself.

Figure 10-1: Dental overview

She once had an allergic reaction to nitrofurantoin (Furadantin®), it manifested as a generalized skin rash. Her doctor advised her to avoid this in the future. She smokes 10 cigarettes per day. She reports using the following prescription medicines:
Lithium (Lithionit®)166mg/d
Lamotrigin (Lamictal®)30mg/d
Esomeprazol (Nexium®)40mg/d
Karisoprodrol (Somadril®) ad lib
Oxazepam (Sobril®) ad lib
She use Nexium® prophylactic for stomach ulcers, and Somadril® is prescribed to her even though it no longer is a part of the Norwegian pharmacopeia. Both Somadril® and Sobril® is used sparingly, and do not influence her dental treatment.

Dental

Tooth 46 is asymptomatic. It serves as the distal supporting abutment for a three-unit bridge. The patient is aware of several teeth with caries, and many teeth with restorations. She feels that mouth dryness is a problem.

Figure 10-2: Treatment area

Examination

Clinical

The intraoral soft tissues are healthy, save for the marginal gingiva, where there is bleeding on probing in many sites. Tooth 47 is restored with an amalgam cupola, has a buccal defect with a carious lesion. A porcelain-fused-to-metal ceramic bridge is abutted on teeth 46 and 44. It has well-fitting margins without caries, is not mobile and is in function. Tooth 43 has a lost class V restoration; the cavity appears caries-free.

	47	46	44
El. Pulp test	Nd	Nd	Nd
Cold	Nd	Nd	Nd
Percussion - ax	-	-	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD	WNL	WNL	WNL
Mobility	-	-	-

Table 10-1: Dental diagnostic tests

Radiographic

Tooth 47 - The crown has a large metallic and a smaller non-metallic restoration, with proximity to the pulp space. The lamina dura is unbroken.

Figure 10-3: Pretreatment radiographs, left is mesioangulated

Tooth 46 - A metallic bridge occludes view of the crown. Margins are continuous with the root. A radioopaque obturation material is seen in the mesial and distal roots. It is homogenous and of adequate dimensions. A mesioeccentric radiograph reveals a 2-1 mesial canal configuration; both canals contain homogenous radioopaque obturation material. Apical to the distal root, the lamina dura is broken and there is a well-defined small radiolucency. There is sign of osteosclerosis inferior to the radiolucency. The mesial root has a lamina dura with apical widening.

Tooth 44 - A metallic bridge occludes wiew of the crown. Margins are continuous with the unfilled root. The lamina dura can be seen around the entire root. All teeth have normal morphology, but are short. The supporting bone has a normal marginal level and has normal structure.

Diagnosis

Tooth 46

Pulpal - necrosis of pulp, K04.1. Previously endodontically treated

Periapical - chronic apical periodontitis, K04.5. PAI 4.

Treatment plan

Non-surgical retreatment in two visits is recommended and planned. Other options are extraction on a later date, or the planning of new prosthetic treatment like bridge based on 47 and 44, or on two implants. None of these options will be needed if the retreatment is successful in controlling the infection. They are therefore not chosen at this point.

Treatment

30. March 2011: Access cavity

Access cavity was prepared, exposing gutta-percha. It was sealed with Cavit-G® and IRM®.

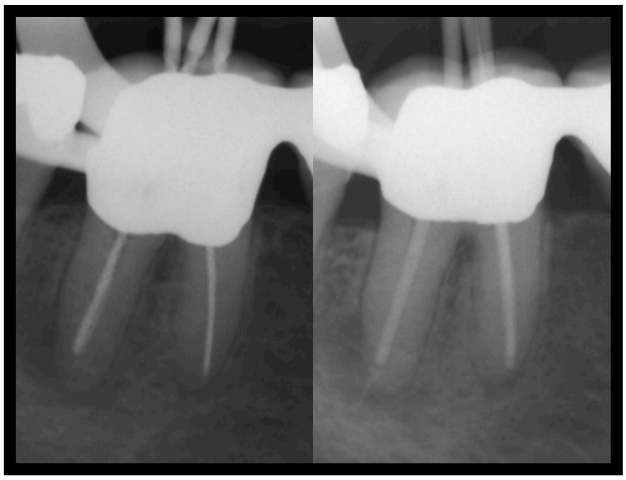

Figure 10-4: Working length and masterpoint radiographs

27. April 2011: Chemomechanical debridement

Rubber dam was applied and the field was disinfected. The gutta-percha root filling was mechanically removed using rotary nickel-titanium files in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm. Hand instruments removed the apical remnants, and working length was established radiographically. Two mesial and one distal canal was found and cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. The Endo-vac® device was used for irrigation delivery. The final canal dimensions were:
Mesial (both) - 17,5mm/ISO55/2%Taper
Distal - 17,5mm/ISO70/2%Taper
Ni-Ti and stainless steel hand instruments were used. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

24. May 2011: Obturation

The patient's tooth was asymptomatic. Rubber dam was applied and the field was disinfected.

Figure 10-5: Posttreatment radiographs bottom left (mesioangulated) and right. Pretreatment mesioangulated top left for comparison

The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. The Endo-vac® device was used again. A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha points and Ah plus® sealer, in the cold lateral condensation technique. Three mm deep orifice plugs of IRM® were placed in each canal. The tooth was permanently restored with a composite restoration. The cavity was cleaned with alcohol and a microbrush. Phosphoric acid etching for 20s preceded the Scotchbond Multipurpose® bonding, and layers of Tetric EVO Ceram® was cured and finished. A final radiograph was taken, showing adequate dimensions of the root filling.

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

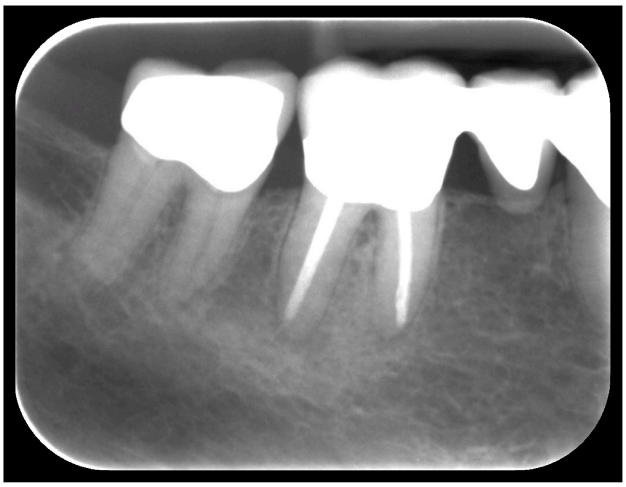

Figure 10-5: Follow-up, 02. May 2012 (1y)

Evaluation

The treatment went as planned. In the mesioeccentric radiographs a larger area is filled out by radioopaque material; seen in the mesial root on the postoperative image. This may be of no importance; the mesial root had no apical radiolucency preoperatively. But it demonstrates that better obturation can follow thorough irrigation, especially in uninstrumented areas. On 1-year follow-up clear signs of healing is seen, PAI is 2

Discussion

The choice of irrigant is important when treating infected teeth; it should have a good balance of toxicity and antibacterial properties. Early works from researchers in Connecticut tested this balance with methods they developed to study this. The

Chromium release test has since been used for cytotoxicity testing of many materials. (1, 2) Their conclusion was that a low concentration of buffered sodium hypochlorite (0,5%) had the ability to dissolve necrotic tissue but not vital tissue. The antibacterial effect was also tested and found adequate, but the model only tested the effect on a suspension of select bacteria.

Other early works provided much data on the tissue-dissolving properties of increasing concentrations of sodium hypochlorite, and faster kill times for bacterial suspensions. As can be expected, higher concentrations worked faster. (3-5) Later, data was produced that did not find differences in cleanliness of root canal walls between 1-5,25% concentrations of sodium hypochlorite. (6)

Different mixtures and dilutions of sodium hypochlorite have been subject to analysis on the effect of storage. Undiluted preparations seem to have long shelf life, above 200 days. Diluted and buffered preparations show sign of degradation after 1-2 weeks. Temperature does not seem to affect in this short timeframe. It seems that dilutions prepared in the clinic is best used within 1-2 weeks. (7-9)

With the development of the anaerobic culture chambers and good methods for sampling root canals, meaningful studies could be done in vivo. The dissolving effect on tissue samples, cytotoxic effects on cell lines or bactericidal effect in suspensions need to be tested in the clinical situation for assessment of relevance. The antibacterial action of different concentrations of sodium hypochlorite was tested, and no large or significant differences were found. (10) Despite these findings, many laboratory trials on bacterial suspensions and effect of concentrations were done. More advanced models were developed, and data from these indicated that irrigation with sodium hypochlorite was effective in reducing or eliminating bacteria on dentin surfaces and even at some depth. (11) Recent advances in this model, do in some ways mirror the results of the more simplistic suspension models, showing faster kill rates and greater kill depths with increasing concentrations. (12)

Turning to the few other clinical data that exists, they do not demonstrate the better effect of increased concentrations. After irrigation regimens, about half of growth samples was still positive, even with a 5,25% concentration. (13)

Because of different ways to perform the clinical trials in endodontics, no conclusive systematic review has been published on the effect of irrigants. An attempt has been made recently, but did not reach a conclusion other than that sodium hypochlorite or chlorhexdine was recommended during root canal therapy. (14) The Cochrane Collaboration manual for systematic reviews was followed. They identified one trial, though, that reported detectable differences in favour of a 5% concentration over lower concentrations of sodium hypochlorite. The culturing technique used was less advanced than what is possible today. (15)

The clinician must therefore fall back on the recommendations of published guidelines and his own judgement of available clinical data. With the dangers of complications from hypochlorite extrusion in mind, the clinical data do not compel the clinician to use the higher concentrations. Concentrations between 1-3% have been used to obtain results that are among the best obtainable. (16)

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Case 11: Vital pulpectomy and retreatment

Introduction

The patient is a 60-year-old Norwegian female. She was referred from a private practicing dentist in Oslo for endodontic treatment of her mandibular right first molar (46) and mandibular right canine (43). Patient record number is 1263951.

Chief complaint

Sporadic pain in tooth 46, she wants treatment for this, and complies with the referral to have tooth 43 treated as well.

Medical history

General

No known medical problems, allergies or diseases. She uses no medications.

Figure 11-1: Dental overview

Dental

The patient had a cusp fracture on tooth 46. She visited the referring dentist for emergency treatment. An old amalgam restoration was removed, a pulp exposure occurred. The tooth was emergency treated with a full crown preparation and placement of a temporary aluminium cap. After the emergency treatment she became aware of pain that occurs only intermittent and of medium intensity. Sometimes she can provoke the pain by occluding on the tooth.

Tooth 43 has no symptoms, an incidental finding on radiographs of tooth 46 prompted the referral of this tooth.

Examination

Clinical

There is healthy alveolar mucosa in the lower right quadrant, with no palpable swelling. Tooth 46 is restored with an aluminium cap.

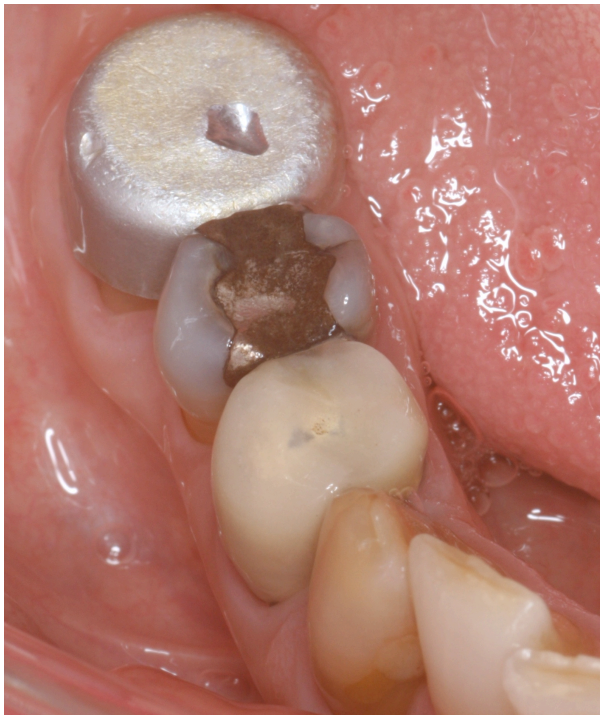

Figure 11-2: Treatment area

45 is restored with an MOD amalgam restoration with intact margins. 44 is restored with a porcelain-fused-to-metal crown. 43 has a discoloured crown, and is restored with a MLD composite, also with some discolouration, but good margins. There is no detectable caries. The teeth in the quadrant are in function. The rest of the dentition shows some wear of teeth and restorations, but there is no other

detectable condition that needs treatment. The patient reports no other problem.

	46	43
El. Pulp test	-	-
Cold sens.	-	-
Percussion - ax	+	-
Percussion - hor	+	-
Palpation	-	-
PPD	<2mm	<2mm
Mobility	-	-

Table 11-1: Dental diagnostic data

The aluminium cap on 46 was removed without local anaesthesia. The perforation was verified with gentle probing, revealing a bleeding and sensible pulp.

Radiographic

46 - normal root morphology, intact lamina dura and visible root canal system. The radioopaque coronal restoration has a close proximity to the pulp space.
45 - radioopaque large metallic restoration, normal tooth morphology, intact lamina dura.

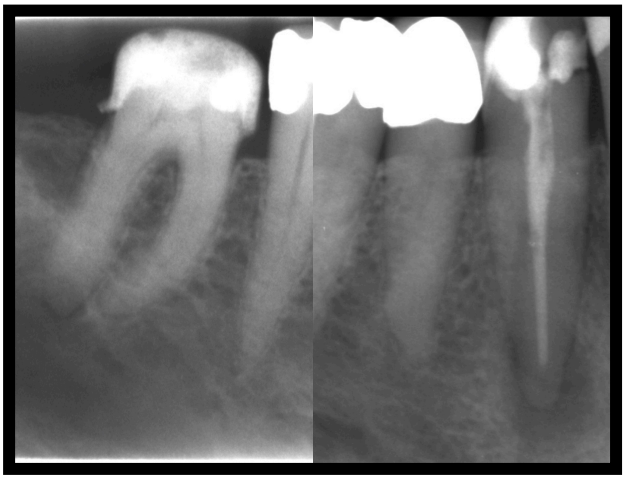

Figure 11-3: Pretreatment radiographs

44 - A radioopaque crown restoration is present; the margins are continuous with the root. The lamina dura is intact, and the root has normal morphology.
43 - The crown is restored with one large and one small radioopaque restoration. The root canal is obturated with a radioopaque material, to 3mm short of the radiographic apex. Voids are seen in the root filling material and the coronal restoration. The root is of normal morphology. The lamina dura is distended and broken at the apex. There is a medium-sized, well-defined radiolucency surrounding the apex. Teeth 46, 45, 44 and 43 has a normal supporting marginal bone level.

Diagnosis

Tooth 46:
Pulpal - irreversible pulpitis, K04.0.
Apical - normal
Tooth 43
Pulpal - necrosis of pulp, K04.1. Previously endodontically treated
Apical - chronic apical periodontitis, K04.5. PAI4.

Treatment plan

Tooth 46: Pulpectomy in one visit
The recommendation for this treatment is strong. Expediency is recommended as well, to avoid infection of the canal system proper. A prerequisite is that the patient also performs the crown therapy. Two inferior options that was not discussed, was to do a pulpotomy of the crown pulp with mineral trioxide aggregate and fabricate a high quality acrylic crown for semi-permanent use, or to do an extraction.

Tooth 43: Non-surgical retreatment in two visits
The recommendation for this is fairly strong. The infection is probably chronic and stable; the tooth was endodontically treated years ago. Yet, it may give rise to an acute infection. If the tooth needs a crown in the future, it will be recommended to treat the apical infection beforehand. To prepare for future restorations and to reduce the risk of acute or progressive infection, even tooth loss, retreatment is advocated. The non-surgical retreatment seeks to eliminate the probable cause, coronal leakage or residual canal infection by debridement and elimination of voids. A surgical retreatment may work as well, but it is more invasive and poses a risk for late failures.

Treatment

29. August 2012: Pulpectomy on 46
Local anaesthesia was administered, using Septocaine®, as a inferior alveolar nerve block supplemented with a crestal injection. The Paroject® device was used

for the latter. The Aluminium cap was removed and rubber dam applied. The field

Figure 11-4: Treatment radiographs 46; Top: Working length and masterpoint. Bottom: Mesioeccentric and orthoradial posttreatment

was disinfected. After access preparation, the field was disinfected once more. 4 bleeding root canal orifices were located. Working length was established using electronic apex locator and radiograph. The root canal system was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. The glide path was kept open during preparation with hand instruments. Reciproc 25 was used to the working length. The preparations were finished with hand use NiTi K-files. The canal system was prepared to the following dimensions:
Mesio-buccal - 20,5mm/ISO40
Mesio-lingual - 20,5mm/ISO40
Disto-buccal - 19,5mm/ISO40
Disto-lingual - 19,5mm/ISO40
In this case, the taper was unknown beacuse of the combined use of the Reciproc 25 instrument and the finishing with 2% tapered hand instruments. The canals were dried and obturated after a masterpoint radiograph, Ah plus® sealer and gutta-percha were used in the cold lateral condensation technique. Plugs of IRM® were placed over the canal orifices, and the cavity was sealed with more IRM®. A final radiograph was taken.

13. September 2012: Re-access and debridement on 43

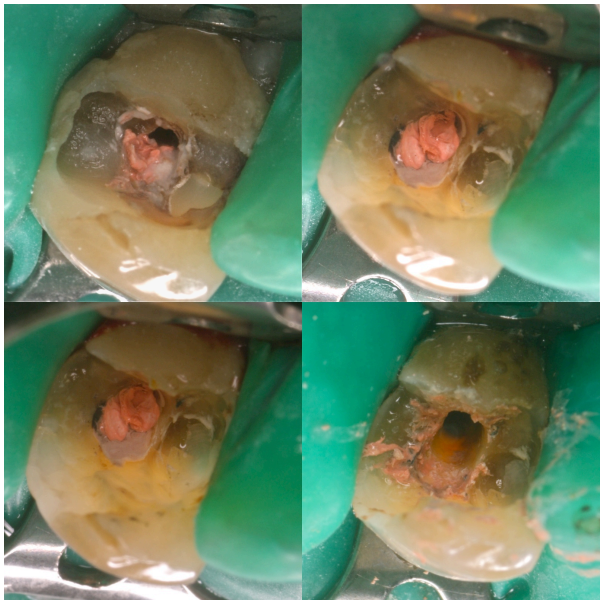

Figure 11-5: Access. 43 Top left: Voids below composite. Top right: Orifice enlargement. Bottom left: Removal of all composite. Bottom right: Improved rubber dam seal, retreatment in progress

The patient had no symptoms from last treatment. Rubber dam was placed and the field disinfected. Restorations were removed, exposing a pulp chamber void of obturation material.

Figure 11-6: Treatment radiographs 43, from left: Inital gutta-percha removal; Working length; Masterpoint

The field was disinfected again, and access was refined with a Gates-X drill. The gutta-percha root filling was mechanically removed using rotary nickel-titanium files

in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm.
Hand instruments removed the apical remnants, and working length was established radiographically. Some drops of Chloroform were used to soften remnants of gutta-percha, along with paper points in a "wicking technique". Only one oval canal was found and cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. The final dimensions were: 27mm/ISO 40/4% Taper. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

19. September 2012: Obturation on 43
The patient had no symptoms from last treatment. Rubber dam was placed and the field disinfected. The canal system was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. A masterpoint radiograph was taken.

Figure 11-7: Posttreatment radiographs 43

The canals were dried and obturated with gutta-percha points and Ah plus® sealer, in the cold lateral condensation technique. 3mm thick orifice plugs of IRM® were placed in the canal. Rubber dam was removed. A final radiograph was taken, showing adequate dimensions of the root filling. The access cavity was cleaned with alcohol and a microbrush, removing remnants of sealer. Some refinement was done with a diamond bur. A toffelmire matrix was placed; the cavity was etched with 37% phosphoric acid. The tooth was restored with Scotchbond Multipurpose bonding and Tetric EVO Ceram composite.

Figure 11-8: Coronal restoration 43

Prognosis

Tooth 46
Endodontic: good.
Periodontal: good
Restorative: good
Tooth 43
Endodontic: good.
Periodontal: good
Restorative: uncertain

Evaluation

The patient did not return to the referring dentist, although a discharge report was written. She signed up for treatment at the faculty's undergraduate clinic. Because of the anticipated time before she will receive treatment, a permanent composite restoration on 43 was deemed to better the prognosis on this tooth. The same could be said for 46, but it was not realistic to allocate time for a full crown treatment in our clinic. The aluminium cap seemed durable enough for some time on the waiting list. Tooth 43 may need a crown in

the future, if the very thin buccal wall fractures.

Discussion

The goal of root canal shaping is a somewhat floating definition today. Researchers from Norway and USA promoted the use of obturation materials that were congruent to the instruments used, which also were standardized. This was dubbed "the standardized technique". (1) The advantages were that the root filling could be pressed down in the root against a cylindrical stop, effectively sealing the preparation. The dimensions required were based on data from Norwegian researchers, indicating how large a cylindrical preparation that was necessary to encompass the pulp space. (2-4) This method of preparation was later evaluated, giving rather good results; 85% success in necrotic teeth with apical radiolucency, 93% in vital teeth with normal periapex, assessed after 3-5 years.

Different philosophies in shaping goals of root canals existed. Preparation styles that went well with other obturation techniques were also used, for instance the tapered step-back and the warm vertical compaction method. (5, 6)

Growth samples from canals were used as a parameter to measure the effect of the preparation in the canal. Initial trials did not show dramatic differences. (7, 8) Trials comparing stainless steel instruments step-back preparations versus rotary nickel-titanium preparations did not show differences, but a trend of lower bacterial counts with higher preparation sizes was noted. A trial comparing larger versus smaller preparations did actually demonstrate large proportions of canals with negative growth after instrumentation. (9) The apical sizes were large, above ISO 50. The same institution more or less repeated the study with another system that mimics the shapes of the step-back technique, with small apical diameters and larger tapers. (10). The study with larger preparations had a little higher frequency of culture-negative samples, post-instrumentation and post-medication. Statistical tests revealed significant differences favouring the larger sizes. Furthermore, the studies reported that samples after calcium hydroxide medication yielded least growth. One must expect a certain number of roots to culture positively after shaping and irrigation, irrespective of which shaping technique is used.

One recent large follow-up study did not find that apical size affected the outcome of treatment. (11) The institution recommended not increasing the apical size above ISO 30, although it was done in some cases, 812 teeth were instrumented at ISO30 or below, with a reported grand success rate of 86% for all diagnoses. For those 358 teeth instrumented above ISO 30, success rate was 76%. A statistical significance was not found. These figures are comparable to other reports. With the low power of evidence in observational studies, one would expect lower success rates, but that was not observed. The question of the optimal apical size remains open.

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Case 12: Pulpectomy in a molarized taurodont premolar

Introduction

The patient is a Norwegian student aged 29. He was referred from University of Oslo's dental care service for students. The referral asks endodontic treatment of his mandibular left second premolar (45). Patient record number is 1161902.

Chief complaint

None. He complies with the referral.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 12-1: Dental overview

Dental

The student dental care service excavated caries to the pulp in tooth 45. The patient has recently extracted 36, there is a temporary filling in 27. This is interpreted as somewhat above average manifestation of dental disease in a young individual. He explains that he is undergoing dental treatment after his time in the Norwegian military; he served as an FAC in Afghanistan. He believes that long hours on watch in combination with "junk food" may explain the dental caries incidence. He now attends a business school, and takes better care of himself. The tooth in question is asymptomatic. There was an attempt at endodontic treatment that was abandoned. This led to his referral.

Examination

Clinical

45 is restored with a temporary filling.
46 has two small class II restorations, one distal amalgam and one mesial composite.
44 is sound. The marginal and alveolar soft tissues are healthy, with no palpable swelling.

	46	45	44
El. Pulptest	19	80	24
Cold	+	-	+
Percussion - ax	-	-	-
Percussion - hor	-	-	-
Palpation	-	-	-
PPD	WNL	WNL	WNL
Mobility	-	-	-

Table 12-1: Dental diagnostic tests

Radiographic

44 has no restorations and normal length. The pulp chamber and root canal divide into two hardly visible canals at the mid-root level. Lamina dura and supporting bone is normal.
The crown of 45 has a large distal radioopaque restoration that enters the pulp chamber. The pulp chamber is outlined by remnants of a radioopaque material. In the lower third of the root, the canal system can no longer be followed. The root divides into three hardly visible separate roots. There is no visible break in the lamina dura, but this is uncertain due to the low visibility. The supporting bone has a normal level.

Tooth 46 has two restorations in the crown with different radioopacity, the distal matches that of metal. The mesial

Figure 12-2: Treatment area

restoration is in close proximity to a pulp horn. There is an accessory root visible exiting from the furcation of 46, the periodontal ligament space is seen joining the distal root apically. There may be a radix ento- or paramolaris. The lamina dura and supporting bone is intact and at a normal cervical level.

Figure 12-3: Pretreatment radiograph

Diagnosis

Tooth 45: Abnormalities in size and form, K00.2 (molarization with taurodontism)
Pulpal - Necrosis of pulp, K04.1
Apical - Normal. PAI 1.

Treatment plan

Pulpectomy in two visits was planned, because of anticipated time needed for the difficult anatomy. There was a possibility that the entire root canal system might not be negotiated. In that case, surgical root resection was discussed as an option. Extraction was not discussed as an option now. Cone-Beam Computed Tomography to reveal the morphology was considered, but the use of the operating microscope to inspect the anatomy was thought adequate.

Treatment

16. November 2011: Canal search

Local anaesthesia was administered as a buccal infiltration of 4% articaine with 1:200000 adrenaline. Most of the temporary restoration was removed to expose the gingival cavity margin. Rubber dam was applied, and provided a good gingival seal. The rest of the restoration was removed and the field disinfected. Straight-line access to the furcation was prepared with Gates-Glidden drill no. 3. Inspection revealed three canal orifices, two mesial with no bleeding tissue, and one distal with bleeding and sensible tissue. Working length was established in the two mesial canals, using a combination of radiograph and electronic apex locator. The pulp chamber was irrigated with sodium hypochlorite. Because of limited time, the pulp chamber was dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

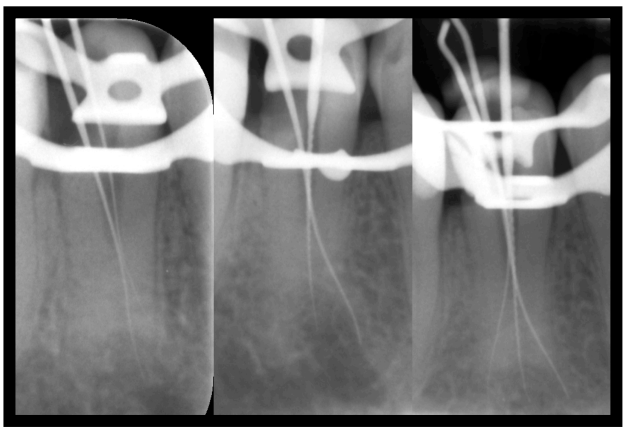

Figure 12-4: Working length radiographs. Left, middle: First visit; Right: Last visit

30. November 2011: Debridement and obturation

The patient's tooth was asymptomatic. Local anaesthesia was administered as a buccal infiltration and an inferior alveolar nerve block of 4% articaine with 1:200000 adrenaline. Rubber dam was applied and the field was disinfected. The canal system was reopened and rinsed again. A working length radiograph was now possible without causing pain. The root canal system was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. Hand use NiTi files was used. The final canal dimensions were:

Distal - 24mm/ISO40/2%
Mesiolingual - 23,5mm/ISO40/2%
Mesiobuccal - 24,5mm/ISO40/2%

A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha points and Ah plus® sealer, in the warm vertical condensation technique. A 3mm thick orifice plug of IRM® were placed in the canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling. A small lateral canal at the level of the furcation is visible.

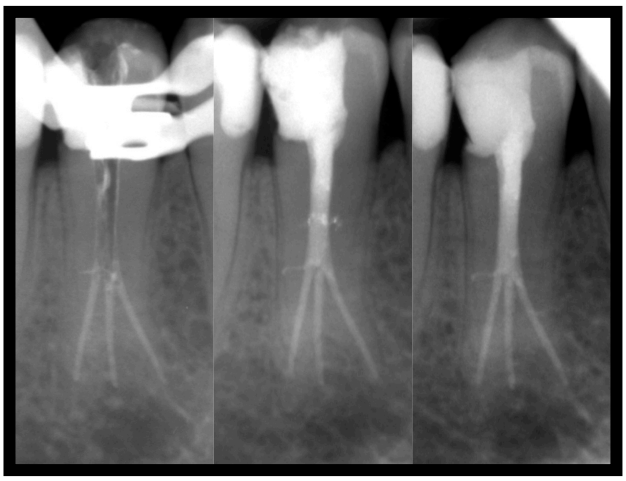

Figure 12-5: Left: Downpack; Center: Posttreatment; Right: Follow-up 24. Apr 2013 (1y 5m)

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The treatment plan went well. Luckily, excessive removal of dentin was not needed to uncover the orifices. Conservation of dentin is important to preserve mechanical strength and in the end a good long-term prognosis. With a deep division of canals, this may not always be possible. An abnormally high pulp chamber with a deep division of canals is termed taurodontism, after how bovine molars are shaped. In a taurodont human molar, the pulp chamber is normally large enough that good visibility may be achieved with a microscope. If this happens in premolars or even canines, some dentin removal may be neccessary to identify, debride and obturate the canals.

Discussion

Taurodontism and molarisation may complicate treatment. Taurodontism has been described for many years, but the definition used today came in 1978, from Israeli researchers. (1) They coined the "taurodontic index"; defined as the relation between the height of the pulp chamber and the distance from the apex to the pulp chamber roof. Values of 0,2-0,3 corresponded to an older term: hypotaurodontism. If 0,3-0,4, it corresponded to mesotaurodontism, and 0,4-0,75 to hypertaurodontism.

The terms hypo- meso and hypertaurodontism originated from a 1928 article. (2) The explanation for the name Taurodontism is given; it comes from the resemblance to oxen teeth. Furthermore, it was well known that ancient sculls of *Homo neanderthalensis* frequently had such teeth. Because of that, such a trait has been named atavistic or retrograde, as it may disappear from man.

The Israeli data from 1978 reported an occurrence of 5,6% of any degree of taurodontism, the two most extreme categories were only 1% and 0,7%, respectively.

A prevalence study in premolars from Brazil found the occurrence of 0,25%; 11 out of 4459 were found to be taurodont.

(3) The researchers did not use the Taurodontic index from Israel, but their own morphology-based criteria, that must be said to be loose. That said, all images of teeth in the article would be above 0,5, only measured by viewing. They found only mandibular premolars, 7 first and 4 second. They displayed one taurodont maxillary premolar not included in the material, just to show it may occur.
In another prevalence study from Spain, an occurrence of 0,79% was found; 3 of 379 teeth were taurodont. They combined the criteria of the two latter studies. (1, 3) The 3 teeth were maxillary premolars.
Taurodontism in premolars may impact endodontic treatment more than in molars, because of the long, narrow channel of the pulp chamber form before it furcates. Placing both files and obturation materials may be a challenge, and the operator may need to enlarge the canal to have direct visualization of the furcation.

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Case 13: Bilateral cervical root resorption

Introduction

The patient is a Norwegian male aged 31. He was referred to the postgraduate education in *periodontology* from his general practitioner; to treat two dental resorption defects. The defects are located in his mandibular second premolars, both the left (35) and the right (45). The periodontal departement is contacting the endodontic department to establish a cooperative treatment. After all, they too have some tradition in treating dental resorptions. Patient record number is 1057155.

Chief complaint

The patient has no symptoms; he complies with the referral.

Figure 13-1: Dental overview

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Dental

His general dental practitioner discovered two defects that he did not diagnose as carious lesions. They were seen on routine radiographs. There were no possible etiologic factors in the patient history, like trauma, surgery or orthodontic treatment. He is fully dentate with small and few restorations; his oral hygiene is good .

Examination

Clinical

35 is slightly rotated, and has a small occluso-distal composite filling. 45 has normal position and a small occluso-mesial composite filling.

	36	35	34	46	45	44
EPT	42	48	35	45	56	38
Cold	+	+	+	+	+	+
Percussion- ax	-	-	-	-	-	-
Percussion- hor	-	-	-	-	-	-
Palpation	-	-	-	-	-	-
PPD	WNL	WNL	WNL	WNL	WNL	WNL
Mobility	-	-	-	-	-	-

Table 13-1: Dental diagnostic data

Radiographic

35 has a small occluso-distal radioopaque restoration that is located to the outer 2/3 of dentine. The root is of normal morphology, a little broader because of its rotation. The pulp space can be traced to the apex and the lamina dura is unbroken. At the crestal level a radiolucent irregular zone can be seen at the mesial side. It does not cross the pulp space, it is not extended occlusally above the cementoenamel junction, but it can bee seen extending diffusely 2-3 mm below the alveolar crest. A mesioangulated radiograph demonstrates that the lesion is situated on the buccal side. On this radiograph, some radiolucent mottling can be seen on the

Figure 13-2: Treatment area; Top row 35, Bottom row 45

distal side of the pulp space. The radiolucency stops just shy of the pulp space, leaving a small radioopaque border of dentin. 33, 34 and 36 can be seen on the radiographs, they have normal anatomy with no visible pathology. 36 has a small radioopaque restoration.

Figure 13-3: Pretreatment radiographs. Top row 35; Bottom row 45; Right coloumn is mesioangulated

45 display similar features. There is a small mesio-occlusal radioopaque restoration that is located to the outer 2/3 of dentine. The pulp space can be traced to the apex and the lamina dura is unbroken. At the crestal level a radiolucent irregular zone can be seen at both sides of the pulp space. It is extended occlusally above the cementoenamel junction, it can bee seen extending diffusely 2-3 mm below the alveolar crest. A mesioangulated radiograph demonstrates that the lesion is situated on the buccal side. Again, the radiolucency stops just shy of the pulp space, leaving a small radioopaque border of dentin. 43, 44, 46 and 47 can be seen on the radiographs, they have normal anatomy with no visible pathology. 47, 46 and 44 all has small radioopaque restorations.

Diagnosis

Tooth 35:
Pulpal - External resorption of teeth, K03.3
Apical - Normal. PAI 1
Tooth 45:
Pulpal - External resorption of teeth, K03.3
Apical - Normal. PAI 1

Although not featured in the ICD-10, a more precise diagnosis would be cervical resorption, Heithersay class 3. This applies for both 45 and 35.

Treatment plan

It was recommended to perform pulpectomy in one visit and subsequently do a surgical repair of the resorptive defect. The patient had to travel a few hours each way, and asked that the number of treatments and follow-ups be minimized, and that his local practitioner was involved to help out with relevant tasks. If both 35 and 45 received a pulpectomy at the same visit, and subsequently both repairs were performed at the same visit, he would need two appointments. His dentist would remove sutures after surgery.
Alternative treatments that were briefly discussed, was extraction and orthodontic closure or implant treatment. This did not harmonize with the patient's priorities; we also saw the proposed treatment as the least invasive.

Treatment

01. March 2011: Pulpectomy 35 & 45

Almost exactly same procedure was followed for both teeth. Local anaesthesia was administered, using Septocaine®, as an inferior alveolar nerve block supplemented with buccal infiltration.

Figure 13-4: Treatment radiographs 35; from left: Working length, masterpoint, posttreatment

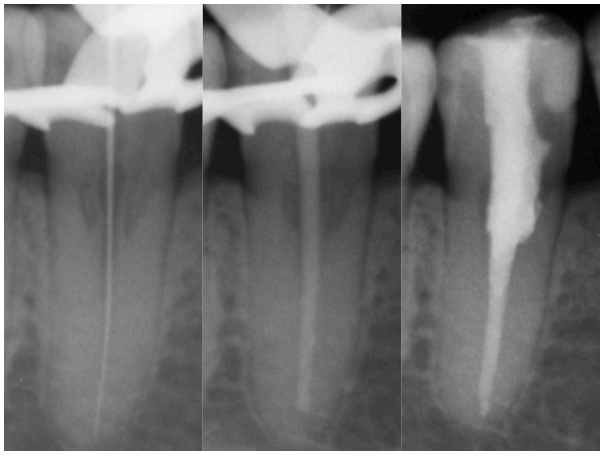

Figure 13-5: Treatment radiographs 45: same as fig. 13-4

Rubber dam was applied and the field was disinfected. After access preparation, the field was disinfected once more. Gates Glidden drill #3 was used to remove the coronal pulp, resorptive tissue and dentin bridges at the cervical level. Cavit-G was smudged against the resorption defect to control bleeding. Working length was established using electronic apex locator and radiograph. The root canal system was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. The preparation was performed with small hand use files and a Reciproc instrument. The final dimensions were:

Tooth 35: 17mm/R50/5% Taper
Tooth 45: 17,5mm/R50/5% Taper
The canals were dried and obturated after a masterpoint radiograph, Ah plus® sealer and gutta-percha were used in the cold lateral condensation technique. Deep plugs of IRM® were placed over the canal orifices, and the cavity was sealed with more IRM®. A final radiograph was taken.

30. March 2011: Resorption repair 35 & 45
Exactly same procedure was followed for both teeth. The surgery was performed in the periodontology departement, with the postgraduate periodontal student co-sitting.

Figure 13-6: Surgical repair of 45, from left: exposure, after debridement, isolated to facilitate adhesive restoration

The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected as an inferior alveolar block; it was used lidocaine 2% with adrenaline 1:80000. A lingual marginal incision was made, raising buccal and lingual envelope flaps, with the papilla preserving technique. A buccal resorption defect was uncovered. The treated and neighbouring teeth was thoroughly inspected for other resorptive defects, none was found. Buccal bone was removed with a round bur; exposing sound dentinal margins 1-2 mm below the defect. The defect was enlarged and cleaned with round bur and saline. Pre-disinfected rubber dam with modified Aseptico 211 clamp was mounted. The field was dry. The resorptive cavity and coronal access was restored using phosphoric acid etchant,

Scotchbond MP® bonding agent and Tetric EVO Ceram® composite.

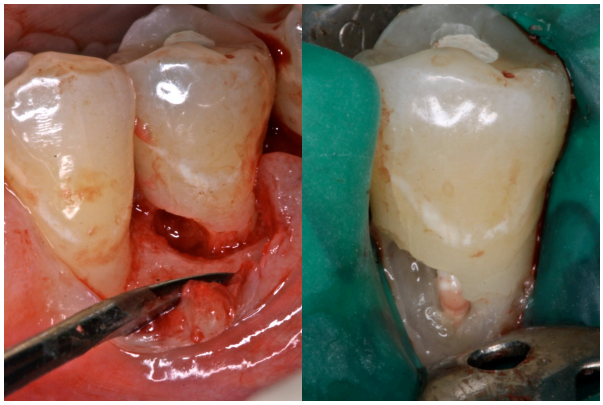

Figure 13-7: Surgical repair of 35, same as for fig. 13-6

Finishing was performed with dam attached. The wound was rinsed and sutured with interrupted sutures (Supramid® 4-0). The patient received standard postoperative care. Sutures were removed 1 week later at his general dentist.

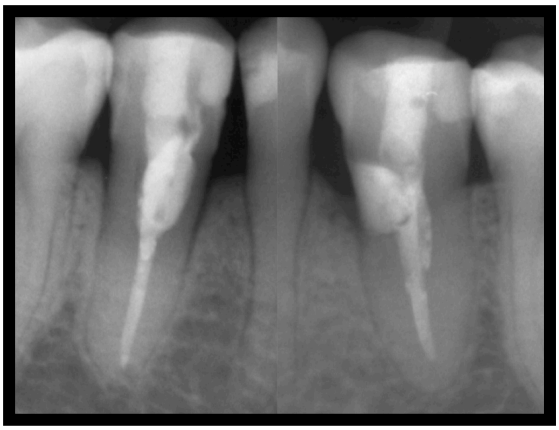

Figure 13-8: Follow-up, 10. Nov. 2011 (6m)

Prognosis

Tooth 35 and 45:
Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The treatment went as planned. In retrospect, CBCT would give a more predictable treatment planning. In this case, it may not have changed the plan. The use of rubber dam during perforation repair enhances bonding procedures and avoids contamination of the wound. This was only possible because of the location of the defects. At the two-year follow-up, PAI is 1 for both teeth, no progression of resorptions can be seen. The marginal gingiva has not retracted significantly.

Figure 13-9: Follow-up, 10. Nov 2011 (6m)

Figure 13-10: Follow-up, 19. Apr. 2013 (2y)

Figure 13-11: Follow-up, 19. Apr. 2013, (2y) normal gingival conditions with little retraction

Discussion

Root resorption in teeth is difficult to diagnose and treat. Furthermore, not too much is known of the prognosis.

From animal experiments in the field of dental traumatology, it was known that trauma or avulsion could induce root resorption and ankylosis in teeth. (1) The resorption taking place after ankylosis, replacing root with bone tissue was termed *replacement resorption*. Small resorptions that came from trauma, that did not ankylose and progress, were termed *surface resorption*. Resorption on the sides of the root could be seen after trauma-induced pulpal necrosis. This was termed *inflammatory root resorption*. Today this is termed Infection-related root resorption, because of its etiology.

Other types than trauma-related resorptions exist. A classic review names the *internal resorption* and the *cervical resorption* type. (2)

The internal resorption originates from pulpal tissue, resorbing a well-outlined rounded defect internally in the root. It exands the borders of the pulp on radiographs, and a necrotic pulp coronal to the lesion perpetuates it. Multi-rooted teeth may display a more complex picture.

The cervical resorption has starting point at the level of the bone crest. Resorptive cells remove dentin, spreading out laterally in the dentin lying between the periodontium and the pulp. It leaves the dentin close to the pulp. A mottled radiographic appearance is seen, with intact pulp space outlined by a thin radioopaque border.

Roots with resorptions are not readily available, so therefore a well-known classic model for creating resorptive defects was developed in Denmark. (3) The method enables the researcher to create defects with precise diameters and depths. The model was used to demonstrate the unfortunate finding that conventional radiographs is not very good in diagnosing smaller lesions, at least not the ones below 1,8mm in diameter. Defects on buccal and lingual sides of roots were not well detected either. That means lesions need to grow in size to above 2mm, maybe more for the ones situated buccal or lingual, if radiographic detection can be done.

The Australian researcher Heithersay studied and treated patients with cervical resorptions. He proposed a classification based on degree of invasiveness of the lesion. (4) Class 1 was if only a small, shallow resorption could be seen. Class 2 went as deep as the pulp, but only on one side, and with no lateral spread into the root or crown. Class 3 circumvented the pulp space, and spread out laterally involving the coronal third of the root. Class 4 extended beyond the coronal third of the root, and it was thought that the lesion established new connections to the periodontium along its course.

Heithersay treated and reported on 101 patients, it remains the largest case series on cervical resorption. Observation time was from 3 to 12 years. 100% tooth survival and success of treatment was seen in class 1 and 2 cervical resorptions. Class 3 had 92% tooth survival, and 78% treatment success. Class 4 had 50% survival and only 13% success.

Class 1, albeit only 4 cases, did preserve pulp vitality in all cases. Class 2 needed root canal treatment in 72% of the cases, class 3 in 95%. The treatment is fairly simple, root-canal treatment if needed and external surgical removal of lesion with restoration of the resulting cavity. Sometimes a cervical lesion that is inaccessible can be removed and restored from the endodontic access cavity, but this

method do not allow for direct inspection of the root surface.
Recent reviews on cervical resorption advocate that conical-beam computed tomography be used for diagnosis if needed. (5)

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Case 14: Pain, CBCT and apicoectomy in a maxillary premolar

Introduction

The patient is a Norwegian women aged 58. She is an Iraqi immigrant, and is fluent in Norwegian. The referral is from the undergraduate student clinic, and asks diagnosis and treatment of non-diagnosed pain in the left maxillary side segment. Patient record number is 1053916.

Chief complaint

Pain in the jaw above a bridge spanning from 23-25.

Medical history

General

The patient is diagnosed with epilepsy. She suffered a trauma to the head in 2007. She uses Lamotrigin (Lamictal®) for her epilepsy. She suffers from chronic pain from many parts of her body, and use paracetamol frequently. She has problems sleeping because of the pain.

She came here from Bagdad, where she worked as a headmaster in a children's school. She is now retired, and has never worked in Norway. She attributes many of her problems to her migration from Bagdad and the circumstances that led to this. Much of her dental work is done in Damascus, where she visits family from time to time.

There are communication problems. Although she speaks Norwegian, there are limitations. An interpreter was not found necessary.

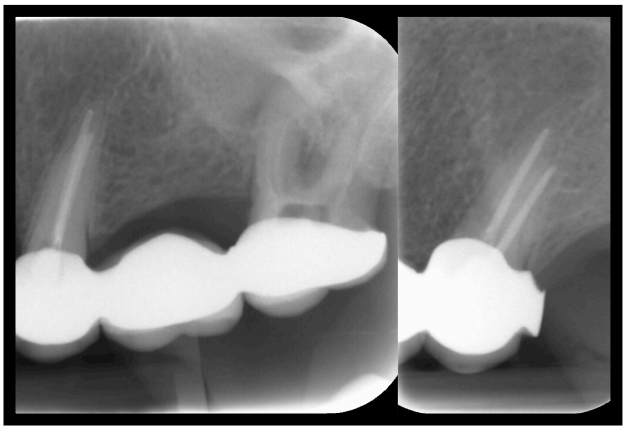

Figure 14-1: Radiographic history, 2010

Dental

A three-unit bridge is now in place from 23 to 25. This was once larger; two distal units were removed in 2010, because of a root fracture. This was done here, at the clinic for Oral Surgery. The maxillary region supporting these two units was painful up to the removal, but has been painless since. This larger bridge was made in 2005, in Damascus. The pain started in 2006-7. There is pain in the cheek and on the alveolar process above the bridge. She feels pain on pressure or palpation. The pain is lessened by paracetamol. It is relatively continuous, with some variation in intensity. She has not experienced swelling in the area. Although she has chronic pain elsewhere in her body, the dental pain has such great impact on her wellbeing that she would like to treat it if possible.

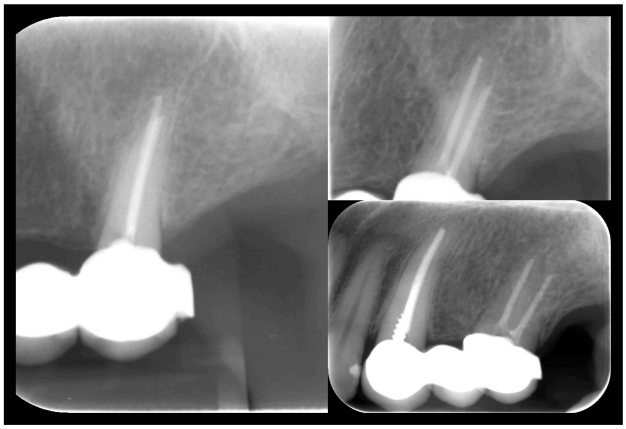

Figure 14-2: Radiographic history, Left: Jan 2011; Right: Mar 2011

Examination

Clinical

The most prominent finding is tenderness to palpation in the apical area of 25. There is not marked tenderness in the masticatory muscles. No swelling or sinus tract is seen in the area of 25. A three-unit porcelain-fused-to-metal bridge with adequate margins spans from 23 to 25. The bridge is not loose on either abutment. Marginal probing is carried out thoroughly.

	23	23
EPT	-	-
Cold	-	-
Percussion- ax	-	+
Percussion- hor	-	+
Palpation	-	+
PPD	WNL	WNL
Mobility	-	-

Table 14-1: Dental diagnostic data

Radiographic

A radioopaque bridge is seen over the crowns of 23 and 25. A radioopaque threaded, short post is in the root of 23. 23 and 25 is both obturated with a radioopaque root filling material. The dimensions of this are adequate in both 23 and 25. 25 has two roots. A mesioeccentric radiograph depicts both roots of 25, and the lamina dura can be traced around the apex of both 23 and 25.

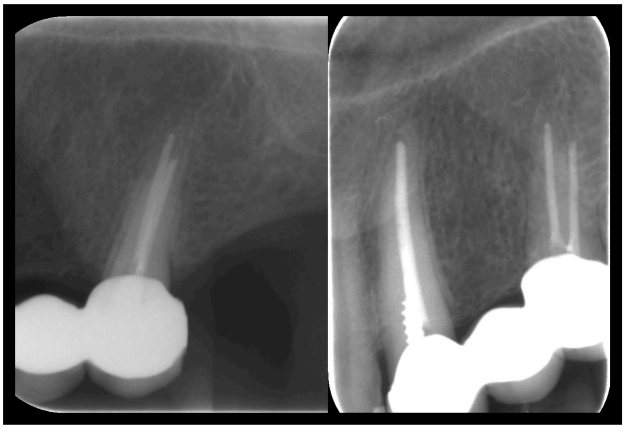

Figure 14-3: Preoperative radiographs, 16. Nov 2011

No diagnosis could be made of these findings, but chronic periapical inflammation was suspected because of the clinical findings. Therefore, it was decided to do a CBCT examination. The patient was referred to the maxillofacial radiologic clinic in our faculty to do this.

For unknown reasons, the CBCT was delayed one year, the patient did not inquire with us about this. A new attempt was made. The CBCT showed a small radiolucency with broken cortical bone buccal to the root of 25, centered on the apex.

Diagnosis

Tooth 25:

Pulpal - Necrosis of pulp, K04.1, previously endodontically treated

Apical - Chronic apical periodontitis, K04.5.

PAI 1.

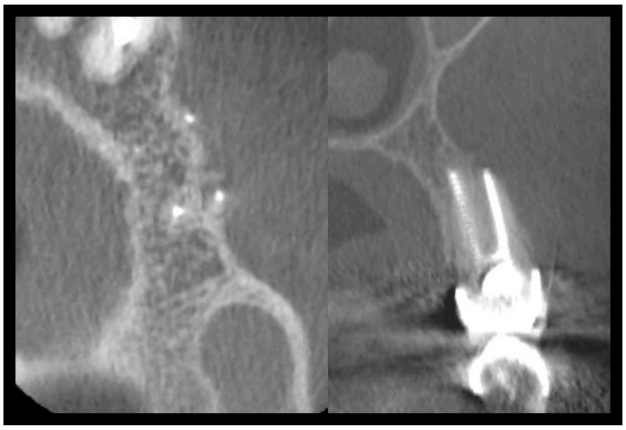

Figure 14-4: CBCT, 06. Des 2011. Imaging done by department for Oral and Maxillofacial Radiology, University of Oslo

Treatment plan

Surgical retreatment was recommended. Other options would be extraction, with sectioning of the bridge distal to 23. This could be the endpoint if a vertical root fracture is discovered. 23 has a poor prognosis if it is to retain a partial prosthesis, due to its endodontic treatment with post.

Treatment

01. March 2012: Apicoectomy

The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A marginal incision is made, running from the centre of the pontic of 24, buccal to 25 and 10mm distal. A vertical incision is made to the mesial. A trapezoid mucoperiosteal flap is raised, exposing the buccal apex of 25 and a small granuloma.

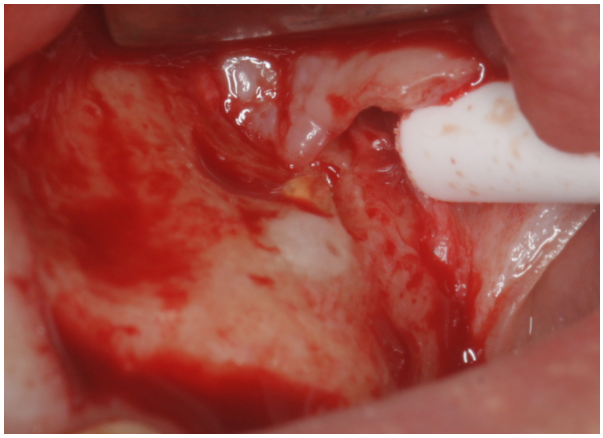

Figure 14-5: Flap reflected, apex of 15 with granuloma protruding from cortical bone

An osteotomy is made to expose both apices. The roots of 25 was resected 3mm with a fissure bur. An unobturated isthmus is seen, but no fracture. Retrograde preparation was done to 3mm depth, removing gutta-percha and preparing the isthmus. An ultrasonic retrograde tip with diamond coating was used on a low power setting, while irrigating with saline.

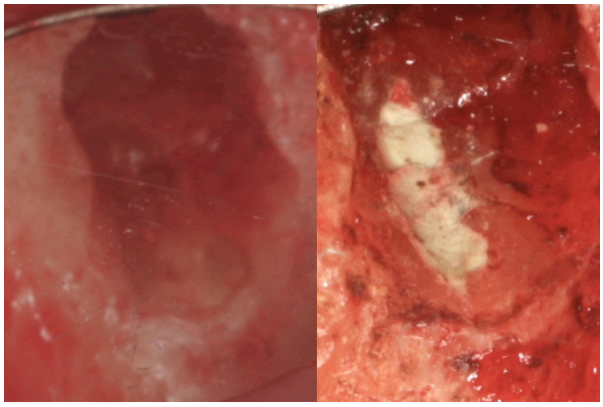

Figure 14-6: Retroprep and retrofilling of canals and isthmus

Hemostasis was achieved by blotting the surrounding bone with a cotton pellet drenched in Ferric Sulfate. The retrograde cavities was obturated with mineral trioxide aggregate, White MTA-Angelus® was used. A radiograph verified dense fillings. The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 4-0 were used. The patient received standard postoperative care.

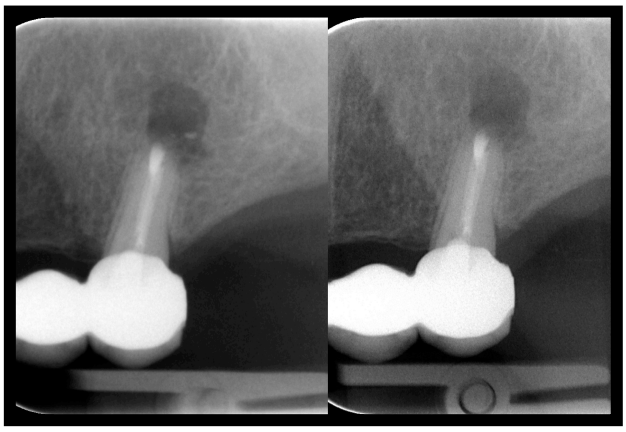

Figure 14-7: Left: Peroperative, Right: Postoperative radiograph, 1. Mar. 2012

07. March 2012: Post-operative control

Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed.

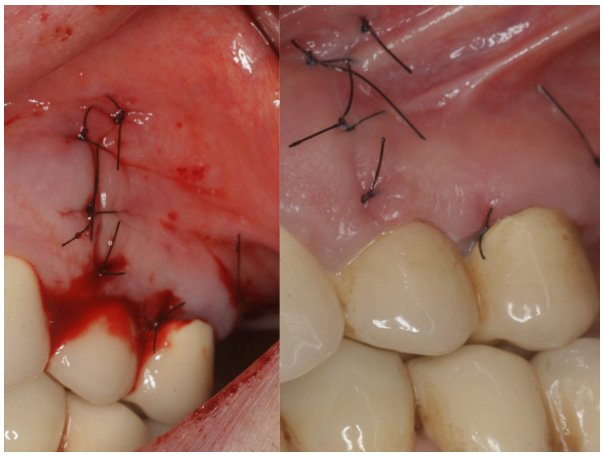

Figure 14-8: Sutures; Left: At day of surgery; Right: 1 w postoperatively

13. June 2012: Follow-up

The patient has no symptoms from the treated region, and is satisfied with the result. A radiograph shows signs of healing. There is not tenderness to palpation.

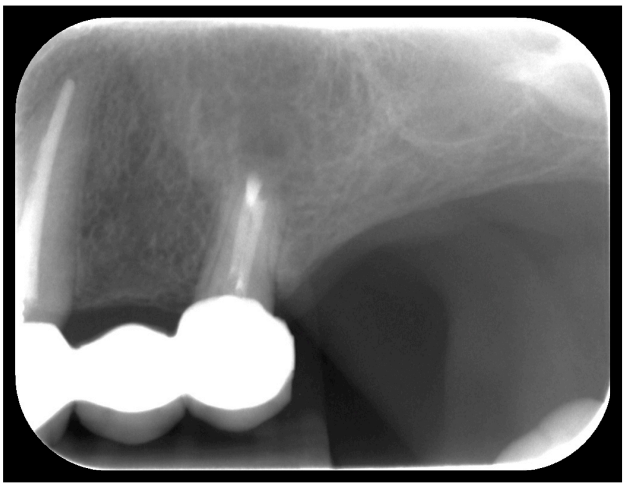

Figure 14-9: Follow-up, 13. Jun. 2012 (3m)

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The delay in diagnosis and treatment was suboptimal. Our language barrier impeded communication. Because of the explorative nature of this treatment, CBCT helped by ascertaining diagnosis. In case diagnosis was wrong, surgical procedures could lead to increased suffering for a patient with neuropathy.

Discussion

Early studies of observer agreement when reading periapical radiographs discovered that more observers disagreed on diagnosis than not. (1) The radiologic depiction of a more or less outlined radiolucency at the root tip is correlated with a histological picture of inflammation. Radiologists had problems of diagnosing small disease changes, and some normal cases were diagnosed with disease. But largely, careful observation of endodontic radiolucencies on radiographs correlated to both its histological presence and its severity. (2)
Many classification systems have been developed to diagnose and to stage apical periodontitis and health. (3-6) Their shortcomings have been discussed in recent articles on three-dimensional imaging. (7) Although radiographs can diagnose the majority of periapical osteolytic or resorptive lesions, some will be overlooked.
Medical Computed Tomography in all its different aspects has too low resolution and too high risk for routine examination of a disease as chronic apical periodontitis. It requires certified operators and is large and expensive. Conical-Beam Computed Tomography (CBCT) is a decade-old method of imaging that is more suitable. Radiation doses are lowered, to hundreds if not tenths micro-Sieverts, many dental practices have acquired one, the interested clinician, aided by a radiologist, may learn its use.
A study published in 2008 used CBCT as the golden standard to evaluate the diagnostic accuracy of periapical and panoramic radiographs in 1508 teeth. (7) The observers were to diagnose apical periodontitis based on the different modalities. The sensitivity for intraoral and panoramic radiographs was 0,55 and 0,28 respectively. Specificity was 0,98 and 1,0. The positive predictive values (PPV) therefore approach 1, while negative predictive values (NPV) was 0,55 for intraoral and 0,44 for panoramic radiographs.
A similar observation done on CBCT scans taken after apicoectomies were made by Danish researchers. (8) But they questioned the clinical significance when relating the higher sensitivity of CBCT to clinical terms like success and failure.
Histopathologic correlation to CBCT images of apical periodontitis was made by Brasilian researchers in dogs. (9) The diagnostic accuracy for intraoral radiographs and CBCT was calculated against histology as the golden standard. The sensitivity for radiographs was 0,77, CBCT 0,91. Specificity was 1 for both modalities, as was PPV. NPV were 0,25 for radiographs, 0,46 for CBCT, which may seem disappointingly low. In Brynolf's classical work the NPV was 0,53.
This validation process will probably still go on. Swedish researches have used CBCT in patients referred for diagnosis of chronic oral pain conditions to select out cases with an undiagnosed apical periodontitis.

(10) They managed to diagnose more patients correctly when supplementing panoramic and intraoral radiographs with CBCT.
Guidelines (11) and position papers conclude that CBCT is a valuable tool to supplement conventional methods when diagnosing apical periodontitis. It should be used after individual assessment, not routinely.

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11. SEDENTEXCT. RADIATION PROTECTION:CONE BEAM CT FOR DENTAL AND MAXILLOFACIAL RADIOLOGY Evidence based guidelines Manchester: The University of Manchester, 2011.

Case 15: Non-surgical and surgical retreatment of a maxillary molar

Introduction

The patient is referred from the undergraduate student clinic in our faculty. He is a Norwegian male, aged 42. He is referred for the retreatment of his maxillary right first molar (16). Patient record number is 1054226.

Chief complaint

The patient has no symptoms. He complies with the referral.

Medical history

General

Non-contributory: No medications, no known allergies or diseases. He smokes 2-3 cigarettes per day.

Figure 15-1: Dental overview

Dental

The tooth is treated endodontically, it is not known when or where. The treating dental student became aware of a radiolucency in the apical area of 16, and because of perceived difficulties with retreatment, referral was made.

Examination

Clinical

No palpable swelling or sinus tract is seen in the apical area of 16. The oral mucosa in the region is normal and healthy. There is good oral hygiene. Tooth 17 is sound. 16 has a large occluso-mesial amalgam restoration, the crown is somewhat discoloured. This is of no aesthetic concern; his smile line is not that high. Tooth 15 is restored with a large occluso-distal composite filling.

Figure 15-2: Treatment area

	17	16	15
Percussion- ax	-	-	-
Percussion- hor	-	-	-
Palpation	-	-	-
PPD	WNL	WNL	WNL
Mobility	-	-	-

Table 15-1: Dental diagnostic data

Radiographic

17 has normal radiographic appearance of crown and root, normal lamina dura.
16 has a radioopaque restorative in most of its crown, a small overhang is seen mesial. Although large, the access and restoration appear not unneccesary enlarged, indicating adequate amounts of remaining dentin. Homogenous but short radioopaque obturating material is seen in three roots. At the mesiobuccal root, the

Figure 15-3: Pretreatment radiographs, left is mesioangulated

material seems to be about 5 mm short. The mesiobuccal root has a moderate large-radius curvature. The lamina dura is broken on the mesiobuccal root, there is a diffuse radiolucency centered on its apex. The lamina dura of the palatal root is normal; the disto-buccal root has a smaller radiolucency and a broken lamina dura.
15 is restored with a radioopaque restoration, filling out most of its crown. The root is obturated with a radioopaque filling material, indicating two separate roots. The material seem homgenous and of adequate dimensions. The lamina dura is slightly distended on the apex.

Diagnosis

Tooth 16:
Pulpal: Necrosis of pulp, K04.1, previously endodontically treated.
Apical - Chronic apical periodontitis, K04.5, PAI 5

Treatment plan

Non-surgical retreatment in two visits is planned. If ineffective on follow-up or technically impossible to perform, surgical retreatment is recommended. He prefers this treatment to extraction and no replacement, which is also a viable option. If he wants to have a tooth in function in the place of 16, a three-unit bridge or even an implant-supported crown may replace 16 if it is lost. But, because of the good marginal periodontium and solid remaining tooth structure, it is advised to conserve 16. Because of economical restrictions, he wants the student to restore 16 with a composite filling after the retreatment. He is advised that a crown will be the more durable choice. This also applies to 15.

Treatment

18. January 2011: Re-access, disinfection.
The amalgam filling was removed. Rubber dam was applied and the field was disinfected. The gutta-percha root filling was mechanically removed using rotary nickel-titanium files in the coronal 2/3. An ISO 40, 4% tapered Bio-Race file was used at 900rpm. Hand instruments removed the apical remnants, and working length was established radiographically. It was possible to reach adequate length. Two joining mesiobuccal canals were found, one previously unobturated. The palatinal and distobuccal canal were normal. The canals were cleaned, using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. Chlorhexidine gluconate 2% soaked the canals for 5 minutes. An isthmus in the mesiobuccal root was cleaned and enlarged with an ultrasonic K-file. The final dimensions were:
Palatinal canal - 20mm/ISO 55/2% taper.
Distobuccal canal - 21mm/ISO40/4% taper
Mesiobuccal and 2nd mesiobuccal canal - 22mm/ISO40/4% taper.
The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

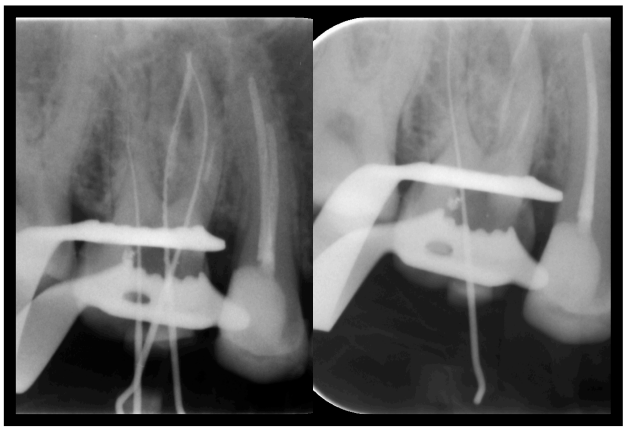

Figure 15-4: Working length radiographs

10. February 2011: Obturation
The patient's tooth was asymptomatic. Rubber dam was applied and the field was disinfected. The canal system was

reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then ethylenediaminetetraacetic acid 17%. A masterpoint radiograph was taken. The canals were dried and obturated with Resilon® points and Epiphany® primer and sealer, in the cold lateral condensation technique. Three mm deep orifice plugs of IRM® were placed in each canal. The tooth was temporarily restored with IRM®. A final radiograph was taken, showing adequate dimensions of the root filling. A small sealer extrusion on the mesiobuccal canal is seen.

Figure 15-5: Radiographs from left: Masterpoint, Posttreatment, hyperangulated

16. February 2012: Follow-up

The patient has no symptoms from 16. A radiograph displays a lack of healing.

Figure 15-6: Follow-up, 16. Feb 2012 (1y)

The radiolucency is still seen clearly, it measures 6,5mm in diameter and is associated with the mesiobuccal root. It is decided to schedule an apicoectomy with retrograde filling of the mesiobuccal root.

28. March 2012: Apicoectomy of mesiobuccal root

Figure 15-7: Treatment area, pre-surgery

The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A marginal incision running from the distal of 17 to the mesial line angle of 14 was made, and a vertical incision from 14 up to the vestibulum. A mucoperiosteal triangular flap was raised, exposing intact cortical bone. An osteotomy over the mesiobuccal root is done with a round bur, exposing the lesion. The mesiobuccal root of 16 was resected 3mm with a fissure bur. The lesion and the apex were removed from its crypt by the aid of a Lucas curette. The enucleated soft tissue was sent for pathological analysis, stored in 4% Formaldehyde. Methylene blue and microscope was used to identify the original canals in the mesiobuccal root, besides inspection for any infractions. A unistrumented isthmus area was seen. Retrograde preparation was done to 3mm depth, removing gutta-percha and preparing the unobturated isthmus area.
An ultrasonic retrograde tip with diamond coating was used on a low power setting, while irrigating with saline. Hemostasis was achieved by the aid of adrenaline and Ferric Sulfate. The retrograde cavity was obturated with mineral trioxide aggregate, White ProRoot® was used. A radiograph verified dense filling.

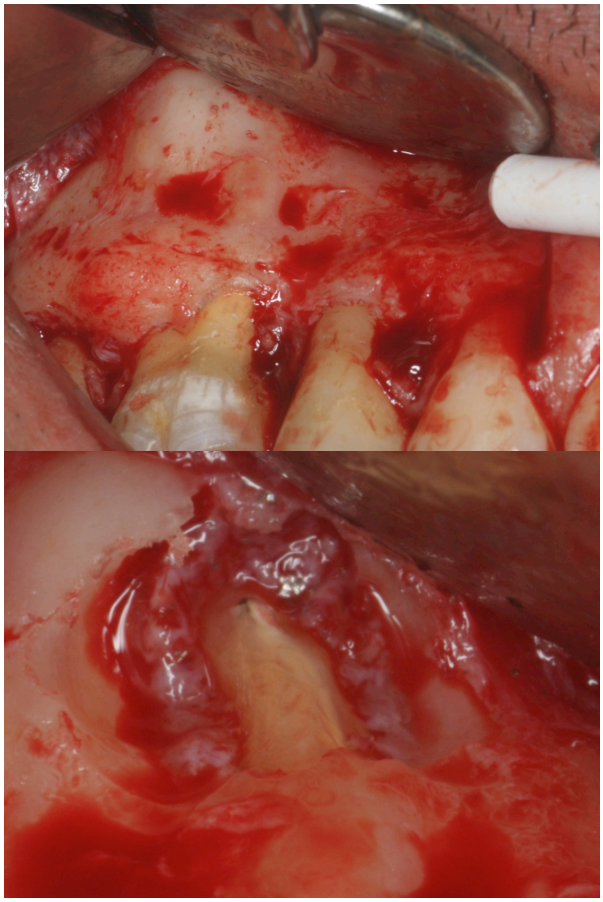

Figure 15-8: Top: flap reflected; bottom: lesion exposed

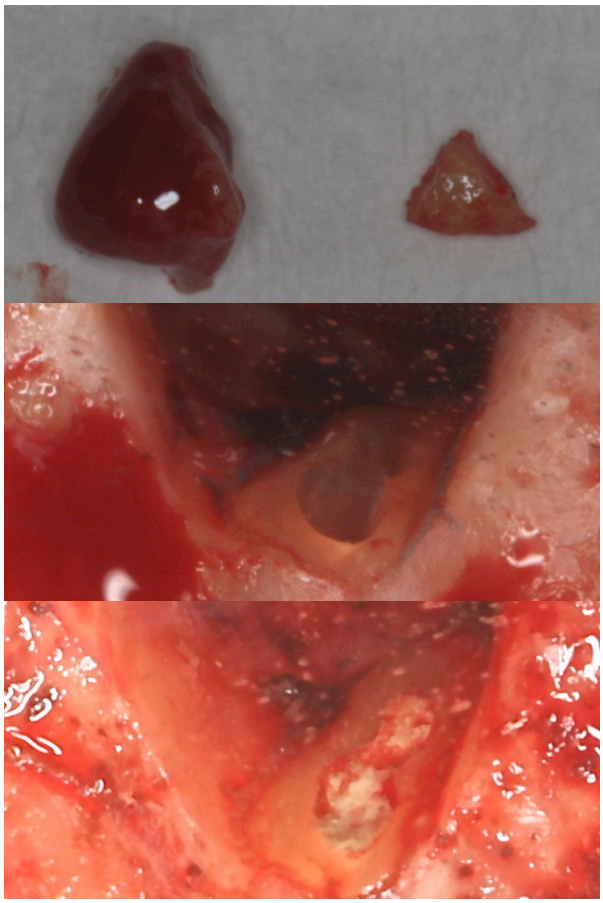

Figure 15-9: Top: lesion and apex; middle: retroprep; bottom: retrofill

The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 4-0 were used. The patient received standard postoperative care.

Figure 15-10: Postoperative radiograph, 28. Mar. 2012

Figure 15-11: Top: sutures at surgery; bottom: sutures 1 w postop

03. April 2012: Post-operative control

Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the

sutures were removed. The 20. April the pathology result came. The diagnosis was granulation tissue with chronic and acute inflammatory cells; some foreign bodies were seen.

Figure 15-12: Follow-up; Left: 13. Jun. 2012, Right: 17. Apr. 2013 (1y 1m), showing complete healing.

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The treatment went as planned. A small disappointment was that in this case there was no sign of healing, when the final radiograph of the non-surgical retreatment displayed a good obturation. The isthmus area found during surgery might harbour microorganisms responsible for this. Even if this isthmus area were diagnosed on a CBCT examination, it may not have been possible to instrument and clean it sufficiently. In some instances, surgical retreatment needs to be performed even if the orthograde treatment seems well performed.

Discussion

Since the early days of endodontology "root surgery" was performed. The classical works of Rickert and Dickson from USA described the method as too radical "for control purposes only". They called for a judicious use of the method, preferably with the diagnostic aid of radiographs. (1) In a remarkable series of five articles, Danish researchers presented a way to describe the result of apical surgery that has dominated follow-up research and clinical practice since. Since the anatomy is surgically altered, it was unknown how the tissues will re-establish after a healing period, and how this would appear on radiographs. Obliquely sectioned roots and healing by scar tissue raised many questions. Surgeons knew of course full-blown failures when they saw it, with abscess formation and tooth loss resulting. Thus, a number of biopsies were taken from periapical areas. (2) This was done on the clinical suspicion of nonhealing. The biopsies were taken in the same way that Nygård-Østbye did in his early works, including bone and apex *en bloc*. Samples were decalcified and analysed, and was classified in three groups. Group 1 was cases with no or mild inflammation, occasional ankylosis, but most importantly re-formation of periodontal membrane. Group 2 was also relatively free from inflammatory cells, but instead of bone, there was scar tissue adjacent to or a distance from the resected apex. Group 3 was where chronic or acute inflammatory cells dominated. 70 biopsies were examined, and though 45 cases were considered in group 1 and 2, only 6 cases was completely free from inflammation. All cases in group 3 had moderate to severely graded inflammation.

These results were correlated to radiographs taken before biopsy. (3) Radiological descriptions were made, and statistical tests of co-occurrence with the three histologic groups were made. Out of this correlation, four radiographic categories of healing were presented in another article. (4)

Group 1 was complete healing.

Group 2 was called incomplete healing with scar tissue.

Group 3 was uncertain healing. It did not quite match the radiographic picture in group 1 or 2, but an improvement was required. A case could stay in group 3 for maximum 4 years after surgery.

Group 4 was unsatisfactory healing. The difference between 3 and 4 was that the osteotomy from the surgery should be unchanged or enlarged at follow-up. It would eventually include some "stragglers"

from group 3 that did not heal completely at 4 years follow-up.

They published a clinical follow-up study of no less than 1000 treated cases with this classification system. The longest follow-up was 10 years. Their results were not bad at all; 81% complete healing, 9% scar tissue, 6% uncertain, 4% failures; all judged at latest follow-up. Worth noting is that there was little change out of group 1 from 1-year to latest follow-up. More cases changed group with time from 2 and 3 up to 1.

The operative techniques and reasoning was published as well. (5) It was custom to replace a root filling at the time of surgery, even if it was recently done or a retrograde filling was placed as well. Retrograde filling was preferred where the canal was inaccessible, e.g. in cases with posts. Cleaning and shaping of the pulp canal, obturation with gutta-percha and sealer before root resection was the most common treatment.

This radiographic surgical classification system has not been replaced yet. This work is an impressive publication series done within the same year.

1. Rickert UG, Dixon CMJ. The controlling of root surgery. 8 International Conference of Dentistry; Paris: FDI; 1931. p. 15-22.

2. Andreasen JO, Rud J. Modes of healing histologically after endodontic surgery in 70 cases. Int J Oral Surg. 1972;1(3):148-60. PubMed PMID: 4199163. Epub 1972/01/01. eng.

3. Andreasen JO, Rud J. Correlation between histology and radiography in the assessment of healing after endodontic surgery. Int J Oral Surg. 1972;1(3):161-73. PubMed PMID: 4199164. Epub 1972/01/01. eng.

4. Rud J, Andreasen JO, Jensen JE. Radiographic criteria for the assessment of healing after endodontic surgery. Int J Oral Surg. 1972;1(4):195-214. PubMed PMID: 4199168. Epub 1972/01/01. eng.

5. Rud J, Andreasen JO. Operative procedures in periapical surgery with contempraneous root filling. Int J Oral Surg. 1972;1(6):297-310. PubMed PMID: 4203646. Epub 1972/01/01. eng.

Case 16: Simultaneous root resection and apicoectomy

Introduction

The patient is referred from the undergraduate clinic for endodontic treatment of his maxillary right first molar. He is a Norwegian aged 36. He is currently on a waiting list for dental treatment, the referral is from the initial screening clinic, and thus he has no-one planning or performing treatment for him yet. Patient record number is 1159695.

Chief complaint

None. He complies with the referral.

Medical history

General

He reports no medications, diseases or tobacco use. He is allergic to one type of antibiotic, penicillin V.

Figure 16-1: Dental overview

Dental

For his age, he had much caries experience. He agrees that this is a problem for him.

Examination

Clinical

The patient has no symptoms in the area. 17 is missing. 16 is restored with a porcelain-fused-to-metal crown, so is 15. The margins are adequate. Marginal probing is carried out meticulously with the possibility of vertical root fracture in mind.

Figure 16-2: Treatment area

	16	15
Percussion- ax	-	-
Percussion- hor	-	-
Palpation	-	-
PPD	WNL	WNL
Mobility	-	-

Table 16-1: Dental diagnostic data

Radiographic

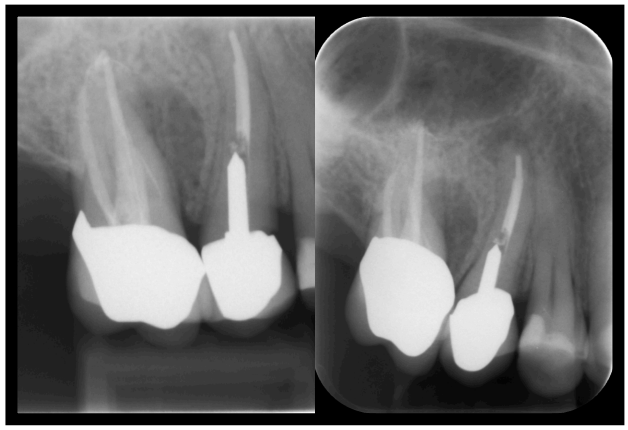

Figure 16-3: Preoparative radiographs, left just misses radiolucency on 15

Radioopaque metallic crown material overlies the crown of 15 and 16. 15 has a large radioopaque post, there is a small discontinuity before root canal obturation material is seen. This is of adequate dimensions, and seems to be two canals overlying each other or joining together apically. The discontinuity reflects the most apical preparation for the post, and is very close to the distal periodontium. The lamina dura is broken at the apex, a well-outlined small radiolucent zone is seen, bridging the small bony gap between the apex and the inferior border of the maxillary sinus.
The roots of 16 is obturated with a material of the same radioopacity as 15. The distobuccal root seem adequately obturated, there is a small amount of radioopaque remnants on the apex of the palatinal root. This look like extruded sealer. The mesiobuccal root is joining the distobuccal at the apex. It seems partially obturated. Differently angulated radiographs are available. It seems like the mesiobuccal root has a classic 2-1 configuration, with one canal well obturated. A small sliver of radioopaque material is seen in the other canal, it is not possible to see if this is a small file fragment or sealer. The mesiobuccal root has a periradicular radiolucent zone in its entire length, measuring 7mm across. It is not centred on the apex, but on the mesial side of the root, close to the apex of the large post in 15.

Diagnosis

Tooth 16
Pulpal - Necrosis of pulp, K04.1, previously endodontically treated
Apical - Chronic apical periodontitis, K04.5
Tentative diagnosis: Vertical root fracture.

Tooth 15
Pulpal - Necrosis of pulp, K04.1, previously endodontically treated
Apical - Chronic apical periodontitis, K04.5.
PAI 4

Treatment plan

Resection of the mesiobuccal root on 16 with concomitant apicoectomy and retrograde filling of 15 was planned. An equally recommended alternative was to extract 16. Later on, an implant-supported crown might be an option. The patient saw the benefits of the more conservative approach, and wanted to try to preserve his own teeth for as long as possible. He was explained that preoperative findings might prompt an extraction of 16 instead of only root resection.

Treatment

25. May 2011: Root resection 16 and apicoectomy 15
The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000.

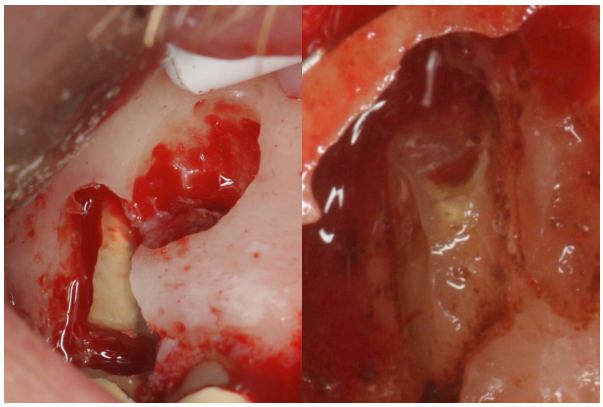

Figure 16-4: Left: Extention of osteotomy and resected root in situ; Right: retroprep on 15

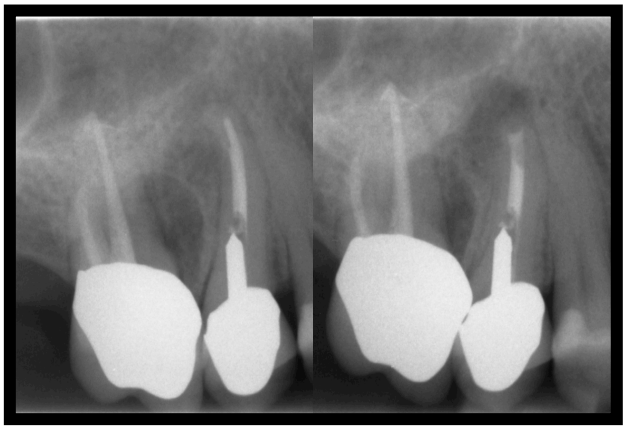

Figure 16-5: Left: MB root of 16 resected; Right: 15 retrofill postoperative radiograph

A marginal incision running from the mesial of 13 and 10mm distal to 16 was made, and a vertical incision from 13 up to the vestibulum. A mucoperiosteal triangular flap was raised. Hard probing discloses marginal communication to the

apex of 16 on the mesiobuccal root. The buccal bone is intact, both on 16 and 15.
The overlying bone on the mesiobuccal root of 16 is removed with a round bur. The root is resected with a fissure bur below the crown margin, and removed with a straight elevator and a forceps. In the process, the root fractures longitudinally, verifying the tentative diagnosis of vertical root fracture. The crypt is cleansed with a Lucas curette, and sharp bony and dentinal edges are smoothed with a bur.
Because of the close relation of the apices of 14 and 15, the osteotomy is enlarged in the direction of 15, to avoid damage to the vascular supply of 14. A small granuloma is exposed. The root is resected 3mm with a fissure bur, removed and the crypt is curetted.

Figure 16-6: Top: Healing at suture removal; Bottom: Follow-up at 15. Sep 2011

No infraction is visible in the microscope. Retrograde preparation was done to 3mm depth, removing gutta-percha. Hemostasis was achieved by blotting the surrounding bone with gauze drenched in lidocaine 2% with adrenaline 1:80000, and a small amount of Ferric Sulfate. The retrograde cavity was obturated with mineral trioxide aggregate, White MTA-Angelus® was used. A radiograph verified dense filling. The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 4-0 were used, 5-0 suture was used to close the vertical incision. The patient received standard postoperative care.

31. May 2011: Post-operative control
Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed

15. September 2011: Follow-up
The patient has no symptoms. There is no pus or abnormal probing depths in the region. Some gingival retraction is noted; this is of no concern, because the smile line is not that high. Tooth 14 tests positive on electric pulp tester and cold (Endo-Ice®).

Figure 16-7: Follow-up. Left: 15. Sep. 2011; Right: 29. Apr 2013 (2y)

Prognosis

Tooth 16:
Endodontic: good.
Periodontal: good
Restorative: good
Tooth 15:
Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

It seemed reasonable to recommend treatment of an additional tooth in the operative field when indications exist. This way the patient avoids additional surgical procedures. Root resection is normally contra-indicated on teeth with fused roots. This was not obvious in the pre-treatment radiographs in this case. The small apical fusion did not pose a problem. The two-year follow-up show complete healing of 15, normal pulp response in 14. 16 is free from symptoms, with healthy gingival conditions. The patient do not have any symptoms from the region.

Discussion

Before the introduction of retrograde tips and operating microscopes, microhead contraangles, amalgam and plain vision was used. Some had great success. (1, 2) Long-term success approached 80%.

Researchers in the USA did an excellent systematic review of observational studies of root-end surgery. (3) Studies were grouped after length of follow-up. Measures of centre were calculated as crude mean and as weighted mean; weighing the significance of the study after a quality rating system. Many studies followed cases in 2-4 years, and reported 78% success. For the 7 studies that followed patients in 4-6 years, the weighted success rate was 72%. 3 studies followed patients for more than 6 years; their success rate was 63%. So an increased morbidity with time may be expected, so-called late failures. They also summarized the success rate of non-surgical retreatment. For the identified studies, they found 71% success in the 3 studies with 2-4 years follow-up. 5 studies had follow-up at 4-6 years, and a success rate of 83%. From these data it may seem that non-surgical treatment is not such a bad alterative in the longer perspective, even if root-end surgery may heal fast initially.

With the introduction of microscopes, ultrasonic retrotips and other obturation materials, comparisons were eventually mad to see if progress had been made. Researchers in USA, Pennsylvania published a systematic review with meta-analysis of the results of treatment performed with "old" and "new" technique. (4) The success rate for "old" technique was found to be 59%, "new" 94%. Curiously enough, classic follow-up studies from Rud or Grung (1, 2) were not included in the "old" technique group. The high success rate and short follow-up time for the "new" group sparked an interesting debate on the conduction of systematic reviews. Canadian researcher Friedman argued in an editorial that the systematic review had selected studies for "new" technique that skewed the results upwards. (5) Short follow-up might negate the effects of late failures. A positive selection of studies in the "new" group where non-surgical retreatment had been performed was also argued; this would presumably skew results upwards as well. Furthermore, some mistrust of the classification of healing in studies in the "new" group would also skew results positively. The answer was just as interesting to follow; the authors claimed a rigorous methodological adherence and that the selection of studies in both groups was not skewed. (6) They claimed to exclude for example the studies of Rud and Grung because of reporting of root-surgery as primary retreatment form, or with the simultaneous orthograde treatment. Furthermore, they did not acknowledge the existence of late failures in the "new" treatment group. Finally, the authors felt that suspicions to the conduction of individual trials should not afflict its inclusion in a systematic review - that would also introduce bias. Both were, however, in agreement that "new" techniques outperformed old ones.

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and endodontic surgery: a systematic review. J Endod. 2009 Jul;35(7):930-7. PubMed PMID: 19567310. Epub 2009/07/02. eng.

4. Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature--part 1: Comparison of traditional root-end surgery and endodontic microsurgery. J Endod. 2010 Nov;36(11):1757-65. PubMed PMID: 20951283. Epub 2010/10/19. eng.

5. Friedman S. Outcome of endodontic surgery: a meta-analysis of the literature-part 1: comparison of traditional root-end surgery and endodontic microsurgery. J Endod. 2011 May;37(5):577-8; author reply 8-80. PubMed PMID: 21496650. Epub 2011/04/19. eng.

6. Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. Reply to Dr Friedman. Journal of endodontics. 2011;37(5):578-80.

Case 17: Apicoectomy with removal of a separated instrument

Introduction

A 60-year-old Norwegian male is attending routine follow-up of endodontic treatment done one year prior on his maxillary right first molar (16). Another postgraduate student, now on leave, performed the treatment. Treatment failure is discovered, and he is recommended further treatment. Patient record number is 0632054.

Chief complaint

None. He attends follow-up on our request.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 17-1: Dental overview

Dental

He has been symptom-free since the orthograde treatment 1 year earlier. The patient record mentions an extruded file fragment in the disto-buccal root. Furthermore, the palatal root had an iatrogenic perforation of the apical foramen; this was obturated with MTA. He reports a lost restoration in tooth 17; he will replace this in our undergraduate clinic.

Examination

Clinical

A non-tender small swelling is palpable in the vestibular apical region of 16. There is no sign of a sinus tract. Otherwise, the oral mucosa in the region is normal and healthy. There is good oral hygiene. He has lost a large MO restoration in 17; there is no sign of secondary caries. 17 has a small buccal and a palatal amalgam restoration. 16 is restored with a porcelain-fused-to-metal crown, with an endodontic access cavity restored with composite. 15 is restored with a large MOD composite.

	17	16	15
EPT			
Cold	+		+
Percussion- ax	-	-	-
Percussion- hor	-	-	-
Palpation	-	-	-
PPD	WNL	WNL	WNL
Mobility	-	-	-

Table 17-1: Dental diagnostic data

Radiographic

Figure 17-2: Radiographic history. Left: May 2009; Right: Oct. 2011

17 displays loss of a large restoration, fused root, normal lamina dura.

16 has a radioopaque crown restoration. There is a radioopaque filling material in

the pulp space, no voids. An apical radiolucency is seen containing a small file-shaped radiodense object, broken lamina dura in buccal roots. Angulated radiographs associate fragment with disto-buccal root. None is visible on palatal.
15 has a radioopaque restoration, normal lamina dura.
The general picture is a restored dentition with adequate bone support, and normal cancellous bone appearance beside the apical radiolucency on 16. When comparing to historical radiographs taken in 2011, the radiolucency is a little larger and more distinct now.

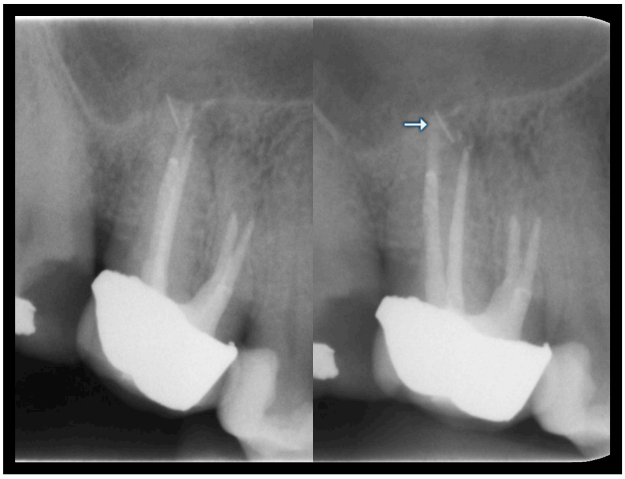

Figure 17-3: Pretreatment radiographs. Right is distoangulated, locating fragment to the DB apex

Diagnosis

Tooth 16:
Pulpal - Necrosis of pulp, K04.1, previously endodontically treated
Apical - Chronic apical periodontitis, K04.5, Sequelae of misadventures to patients during surgical and medical procedures, Y88.1. PAI 4.

Treatment plan

The recommendation for performing a surgical retreatment of the buccal roots on 16 is strong. As a less recommended option, one might choose to continue observation of 16 and extract the tooth in the event of exacerbation or enlargement of the apical infection. A three-unit bridge might have a good prognosis, if replacement of 16 is wished for.

Treatment

19. September 2012: Apicoectomy

The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A marginal incision running from the distal of 17 to the mesial line angle of 14 was made, and a vertical incision from 14 up to the vestibulum. A mucoperiosteal triangular flap was raised, while doing so the lesion was carefully dissected free from the surrounding tissues. The file fragment protruded, and was removed with forceps.

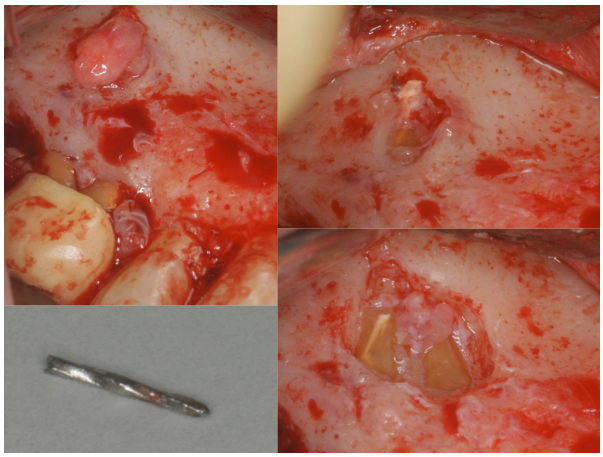

Figure 17-4: Clocwise from top left: Granuloma exposed; File fragment visible; Lesion removed; File fragment

The lesion was released from its crypt by the aid of a Lucas curette. The enucleated soft tissue was sent for pathological analysis, stored in 4% Formaldehyde. The two buccal roots of 16 was resected 3mm with a fissure bur. Methylene blue and microscope was used to identify the original canals in the mesiobuccal root, besides inspection for any infractions. Retrograde preparation was done to 3mm depth, removing gutta-percha in the distobuccal root. In the mesiobuccal root, new cavities had to be made because of the short and deviant preparations. An ultrasonic retrograde tip with diamond coating was used on a low power setting, while irrigating with saline. Hemostasis was achieved by blotting the surrounding bone with a cotton pellet drenched in Ferric Sulfate.

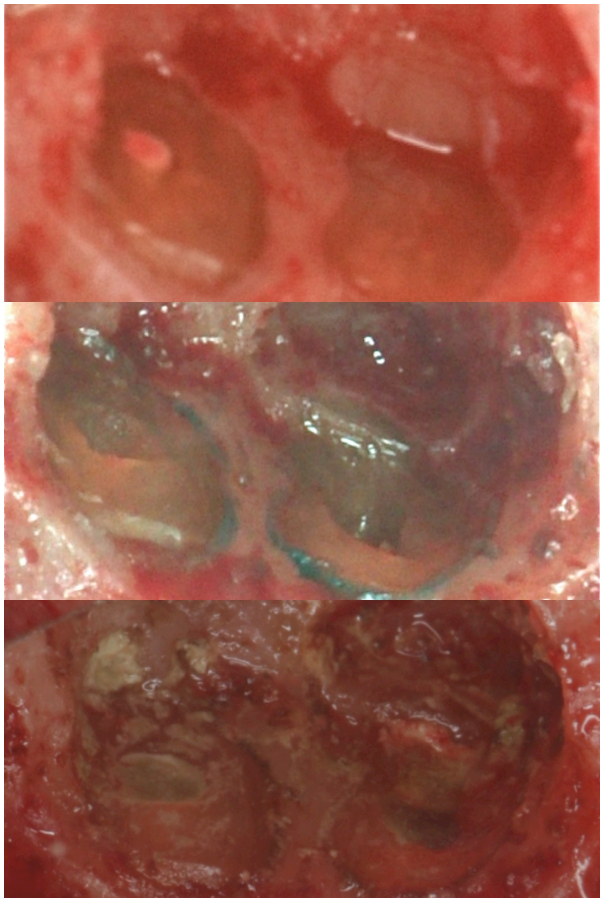

Figure 17-5: From top: Resection; Retroprep with methylene blue stain; Retrofill

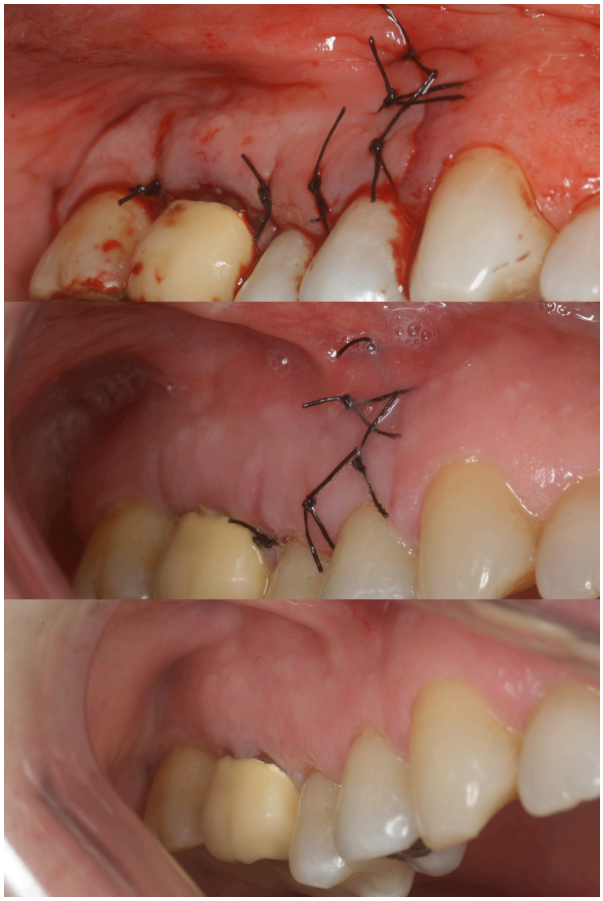

Figure 17-6: From top: Day of surgery; 1 w postoperatively; 2 m postoperatively

The retrograde cavities was obturated with mineral trioxide aggregate, White MTA-Angelus® was used. A radiograph verified dense fillings.

The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 4-0 were used. The patient received standard postoperative care.

26. September 2012: Postoperative control

Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed. A temporary restoration of IRM® was placed in 17.

Figure 17-7: Top: Retroprep; Bottom: Postoperative radiograph, 19. Sep. 2012

Prognosis

Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The treatment went as planned. In retrospect, a conical-beam computed tomogram (CBCT) would better depict the palatinal root. The maxillary molar

segments are often difficult to diagnose accurately in the periapical region, because of the summation of many anatomical structures in a conventional radiograph. CBCT might discover the need for a resection of the palatinal root. On the other side, so will follow-up, and even though most surgical retreatments have a good prognosis, the tooth may fail for a number of other reasons, obviating the need for CBCT.

Figure 17-8: Follow-up radiographs, 6. Des 2012, right is distoangulated (3m)

Discussion

In his classical works on dental morphology, Weine described three configurations of the mesiobuccal root of the maxillary first molar. (1) Type 1 contained one pulp canal in the root. Type 2 had two pulp canals exiting from the pulp chamber; joining in the apical 1-4mm. Type 3 had two separate canals in the entire length of the root. More recent studies reported the common occurrence of isthmi between the main canals, or if one canal was present, it might be band-shaped. (2) The latest studies on canal complexity use micro-computed tomography, publishing beautiful pictures and sometimes analyses of our treatments that are not that flattering. Danish researchers, for example, published a study analysing how much of the canal contents that get mechanically debrided, when isthmus tissue was present in the mesio-buccal root of the maxillary first molar. (3) The instrumentation technique was traditional, preparing apical boxes of ISO40 with different tapers. As might be expected, large areas were untouched by the instruments. Thus, our treatment relies as always not only on shaping canals, but the bactericidal action and ecologic alteration of irrigants, medications and obturations. It is no wonder that treatments may fail and need surgical retreatment.

When resecting the apex, the cutting direction should be almost perpendicular to the root axis. (4) When doing so, a better sealing effect of the retrograde filling can be expected. Smooth cuts without jagging is recommended. Resecting 3mm of the apex will remove most of the root that contain lateral canals or a delta. This would expose dumbbell-shapes and isthmi. In a review 20 years ago, American researchers spoke of new tools for retrograde preparation: the ultrasonic tips. (5) After a discussion of whether or not they produced harmful cracks, ultrasonic tips with diamond coating are now universally preferred over the microhead contraangles used before. (6) They are able to shape dumbbells and isthmi better than burs, and without the previously necessary oblique resection surfaces.

If tools for visualisation are added to the armamentarium, the uninstrumented areas may be better treated. The surgical operating microscope and even endoscopes are used for magnification. Dyes, like methylene blue, may be used to stain root-ends, helping the operator to identify cracks and pulpal tissue. Very convincing pictures have been published. (7)

With the use of modern tools, the potential for success is increased.

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Case 18: Retreatment, whitening and apicoectomy

Introduction

The patient is a Norwegian male aged 59. He was referred from a faculty member for surgical retreatment of his maxillary left lateral incisor (22). Patient record number is 1266484.

Chief complaint

He is frustrated with the long duration of attempts to retreat of his upper left lateral incisor. He has a swelling above this tooth, but no pain or other problems.

Medical history

General

Unremarkable. No reported medication or allergies.

Figure 18-1: Dental overview

Dental

Teeth 21 and 22 are earlier root-canal treated because of trauma. The swelling has existed for several years, but the patient cannot remember associated episodes of pain, sinus tract formation or other adverse events. His regular dentist discovered the swelling on a routine examination, and retreatment was begun, but the course protracted. Because of his occupation as an engineer in dental research, he came in contact with a member of the faculty staff, who referred him to our department

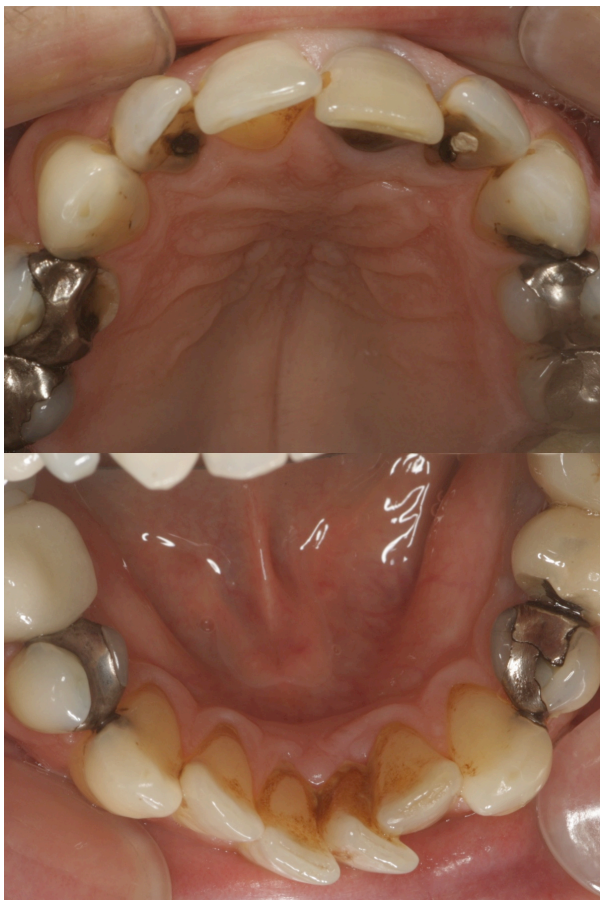

Table 18-2: Occlusal view

Examination

Clinical

A hard, marble-sized swelling is palpable over the apex of tooth 22.

Tooth 21 has a mesial and distal restoration with discolouration. The crown is brown-grey discoloured. A small, restored access cavity is located palatinally, towards the cingulum.

Tooth 22 has a mesial and distal restoration with discolouration. The crown is brown-grey discoloured. A small, temporary restored access cavity is located palatinally, towards the cingulum

Otherwise there is a well-restored dentition, but many restorations are old and worn.
The oral hygiene is good: almost no plaque, pale pink mucosa, non-bleeding gingival margins. There is some gingival hyperkeratosis, and a retraction on 23. Some calculus resides on the lingual surfaces of the lower incisors.

	11	21	22	23
El. pulp test	19	80	80	21
Cold	+	-	-	+
Percussion- ax	-	-	-	-
Percussion- hor	-	-	-	-
Palpation	-	-	-	-
PPD	WNL	WNL	WNL	WNL
Mobility	-	-	-	-

Table 18-1: Dental diagnostic data

Radiographic

11: normal root, two small radiolucent restorations, normal lamina dura
21: Two coronal restorations, lucent and opaque. Radioopaque material in the canal, thinned-out apically. The apex borders on the lucency seen on 22, the lamina dura cannot be traced.

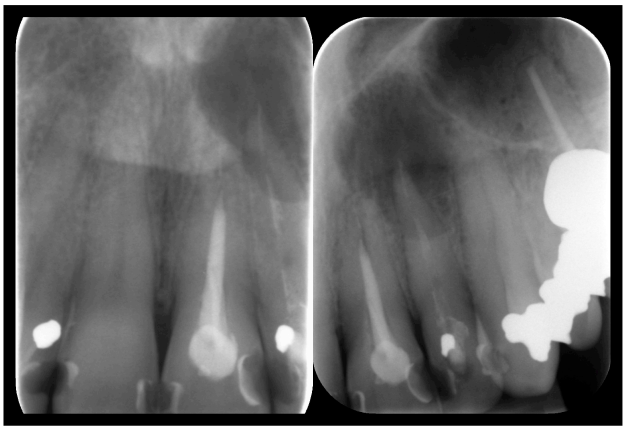

Figure 18-3: Pretreatment radiographs

22: Two coronal restorations, lucent and opaque. Canal filled with small radioopaque slivers and a material with dentin-like radiodensity. A large, well-outlined circular radiolucency encompasses the apex. Lamina dura is absent.
23: normal root, two small radioopaque restorations, normal lamina dura.
Not mentioning the radiolucency, the supporting bone trabeculation and marginal levels is of normal quality and level.

Diagnosis

Tooth 21:
Pulpal - Necrosis of pulp, K04.1, previously endodontically treated
Apical - Chronic apical periodontitis, K04.5.
PAI 3.
Tooth 22:
Pulpal - Necrosis of pulp, K04.1, currently undergoing retreatment
Apical - Chronic apical periodontitis, K04.5.
PAI 5

Treatment plan

Non-surgical retreatment of 21 and 22, followed by intracoronal whitening and restoration with composite.
If successful, surgical enucleation of the large lesion with root resection follows. The chronic apical infection is probably a stable chronic condition. The fact that retreatment is already initiated do not compel us to follow, should we decide against. Extraction of both 22 and 21 with prosthetic treatment may be an alternative. Implant placement may need alveolar ridge augmentation first, because of the defect left by the infection on 22. A bridge can be done from the solid and vital teeth 23 to 11, maybe even 12. Removable prosthetics should only be considered as the least expensive option. He has a low smile line and gingival margin aesthetics is not an important issue. Teeth 21 and 22 have good marginal bone support and normal root length. Treatment of the apical infections has a good prognosis. The crowns exhibit some weakening because of the access cavities and the class 3 restorations; the may be at risk for fracture. There is a good possibility that a fracture is restorable with a full crown, maybe even a post. Therefore, conservative treatment is the most recommended treatment option. The patient has a strong preference to preserving his own teeth. Considering this, there really was no doubt on which treatment should be chosen. An element of the treatment plan that is open for discussion is the last part, surgical enucleation. Here, the referring dentist suspected that healing would not ensue

after non-surgical retreatment only. The reasons for this were that it was an old lesion, a large lesion, and on an earlier obturated tooth. Furthermore, the fact that the patient has had a protracted retreatment course already, expedient treatment without an observation period and further treatments pending were wanted.

Treatment

01. November 2012: Re-access, debridement
Rubber dam was applied with holes for 21 and 22, using an Aseptico 211 clamp on 21, and a piece of rubber dam wedged between 22 and 23. The restoration overlying the access cavities was removed and the field disinfected. The canal space of 22 was filled with a calcium hydroxide paste, while 21 was obturated with gutta-percha.

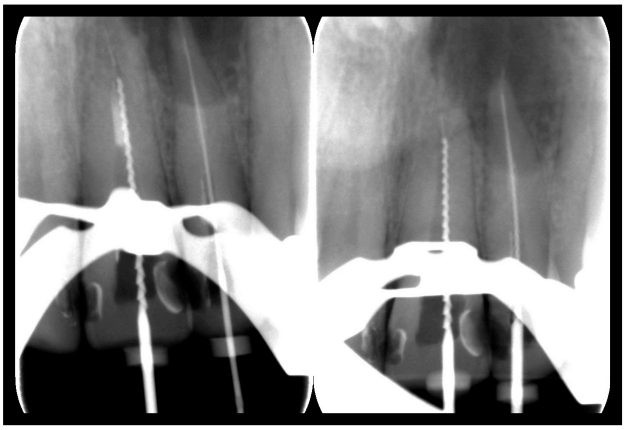

Figure 18-4: Treatment radiographs. Left: Incremental removal of guttapercha; Right: Working length

The gutta-percha in 21 was removed with an X-Gates drill and hand instruments. Working length was established in both teeth with a radiograph. In tooth 21 the previous treatment had left two portals of exit apically, probably because large stainless steel reamers had transported the original canal and made a buccal perforation. Remnants of gutta-percha lying just outside the apex were removed using a Hedstrom file. The canals of 21 and 22 was debrided and irrigated with sodium hypochlorite 1% and EDTA 17%, with a 30G Maxiprobe® cannula. Hand use NiTi files was used in 21, with ISO 60 as the last size, working length at 21mm. In 22 Bio-Race instruments were used, with 22mm/ISO40/4%taper as the final dimensions. The canals were dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

28. November 2012: Obturation, walking bleach
The treated teeth were asymptomatic. Rubber dam was applied and the field was disinfected. The canal system of 21 and 22 was reopened and rinsed again, using the final instrument dimensions from the first visit. Irrigation was done using sodium hypochlorite 1% and passive ultrasonic agitation, then EDTA 17%. A masterpoint radiograph was taken. The canals were dried and obturated with gutta-percha points and Ah plus® sealer, in the warm vertical condensation technique. A 3mm thick orifice plug of Cavit® were placed in the canal at the level of the marginal bone. The access cavity was cleaned with a microbrush and chlorhexidine alcohol tincture.

Figure 18-5: Clockwise from top left: Masterpoint; Downpack; Backfill; Posttreatment

Granulate of sodium perborate was ground in a mortar to a fine powder, and mixed with 0,9% saline to a thick slurry. The mixture was placed in the pulp chambers of 21 and 22. The teeth were temporarily sealed with IRM®.

12. December 2012: Walking bleach
Some improvement in colour was noted, but if possible, more was wanted. The IRM® restorations was intact. The sodium

perborate mixture was changed to a fresh preparation, and sealed as above.

19. December 2012: Composite restoration

The patient was satisfied with the result of the whitening. The access cavities was cleaned, and restored with composite. 37% Phosphoric acid gel was applied, rinsed, followed by 2% aqueous chlorhexidine solution. The solution was dried leaving a moist dentin surface; Scotchbond MP® was brushed on and light-cured. Tetric EVO Ceram shade A1 was used in layers to restore the access cavities. A final radiograph was taken, demonstrating adequate root-canal obturation and coronal restorations without voids. The patient was happy with the improved shade of his discoloured teeth.

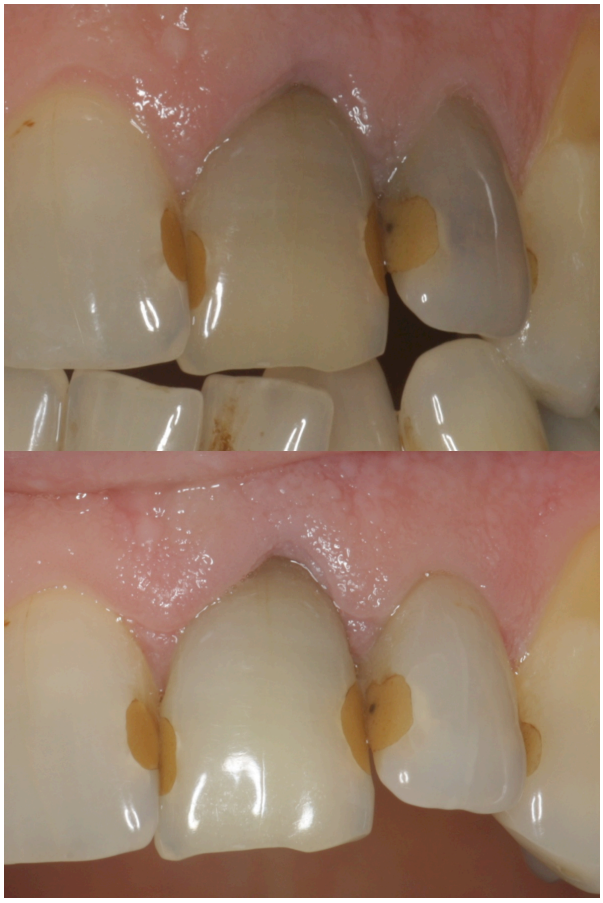

Figure 18-6: Result of whitening and restoration

30. January 2013: Apicoectomy

The swelling persisted. It was decided to continue the plan with a surgical removal of the large lesion. The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A marginal incision running from the centreline of 24 to the distal line angle of 11 was made, and a vertical incision from 11 up to the vestibulum. A mucoperiosteal flap was raised, while doing so the lesion was carefully dissected free from the surrounding tissues. The lesion was released from its crypt without rupturing by the aid of a Lucas curette. It was centred on the apex of 22. The lesion measured about 15 mm in diameter, and had a tough fibrous capsule. It was sent for pathological analysis, stored in 4% Formaldehyde. A small granuloma was scraped from the apex of 21. 3mm long apices of 21 and 22 were resected with a fissure bur. Methylene blue was applied to the resected surfaces, to identify cracks or infractions when inspecting in the operation microscope.

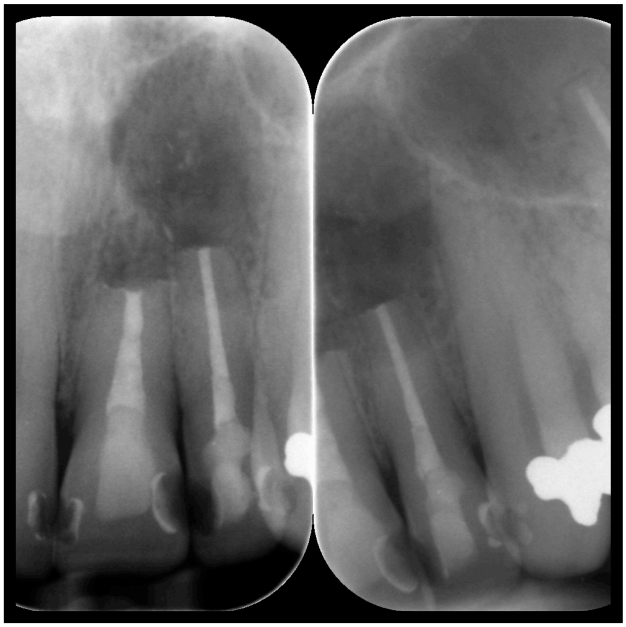

Figure 18-7: Postoperative radiographs

None were found. Retrograde preparations were done to 3mm depth, removing gutta-percha. An ultrasonic retrograde tip with diamond coating was used on a low power setting, while irrigating with saline. Haemostasis was achieved by blotting the surrounding bone with a cotton pellet drenched in Ferric Sulfate. The retrograde cavities were obturated with mineral trioxide aggregate, White ProRoot® was used. A radiograph verified dense fillings. The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 4-

0 were used. The patient received standard postoperative care.

6. February 2013: Suture removal

Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed. The patient exhibited ulcerations and hyperkeratosis on the buccal attached gingiva in all lateral segments. Photos were taken. The cause was not identified, suspicion was raised towards Corsodyl® mouthrinse or vigorous toothbrushing. He was advised to not use the mouthrinse any more. Follow-up appointments were offered, but the patient declined. He was urged to call for further assistance if the ulcers did not disappear quickly.

Figure 18-8: From top: Sutures 1 w postoperatively; 2nd qudrant with desquamation; 4th quadrant with desquamation

Prognosis

Tooth 21:
Endodontic: good.
Periodontal: good
Restorative: good
Tooth 22:
Endodontic: good.
Periodontal: good
Restorative: good

Evaluation

The treatment went as planned for. Although he had already been treated for a while, he showed understanding for the time needed to perform the treatment here.

Discussion

Examination of patient and non-patient groups has revealed large proportions with low technical quality of the root-filling. (1-3) A higher frequency of apical pathology is associated. When left untreated, or at times spontaneously, an apical periodontits may exhibit a large radiolucency. This may be a sign of its long duration, but not necessarily. Some researchers analyzing factors affecting prognosis of treatment, do not find that the size of the lesion matters. (4, 5) Others, on the other hand, do. (6, 7) The latter reports speculate that they found associations because of the analysis method. The latter two studies did not dichotomize the lesion size as the two first, but treated lesion size as a continuous variable, and attributes this to its found significance. In a systematic review with meta-analysis, a large or small lesion did not affect the treatment outcome. Here, lesion size was dichotomized. (8)

Other researchers have focused entirely on the treatment of apical periodontitis with large lesions. (9) Follow-up series show that meticulous therapy may give good results, 74% success. The view that large radiographic lesion size need concomitant surgical treatment is not supported in other reviews either. (10)

Studies correlating histopathological diagnosis with radiographic diagnosis have found that computed tomography was able to differentiate between cyst and granuloma. (11) This small cadaver study included 7 granulomas and one cyst. Early reviews supported the view that radiographic lesion size correlated to the occurrence of inflammatory radicular cysts, requiring surgical enucleation. The need for surgical therapy for cysts was clearly stated in early versions of Grossman's textbook Root Canal Therapy. (12) Later

reviews found no correlation between the histopathologic diagnosis and gray levels in the radiolucent area (13), the presence of a radioopaque lamina around the lesion (14), or its radiographic size. (15)

The decision to treat a large lesion surgically right after or at the time of retratment or primary root canal therapy must therefore be based on patient preferences, not commended solely by data. Large lesions may well heal after retreatment or primary root-canal therapy without the aid of an operation.

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Case 19: Apicoectomy with submarginal incision

Introduction

The patient is a 70-year-old Norwegian woman. She is referred from her general dental practitioner, whom is also a faculty member. The referral asks that an apicoectomy be performed on her left maxillary canine (23). Patient record number is 1162562.

Chief complaint

The patient complies with the referral first and foremost. But she also agrees that the described symptoms are real, and would like to get rid of the palpable tenderness to the left of her nose wing. On the other hand, she is not a complaining type.

Figure 19-1: Dental overview. Smile line at top, note old scar

Medical history

General

She has once had antibiotic-associated colitis, without hospitalization. The colitis had a quick onset and a classical picture. She states that her treating physician had a strong suspicion of an acute allergic reaction to the antibiotic. The antibiotic type she cannot remember, but it was prescribed for the treatment of a urinary tract infection. This was many years ago. Otherwise, she is healthy and has no medications or other allergies.

Dental

Tooth 23 had root canal treatment performed by the referring dentist last year. The initial diagnosis was pulp necrosis with chronic apical periodontitis. After the treatment, there was persisting low-grade pain in the apical region of 23. The referring dentist states that he uses the same treatment regimen we do at the University Clinic.

Examination

Clinical

Tooth 23 has one mesial composite and a distal amalgam restoration. The access cavity on the palatinal side is also composite. The neighbouring teeth are restored with porcelain-fused-to-metal crowns. The oral mucosal tissues are healthy with no sign of redness or sinus tract. There is a distinct tender palpable spot over the apical region of 23, both intra- and extraoral.

Figure 19-2: Occlusal view of treatment area

	25	24	23	22
El. Pulp test				
Cold	+	+	-	-
Percussion - ax	-	-	+	-
Percussion - hor	-	-	-	-
Palpation	-	-	+	-
PPD	WNL	WNL	WNL	WNL
Mobility	-	-	-	-

Table 19-1: Dental diagnostic data

Radiographic

22 has a metallic crown with a wide and short post. The root has normal morphology; a radioopaque material obturates the canal space apically, with a 2 mm discontinuity between it and the post. The lamina dura is continuous.

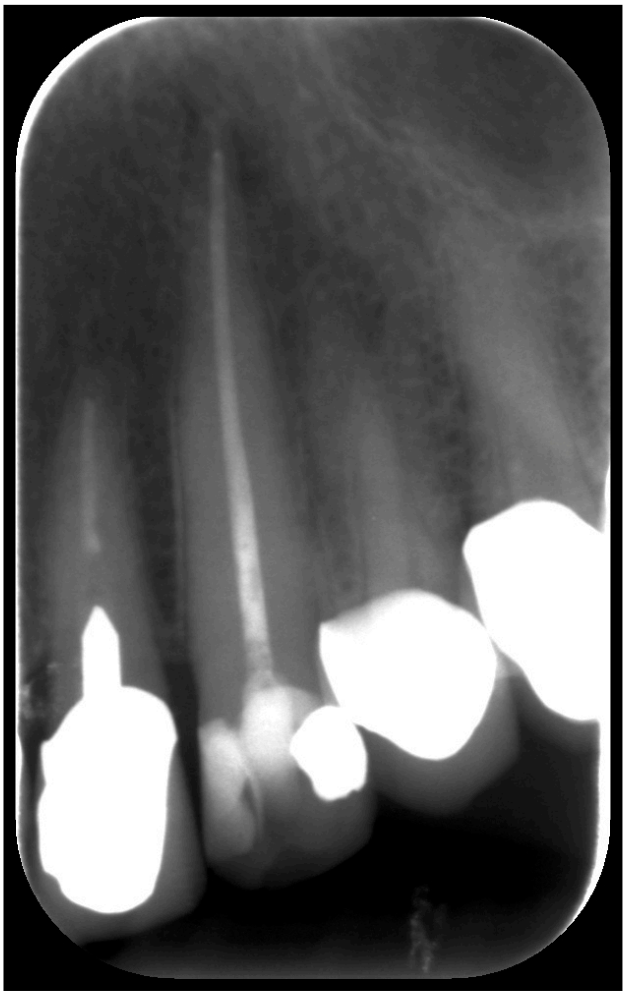

Figure 19-3: Pretreatment radiograph

The crown of 23 contains restoratives of two different radioopacities. The root is long, normal to a maxillary canine. A radioopaque material obturates the canal space. A small area with inhomogeneous radioopacity is seen bridging the coronal restorations and the canal obturating material. The lamina dura is broken apically, with a small, well-defined radiolucent zone in the trabecular bone surrounding the apex.

24 and 25 appears in the radiograph, but is superimposed on each other, and skewed because of the mesioeccentric passage of the central ray. Both teeth are restored with a radioopaque crown. Two apices are seen on 24, with an unbroken lamina dura. The marginal bone level is normal on 22 and 23, not visible on 24 and 25.

Diagnosis

Tooth 23:

Pulpal - Necrosis of pulp, K04.1, previously endodontically treated

Apical - Chronic apical periodontitis, K04.5.

PAI is 4.

Treatment plan

In this case, a choice had to be made between a surgical and a non-surgical treatment recommendation. Because of the radiographic adequacy and presumed good endodontic routines of the referring dentist, it was decided to rank the surgical treatment option above the non-surgical. Another factor in this favour was that 23 was severely weakened and discoloured, with infraction lines after the many restorations in the crown, and a quick healing response was wanted. If a future crown was made, both the effective treatment of the apical infection and the reduced risk of gingival retraction in a future surgical procedure were thought of as a benefit. Secondarily, non-surgical retreatment and reassessment after one year was an option. The patient agrees to the proposed treatment plan.

To reduce the risk of retraction around her other crowned front teeth a submarginal incision was planned. She had a high smile line, and would expose the crown margins should the gingiva retract after surgery.

Treatment

01. March 2012: Apicoectomy

The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A

submarginal incision running from the proximal space of 21 and 22, undulating distally to the proximal space of 24 and 25 was made. Vertical incisions distal and mesial were added.

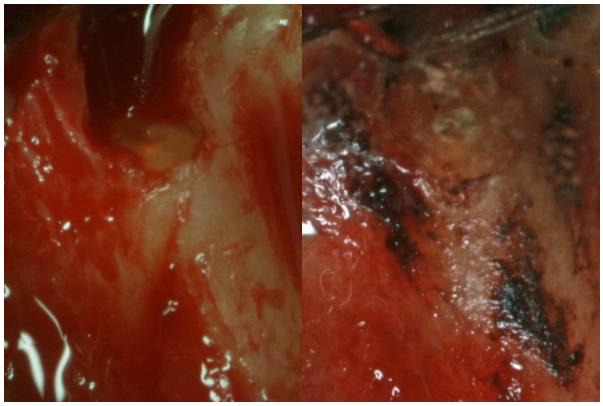

Figure 19-4: Left: Resection; Right: Retrofill

A mucoperiosteal flap was raised, while doing so the lesion was exposed; a small granuloma eroding the buccal cortical bone adhered to the apex of 23. Superimposed on this were some muscle fibres. The granuloma was carefully removed with a curette. The root of 23 was resected 3mm with a fissure bur. Retrograde preparation were done to 3mm depth, removing gutta-percha. An ultrasonic retrograde tip with diamond coating was used on a low power setting, while irrigating with saline. Haemostasis was achieved by blotting the surrounding bone with a cotton pellet drenched in Ferric Sulfate. The retrograde cavity was obturated with mineral trioxide aggregate, White MTA-Angelus® was used. A radiograph verified dense filling, two attempts had to made.

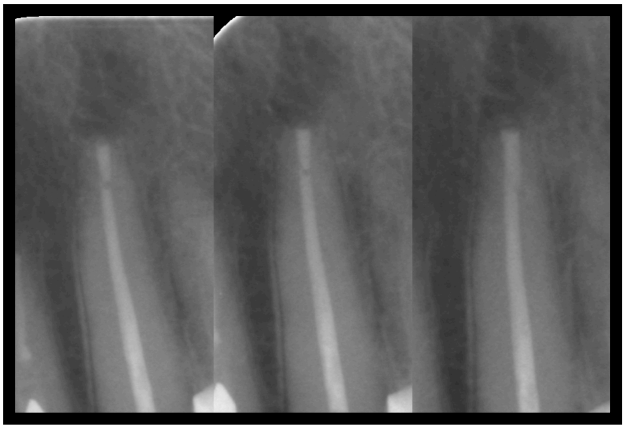

Figure 19-5: Left and centre: Voids in retrofill; Right: Postoperative result, 1. Mar. 2012

The wound was cleansed of black Ferric Sulfate remnants, and the flap sutured in place. Interrupted sutures of Supramid® 5-0 were used. The patient received standard postoperative care.

07. March 2012: Postoperative control

Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed. The distinct tenderness to the left of the nosewing was gone.

Figure 19-6: From top: Day of surgery; 1 w postoperatively; 9 m postoperatively

Prognosis

Endodontic: good
Periodontal: good
Restorative: uncertain, due to large restorations and infractions. A crown would have good prognosis.

Evaluation

The treatment went as planned. No antibiotic use was called for. The follow-up radiograph shows sign of healing.

Discussion

Some gingival retraction may be expected after the reflection of a surgical flap. Early works on periodontal flap surgery indicated that the marginal bone receded 0,6-1,0mm, least if a full-thickness mucoperiosteal flap was reflected. (1) Other early works on the presence or absence of gingival papillae indicated that the distance from the interproximal contact to the marginal bone was important. (2) For distances above 6mm, papilla presence was less found.

Figure 19-7: Follow-up, 6. Des 2012 (9m)

Furthermore, if an apicoectomy were performed, and the result was judged unsuccessful at follow-up, more gingival recession was found. (3) From this work it was clear that pre-existing anatomical factors, our intervention, and infection probably influenced the healing of gingival tissue. Only minor changes could be perceived as a failure by the right patient. Gingival retraction can reveal unsightly crown margins, result in "black triangles" when papillae recede, exposed root dentine is more yellow than enamel. A small added risk of caries might result, but the problem of gingival recession after surgery is mainly aesthetic.

The papilla-base incision was developed as a method to avoid papilla retraction. In brief, it reflects a buccal full-thickness flap without elevating the papillae. Careful tissue approximation and small diameter sutures aid in a seamless wound closure. (4) A review of flap designs by Swiss oral surgeons lists three options for minimal trauma to the marginal gingiva: Papilla-base incision, submarginal incision and the papilla-saving incision. (5) The papilla-saving incision is basically a small flap involving one tooth, not elevating any papillae.

Very little research has been done on gingival recession after endodontic surgery with modern techniques. A study of the papilla-based technique with normal marginal incisions as comparison followed twelve patients for one year. (6) They found that the papilla receded very little with the papilla-based incision. The normal marginal incision with elevation of the buccal papilla gave a mean recession of 1mm. The midpoint of the tooth was not measured, only the papillae.

Another similar study compared four incision types when performing root-end surgery: Normal intrasulcular, papilla-based, submarginal and papilla-saving incision. 70 patients were followed for one year, with another publication reporting on 5-year follow-up. (7, 8) Measurements were taken mesial, distal and midpoint on the teeth involved. Patient- and treatment-related factors were noted. At 1-year follow-up a negative effect could be seen for patients with shallow periodontal probing depth, thin gingival tissues, and all incision types except for the submarginal incision. A systematic visual judgement of the result in each case concluded that apical surgery did not affect gingival tissues very much overall. At 5 years, patient-related factors and healing of apical periodontitis was more important than incision type. Smoking and age was the

more important patient-related factors. The authors conclude that carefully performed apical surgery has little impact on gingival levels. The submarginal incision type may give less gingival recession at 1 year. At 5 year, the natural recession of gingiva that occurs over time become more important then the surgical intervention.

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Case 20: Horizontal root fracture with removal of apical fragment

Introduction

The patient is a Norwegian girl aged 16 at the time of referral. The referring party is the Public Dental Service in Oslo. She is referred for endodontic treatment of her maxillary left central incisor, because of a recent trauma. Patient record number is 1056097.

Chief complaint

The tooth is tender when chewing, she is afraid it will dislodge if biting on hard foods.

Medical history

General

Non-contributory: No medications, no tobacco use, no known allergies or diseases.

Figure 20-1: Dental overview, Oct. 2010

Dental

The patient has been under the observation of the Public Dental Service after a trauma, which induced a horizontal root fracture in 11. The referring dentist can now see a radiolucency along the sides of the fracture, and there is tenderness to palpation and chewing. An attempt at root-canal treatment has been made. The patient, being a teenage girl, is very concerned over the thought of losing her tooth, and is very motivated for treatment. She attends the consultation without accompanying parents.

Examination

Clinical

The patient has a high smile line; short upper lip and spacing between her upper incisors. Tooth 11 has normal position and is only slightly more mobile than its neighbours. 11 has a palatinal temporary restoration, of adequate dimensions. 21 and 12 is sound.

	12	11	21
Cold	+	-	+
Palpation	-	+	-
Percussion	-	-	-

Table 20-1: Dental diagnostic data

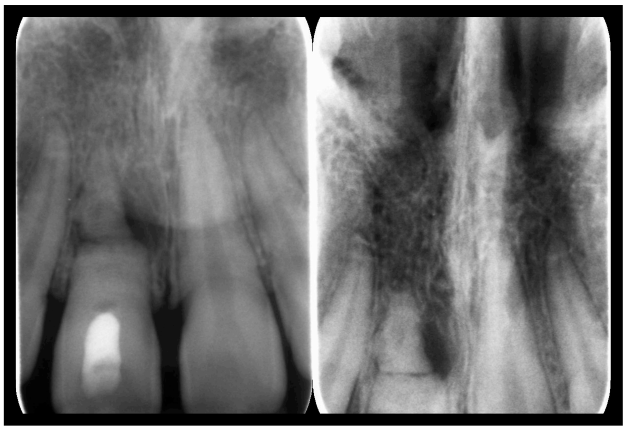

Figure 20-2: Pretreatment radiographs

Radiographic

11 has a radioopaque restoration that obturate the centre of the crown. There is no visible pulp space. At the mid-root level the root has a discontinuity, the apical root fragment is seen lying a little displaced in relation to the coronal fragment. The lamina dura is distended on the sides of the

discontinuity, and on the mesial side there is a radiolucent zone. At the cervical and apical level, the lamina dura is normal.
21 and 12 have normal morphology, continuous lamina dura and no visible pathology.

Figure 20-3: From top: Pretreatment; Post-treatment 2010; Post-treatment occlusal view 2010

Diagnosis

Broken tooth S02.5
Pulpal - Necrosis of pulp K04.1
Apical - Chronic apical periodontitis K04.5, PAI score is not relevant, Andreassen&Hjørting-Hanssens classification of healing in root-fractured teeth would correspond to type 4 - with interpositioned granulation tissue.

Treatment plan

In this case, preventing or postponing the loss of the tooth is a valued outcome for the patient. Thus, endodontic treatment is strongly recommended; Non-surgical treatment of the coronal fragment is the first option, if that do not suffice to control the infection removal of the apical fragment is recommended. Alternative treatments are not considered at this stage unless endodontic treatments fail.

Treatment

26. October 2010: Instrumentation
The area was anesthetized with infiltration of 4% articaine (Septocaine®) with 1:200000 adrenaline. Rubber dam was applied and disinfected. The temporary restoration was removed; old calcium hydroxide paste was irrigated out. The calcified canal was negotiated to the fracture line; working length was confirmed electronically and radiographically. The root canal was cleaned and enlarged while irrigating with sodium hypochlorite and EDTA, with a 30 G Maxiprobe® cannula. Hand use files was used. The final canal dimensions were 13,5mm/ISO80/2%. The canal was dried and calcium hydroxide paste was spun down with a lentulo spiral, the access cavity sealed with Cavit-G® and IRM®.

Figure 20-4: Treatment radiographs, from left: Working length; masterpoint; MTA placement; Posttreatment result, 11. Nov 2010

11. November 2010: Obturation and restoration
The patient had no symptoms. Tooth 11 was anesthetized and affixed rubber dam. The root canal was cleaned, irrigated and dried like last appointment. The canal was obturated with grey MTA-Angelus® and a plug of IRM® at the level of the cementoenamel junction. The access cavity was cleaned with a microbrush and alcohol. A composite restoration was placed and finished; Phosphoric acid etch,

Scotchbond MP® bonding and Tetric EVO Ceram® shade A1 was used.

31. May 2011: Follow-up
The patient had no symptoms from 11; no accentuated mobility, no sinus tract or tenderness to percussion or palpation. Unfortunately, a control radiograph clearly showed an increase in the radiolucent zone. The infection was deemed to have worsened, even in the absence of symptoms. A recommendation to perform an apicoectomy was made. The patient was scared of this, and cancelled a scheduled appointment for surgery. She did not show up before next year. Telephone contact was made during the year.

Figure 20-5: Dental overview, Apr. 2012

26. April 2012: Apicoectomy
Finally, the patient found courage to go through the proposed treatment. She attended alone. The clinical picture was like before, but a now there was a marked swelling buccal to 11. She had pain occasionally. The patient was given a chlorhexidine mouthrinse, Corsodyl®, and was prepared and draped in the routine fashion. Local anaesthesia was injected; it was used lidocaine 2% with adrenaline 1:80000. A marginal incision was made; running from the distal line angle of 12 to the distal line angle of 21. In addition a vertical incision was made from 12 and up to the vestibulum. A mucoperiosteal triangular flap was raised. The apical fragment and associated infection was carefully removed using a Lucas curette and forceps. The residual cavity and coronal fragment fracture surface was cleaned and irrigated with saline. The flap was sutured in place. Interrupted sutures of Supramid® 5-0 were used. The patient received standard postoperative care.

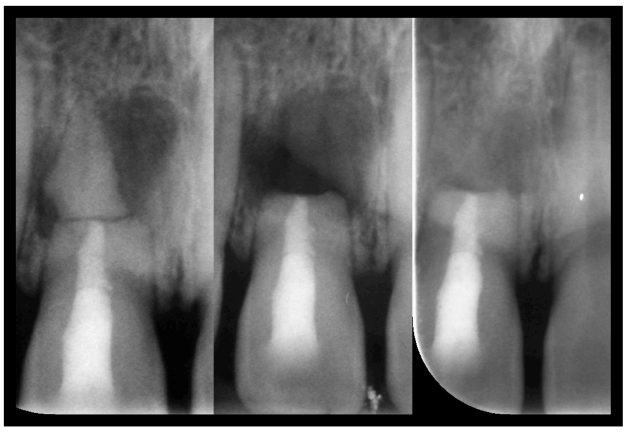

Figure 20-6: From left: Pretreatment; postoperative result 26. Apr. 2012; follow-up 6. Sep. 2012

Figure 20-7: Clockwise from top left: Exposed lesion; apicoectomy; close-up of resection surface; resected apex

03. May 2012: Postoperative control
Little postoperative discomfort were experienced, and for only a short while. The wound healing was good, and the sutures were removed.

06. September 2012: Follow-up
The patient had no symptoms. A radiograph displayed signs of healing.

Figure 20-8: Top: Day of surgery; Bottom: 1 w postoperatively

Prognosis

Endodontic: good.
Periodontal: uncertain
Restorative: good

Figure 20-9: Top: Pre-surgery; Bottom: 6 m postoperatively

Evaluation

The procedures went as planned. In this case, there would be no large benefit of involving the child's parents in the treatment planning, as there were no questions to what treatments to choose. If other options needed consideration, her parents would need to be involved. Their support may have prompted her to not postpone the surgical treatment, but it did not affect the outcome.

Figure 20-9: Follow-up, 17. Apr. 2013 (1y). Uncertain healing.

Discussion

The Danish researchers Andreasen and Hjørting-Hansen classified modes of healing and failure of horizontal root fractures after correlating histology with radiographs. (1) The following classifications are used by most when assessing radiographs of fractured teeth:

Healing by hard tissue union
Healing by interposition of connective tissue
Healing by interposition of bone and connective tissue
Nonunion, interposition of granulation tissue

The International Association of Dental Traumatology (IADT) develops guidelines for treatment of dental injuries. The last guidelines on fractures in the permanent dentition were published last year. (2)

Briefly, the coronal fragment may be displaced, and loose its blood supply. This should be diagnosed with pulp testing. Normal paralleling radiographs and if needed vertically angulated or occlusal projections should be used to diagnose root fracture. Displaced fragments should be repositioned and stabilized with a flexible splint for 4 weeks. For fracture lines located in the cervical part of the root, 4 months fixation is recommended. Monitoring for at least 1 year is necessary to rule out complications. If pulpal necrosis develops, the coronal fragment should be endodontically treated. A negative pulp test may persist for up to 3 months, before regaining sensibility. Clinical signs of infection or a developing radiolucency at the fracture line is symptoms of failure. Furthermore, pulpal obliteration frequently occurs in root-fractured teeth.

In one of the larger observational studies on root-fractured teeth, necrosis and infection of the coronal fragment developed in 20% of the cases. (3) Five-hundred and thirty-four cases of root-fractured teeth were followed up by researchers at the Eastman Institute, Stockholm. The follow-up lasted longer than 5 years. Of the 109 failing teeth, 95 had root-canal therapy in the coronal fragment. Of these, 75 (79%) healed. Of the total material, 425 (80%) survived in the observation period or healed completely. Teeth with a fracture in the cervical part of the root required extraction 70% of the time. The prognosis was compared to earlier studies of prognosis, and was found to be stable since 1975. Conservation of the root-fractured tooth is recommended; alternative treatments should be reserved for the cases that fail.

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