Department of Endodontics

Postgraduate Program in Endodontics

Case Book
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Autumn Semester 2014
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Endodontic Treatment Guidelines

Treatment of Tooth with Apical Periodontitis

Pre-operative radiograph.
Anaesthesia.
Removal of plaque, caries and leaking fillings.
Pre-endodontic tooth build-up if required for isolation.
Access cavity preparation.
Localization of canal orifices.
Application of rubber dam.
Disinfection of the working field with 0.5% chlorhexidine in 70% ethanol.
Measurement of working length, using apex locator and working length radiograph.
Instrumentation to desired apical length and size:
  - Goal: 0.5-1mm short of the anatomic apex
Frequent irrigation with:
  - 0.5% sodium hypochlorite (NaOCl)
  - Alternative: 0.5 % chlorhexidine (from 2013)
  - Final irrigation with 17% ethylenediamine tetraacetic acid (EDTA)
Drying of the canals with paper points.
Mastercone radiograph.
Root filling:
  - Obturation techniques:
    - Lateral compaction, warm vertical compaction, apical plug with MTA
  - Sealers:
    - AH Plus
  - Seal Core materials:
    - Gutta-percha
Temporary IRM top filling with a 2 mm IRM plug in the canal orifice
  - Alternatively a final composite restoration
Removal of rubber dam.
Post-operative radiograph.
Treatment of Tooth with Apical Periodontitis

The same treatment as for teeth without apical periodontitis, but two-appointment treatment is the standard procedure: 2-3 weeks between 1st and 2nd appointment is the standard, mainly due to practical reasons:

- Intra-canal dressing with Ca(OH)$_2$
- Two-layered temporary top filling: Cavit G and IRM

In retreatment cases: Final irrigation with 17% EDTA and 2% chlorhexidine-digluconate.

The periapical index (PAI) (Ørstavik et al. 1986) is used for radiographic evaluation.

Emergency treatment

Acute irreversible pulpitis:

- Pulpotomy
- Eugenol pellet in pulp chamber
- IRM top filling
- NSAIDs when severe pain

Acute apical periodontitis:

- Incision and drainage of abscess/pus if applicable
- Preparation of canals and intracanal dressing (Ca(OH)$_2$) as the optimal treatment
- NSAIDs when indicated
- Systemic antibiotics if systemic complaints and disseminating infection
Endodontic files for instrumentation of canals

Hand files:
- K-files
- Stainless steel files (SS)
- Hedstrøm files
- Nickel-titanium files (NiTi files)

NiTi rotary files:
- Biorace
- Reciproc

Endodontic surgery

All relevant radiographs mounted on viewer or screen.

Anaesthesia.

1 minute mouth rinse with Corsodyl® (Chlorhexidine 2mg/ml).

Incision:
- A horizontal incision extending one to several teeth mesial and distal of the involved tooth and one vertical-releasing incision, usually placed at the mesial end of the prospective flap.

Retraction:
- To hold the flap away from the surgical site, providing maximum access and visibility, without causing harm to the flap or the surrounding tissues.

Osteotomy:
- Involves removal of cortical and cancellous bone to gain direct access to the apical portion. This is achieved routinely by using burs/rotary instruments.

Surgical curettage:
- To remove all pathologic tissue, foreign bodies, and root and bone particles from the periradicular area.

Biopsy:
- Any soft tissue lesion removed during the surgical procedure should be submitted for biopsy.

Microbiological sample:
- With paper point directly in the periapical sample, placed in pre-reduced anaerobic transport medium, or periapical tissue placed in 4% formalin for scanning electron microscopy.
Root end resection:
- By sectioning the apical segment of the root and/or bevelling it to the line of sight/3 mm.

Ultrasonic root end preparation:
- To provide a clean, well-shaped class I cavity.

Haemorrhage control:
- Local anaesthetic solutions possessing vasoconstrictor properties; Stryphnon gauze (Adrenalonchlorid 0.33 mg/cm²); Ferric sulphate (Fe₂[SO₄]₃ with 15.5% astringent and 21% stasis).

Root-end filling:
- Using either IRM or MTA. Use of the MAP system (Micro-Apical Placement) or the MTA pellet-forming block will ease the application of MTA.

Cleaning of surgical site:
- Saline solution to remove debris, and tissue edges are re-approximated in their correct position to promote healing by primary intention.

Compression of the repositioned tissue with a saline-moistened piece of gauze will reduce the coagulum to a thin fibrin layer between the repositioned tissue and cortical bone. Tissue margins should rest passively in the desired place before suturing.

Wound closure:
- Using nonabsorbable suture material in sizes 4-0 and 6-0.

Post-operative radiograph is taken for control of procedures and as reference for follow-up.

Postsurgical care:
- A disposable ice pack is covered with a soft towel, and the patient instructed on where and how to hold the ice pack firmly in position against the facial tissues approximating the surgical site.
- Unless contraindicated for some reason, the patient is instructed to take Ibuprofen 400mg every 4 to 6 hours for the first 48 hours. The patient is advised to rinse with Corsodyl® twice a day until suture removal.

Suture removal:
- The epithelial seal at the wound edges is evident within 2 days - suture removal can take place earliest after 48h but nor later than 6-7 days.
Abbreviations

- Nd: not determined.
- V&h: vertical and horizontal.
Case 1

Endodontic treatment of the mandibular right second molar with irreversible pulpitis and cracked tooth syndrome

![Image](image-url)

**Fig. 1. Frontal view.**

**Patient**
43-year-old Caucasian female.

**Chief complaint**
The patient complained about pain in the posterior region in the lower right jaw. She felt sudden pain and tenderness when chewing and biting. She also complained about increased sensitivity to thermal changes (both cold and warm stimuli) and discomfort during tooth brushing. The pain started after placement of a filling in the molar tooth in this jaw.

**Medical record**
The patient had recurrent headaches and was medicated with Sarotex.

**Dental history**
The patient was referred to the postgraduate clinic from the student clinic for evaluation and treatment of the mandibular right second molar. The tooth had previously been treated with an occlusal composite restoration due to occlusal caries three years earlier (2007), followed by a temporary restoration (IRM) in 2010 due to post-restoration pain. Since the pain persisted, another temporary IRM filling, with concomitant reduction of cusp heights but without cuspal coverage was placed.

![Image](image-url)

**Fig. 2. Craze lines are visible at the buccal and distal aspect of the tooth.**

**Clinical findings September 15th, 2010**

**Soft tissue:** Normal findings.

**Dental:**
Tooth 45: Sound.
Tooth 46: Missing.
Tooth 47: Occlusal temporary filling; several craze lines/fracture lines can be seen in the enamel (Fig 2.) When using a FracFinder on the different cusps of tooth 47, the patient felt sharp pain when the distal cusps were tested.

**Clinical tests September 15th, 2010**

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</tr>
<tr>
<td>Biting</td>
<td>-</td>
<td>-</td>
<td>+</td>
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*v, vertical
Radiographic findings September 15th 2010
Dental: Tooth 47 has a radiopaque occlusal filling. Periodontal: Marginal bone loss. Periapical: Teeth 45 and 46 have a continuous PDL space.

Fig. 3. Periapical radiograph 15.09.2010.

Diagnosis September 15th 2010

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<thead>
<tr>
<th>Diagnosis</th>
<th>Code</th>
<th>Description</th>
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<td>Pulpal</td>
<td>K04.01</td>
<td>acute irreversible pulpitis</td>
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<tr>
<td>Periodontal</td>
<td>K05.03</td>
<td>chronic marginal periodontitis</td>
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<tr>
<td>Periapical</td>
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<td>Within normal limits</td>
</tr>
<tr>
<td>Dental</td>
<td>S02.50A</td>
<td>cracked tooth</td>
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Treatment plan
Treatment of the inflamed pulp tooth 47.

Problem list
Cracked tooth.

Treatment September 15th 2010
2 carpules of Xylocaine/adrenaline was applied to establish anaesthesia. Access opening and localisation of three canal orifices. Bleeding from all canals. The distal fracture line extended through the distal marginal ridge.

Mechanical: Bur, NiTi hand instrumentation #20, Biorace: MB: #40/0.04 (BR5) /16 mm ML: #40/0.04 (BR5) /16 mm D: #60/0.02 (BR7) /15 mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Fig. 4. Working length radiograph.

Intra-pulpal injection of anaesthetic was applied during the session due to pain when negotiating the canals. The patient was told that the tooth would have a less favourable prognosis unless a dental crown was made.

Treatment September 29th 2010
The patient experiences fewer symptoms. The tooth is slightly tender to percussion, and the last two days she felt some tenderness when biting and tooth brushing. Several other teeth are also tender to percussion. Anaesthesia: 2 carpules of Xylocaine/adrenaline.
The canals were obturated using gutta-percha (0.04 and 0.02 taper) and AH Plus and the tooth was sealed with IRM.
Discussion

The term “cracked tooth syndrome” (CTS), was first introduced by Cameron in 1964 (1). He defined a cracked tooth as an “incomplete fracture in a vital posterior tooth that involves the dentine and occasionally extends into the pulp.” Diagnosis of incompletely fractured teeth with symptoms is time consuming and may represent a diagnostic problem. The discomfort or pain can mimic that arising from other pathologies, such as sinusitis, temporomandibular joint disorders, headaches, ear pain, or atypical orofacial pain (2). There may be a history of a course of extensive dental treatment involving repeated occlusal adjustments or replacement of restorations, which fail to eliminate symptoms. The American Association of Endodontists (AAE) categorized longitudinal tooth fractures into 5 major classes: craze line, fractured cusp, cracked tooth, split tooth, and vertical root fracture (VRF) (3).

The diagnosis of CTS has been based in the past exclusively on tooth symptomatology. Common patient subjective findings with incompletely fractured teeth include:
1. Sustained pain during biting pressures, 2. Pain only upon release of biting pressure, 3. Occasional, momentary, sharp pain during mastication, 4. Sensitivity to thermal changes, 5. Sensitivity to mild stimuli, such as sweet or acidic foods, and 6. Persistent dull pain.

Common clinical objective findings with incompletely fractured teeth:
1. Pain to selective percussion on specific tooth margins or cusps. The percussion may be in the long axis of the tooth or angled against a labial or cuspal slope, 2. Generalized discomfort to percussion, 3. Presence of craze or fracture lines on the facial or lingual surfaces or marginal ridges, 4.
Significant gaps between old restorations and tooth structure, 5. Cracked restorations, and 6. Evidence of the initial vertical loss of alveolar bone adjacent to the proximal root surface (4).

A variety of protocols have been described in the contemporary literature for the definitive management of incomplete posterior tooth fractures, ranging from the application of directly bonded intra-coronal restorations and directly bonded extra-coronal restorations (5) and indirect extra-coronal restorations with varying amounts of tooth coverage (6). Seo et al. (7) analysed the characteristics, distribution, and associated factors of longitudinal fractures in 107 teeth from 103 patients. Eighty-seven teeth were diagnosed with a cracked tooth (81.3%), 14 were diagnosed with vertical root fracture (VRF, 13.1%), 4 had a split tooth (3.7%), and 2 had a fractured cusp (1.9%). In 82.2% teeth showed a sensitive reaction on the bite test. The upper first molar (28.0%) was most frequently cracked, followed by the lower first molar (25.2%), the lower second molar (20.6%), and the upper second molar (16.8%). Longitudinal tooth fractures occurred mainly in restored teeth and in patients in their 40 years of age. Out of 107 of longitudinal fractured teeth, 33 (30.8%) were treated endodontically and 74 (69.2%) were not. VRF was associated with endodontic treatment. Roh et al. (8) reported on 154 cases of teeth with cracks. In their study cracked teeth were observed most frequently in the teeth with no restorations (60.4%) and with class I restorations (29.2%).

The most prevalent age was in those over 40 years of age (31.2% in their 40s, 26.6% in their 50s) and the prevalence was similar in men (53.9%) and women (46.1%). Cracked teeth were found most frequently in the maxillary molars (33.8% in first molar, 23.4% in second molar), followed by mandibular molars (20.1% in first molar, 16.2% in second molar). 96.1% of the cracked teeth responded to the bite test, and 81.1% of the cracked teeth were observed in the mesiodistal direction.

In a material from Krell & Rivera (9) 796 out of 8175 cases seen in an endodontic practice during a six-year period were diagnosed as cracked teeth (9.7%). Mandibular second molars (243/796, 30%) had the largest incidence followed by mandibular first molars (231/796, 29%) and maxillary first molars (167/796, 21%). Of 127 patients specifically diagnosed with reversible pulpitis (RP), 27 converted to irreversible pulpitis (N=21) in 58 days or to necrotic pulp (N=6) in 149 days. The outcomes of this study suggested that if a crack is identified early enough in cases with a diagnosis of RP and a crown is placed, root canal treatment will be necessary in about 20% of these cases within a 6-month period.

Tan el al. (10) assessed the survival rate of root filled cracked teeth over a 2-year period in a tertiary institute. Forty-nine patients who had root canal treatment completed on their cracked teeth at the National Dental Centre (Singapore) were recalled for a 2-year review. The survival rate of the root-filled cracked teeth was 85.5%. Cracked teeth that were the terminal teeth in the dental arch, teeth with pre-root filling periodontal pocketing and teeth with multiple cracks were more likely to be extracted.

Opdam et al. (5) performed a seven-year clinical evaluation of painful cracked teeth restored with a direct composite restoration. Twenty teeth were restored without and 21 with cuspal coverage. After 7 years, 40 teeth could be evaluated. Three teeth without cuspal coverage needed an endodontic treatment, of which 2 failed as a result of
fracture. No failures in restorations with cuspal coverage occurred. They suggested that a direct bonded composite resin restoration could be a successful treatment for a cracked tooth. In a study by Brynjulfsen et al. (11), 32 patients with poorly localised orofacial pain were finally diagnosed with 46 incompletely fractured teeth. In cases with incompletely fractured mandibular teeth, the pain was felt throughout the arch and in tissues including neck, ear, chewing muscles and TMJ on the same side. The longer the duration of pain before the diagnosis of an incompletely fractured tooth was established, the more diffuse was the distribution of pain. Often symptoms projected to both jaws. Headaches occurred in the group of patients with symptoms for more than 5 years prior to treatment. Endodontic or restorative treatment relieved the symptoms in 90% of the patients during a two-year follow-up, whilst persisting symptoms in 10% were considered as part of an orofacial pain complex of unknown aetiology.

The patient in the present case had an incomplete fractured tooth. Although treatment will succeed in many cases, some cracked teeth may eventually evolve into split teeth and require extraction. Placement of a cuspal-reinforced restoration, in this case a crown, providing optimum protection for the tooth, does not guarantee success, but is thought to be beneficial in most cases.

References
Endodontic treatment of the mandibular right second molar with irreversible pulpitis and iatrogenic furcal perforation

Patient
59-year-old Caucasian male.

Chief complaint
The patient complained of severe permanently pain which got worse in the evening/at night. He was suppressing the pain with analgesics (NSAIDs).

Medical record
Non-contributory.

Dental history
The patient was referred to the postgraduate clinic from a general dental practitioner for endodontic treatment of the mandibular right second molar. The tooth had previously, and recently, been accessed by the referring dentist with the result of an iatrogenic furcal perforation.

Clinical findings January 28th 2014
Soft tissue: Normal findings.
Dental: Tooth 45: Dental crown.

46: Composite restoration ODB, occlusal temporary filling.
47: Dental crown, occlusal temporary filling (Fig. 2).

Radiographic findings January 28th 2014
Dental: Tooth 45: Radiopaque coronal restoration, poorly fitted crown with possible caries at the distal aspect, a post in the canal and a radiopaque root filling material. A radiolucency is seen between the post and the root filling.
Tooth 46: Radiopaque coronal restoration and a radiopaque root filling material.
Tooth 47: Radiopaque coronal restoration, a radiolucency can be seen in the floor of the pulp chamber in the furcation area.

Periodontal: Marginal bone loss.
Periapical: Tooth 47 has a continuous PDL space (PAI I). Tooth 46 has a widened PDL space and an apical radiolucency mesial root (PAI 3). Tooth 45 has an apical radiolucency (PAI 4).

**Diagnosis January 1st 2014**

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<td></td>
<td>Within normal limits</td>
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**Treatment plan**
Treatment of the inflamed pulp.
Reparation of furcation perforation.

**Problem list**
Communication of perforation to oral cavity. Weakened tooth.

**Treatment January 28th 2014**
Two carpules of Xylocaine/adrenaline was applied to establish anaesthesia.
Intrapulpal injection was necessary.
Access opening and localisation of perforation and undiscovered MB canal orifice (Fig. 5).

**Mechanical:** Bur, NiTi hand files #20, RECIPROC® one file endo:
MB: #40/18mm
ML: #40/18mm
D: #50/18mm

**Chemical:** 0.5% chlorhexidine, 17% EDTA.
Reparation of furcal perforation with MTA seal.

**Intracanal medicament:** Ca(OH)₂.
**Temporary filling:** Moistened cotton pellet, cavit, IRM.

**Fig. 3 Periapical radiograph 28.01.2014.**

**Fig. 4 Working length radiograph.**

**Fig. 5. Furcal perforation.**
Discussion
Perforations from the pulp to the surrounding periodontium may occur from resorptive defects, caries or iatrogenic events during endodontic treatment. Perforations create an artificial communication between the root canal system and the supporting tissues of the teeth (1). Ingle (2) reported that perforations were the second greatest cause of endodontic failure and account for 9.6% of all unsuccessful cases. Factors that affect treatment prognosis of perforation repair include the level, location and size of the perforation, the time delay before perforation repair and the material used to seal the perforation (3). The location of the perforation is of crucial importance. Close proximity to the gingival sulcus may lead to endodontic-periodontal problems through contamination of the perforation with bacteria from the oral cavity through the sulcus (4). Perforations near the crestal bone are susceptible to epithelial migration and rapid pocket formation and treatment of these has a low success rate (5). The purpose of treating furcal perforation is to seal the artificial communication between the endodontic space and the periradicular tissue to prevent alveolar bone resorption and damage to the periodontal ligament. These complications are not infrequent in cases of furcal and/or old perforations, which show a worse prognosis than fresh, small, coronal, and apical perforations. Mineral trioxide aggregate (MTA) is widely used to seal perforations because of its biocompatibility and sealability. Lodiene et al. (6) created furcation perforations in 82 extracted human maxillary and mandibular molars, and sealed them with either mineral trioxide aggregate (MTA), glass ionomer cement or resin composite. The bacterial
leakage method was used with *Enterococcus faecalis* as microbial tracer. They found that the percentage of leaking samples was significantly higher in the resin composite group. Scanning electron microscopy (SEM) inspection revealed the presence of bacteria in all leaking specimens. Bacteria were observed along the filling-dentine interface as well as in dentinal tubules at some distance from the filling. The authors concluded that teeth repaired with MTA were more resistant to bacterial leakage.

Ford et al. (7) investigated the histologic response to intentional perforation in the furcations of 28 mandibular premolars in seven dogs. In half the teeth, the perforations were repaired immediately with either amalgam or MTA; in the rest the perforations were left open to salivary contamination before repair. All repaired perforations were left for 4 months before histologic examination of vertical sections through the site. In the immediately repaired group, all the amalgam specimens were associated with inflammation, whereas only one of six with MTA was; further, the five non-inflamed MTA specimens had some cementum over the repair material. After 4 months, all the amalgam specimens were associated with inflammation; in contrast only four of seven filled with MTA were inflamed. The authors suggest that MTA is a far more suitable material than amalgam for perforation repair, particularly when used immediately after perforation.

Another study (8) assessed the ability of Portland cement, white Angelus-mineral trioxide aggregate (MTA), and MTA Bio to seal furcal perforations in extracted human molar teeth. Leakage existed in every sample and was very variable in all the experimental groups. The sealing ability promoted by the 3 cements was similar; no cement was able to produce a fluid-tight seal.

In a case series (9) MTA was used as repair material for furcal perforation. Ten cases of furcal perforation were selected at the department of Endodontics, University of Florence. All the perforations were cleaned with NaOCl, EDTA, and ultrasonic tips and sealed with MTA without internal matrix. Finally, the teeth were endodontically treated and coronally restored. Clinical and radiographic follow-ups were done at 6 months, 1 year, 2 years, and 5 years. After 5 years, the absence of periradicular radiolucent lesions, pain and swelling along with functional tooth stability indicated a successful outcome of sealing perforations in 9 out of 10 teeth. One patient dropped out of the study after the 1-year follow-up and could not be contacted for further recalls. The results confirmed that MTA provides an effective seal of root perforations and clinical healing of the surrounding periodontal tissue.

**References**


Case 3

Endodontic treatment of a mandibular right first incisor in a patient with DiGeorge Syndrome (velo-cardio-facial syndrome)

Patient
21-year-old Caucasian male.

Chief complaint
Non-contributory.

Medical record
The patient was diagnosed with DiGeorge Syndrome. He was quite anxious in new situations. Due to asthma he was medicated with Symbicort, Ventoline and Serevent. Because of congenital heart disease he was in need of prophylactic antibiotics before dental treatment.

Dental history
The patient was referred to the post-graduate clinic from the public dentistry for endodontic treatment of the mandibular right lateral incisor. The mandibular right lateral incisor presented with a history of persistent fistula; tooth 42 had previously been treated endodontically, including cleaning/shaping to size #50 with rotary instruments (Biorace) and treatment with intracanal dressing of Ca(OH)₂.

Clinical findings September 20¹⁰¹¹
Soft tissue: Gingivitis.
Dental:
Tooth 41: Composite build-up IP.
Tooth 42: Fractured crown, occlusal temporary filling (Fig. 2).
Tooth 43: Buccal enamel caries.

Clinical tests September 20¹⁰¹¹

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Radiographic findings September 20¹⁰¹¹
Dental: Tooth 31 has a radiopaque root filling material. Teeth 41, 42 and 43 have radiopaque restorations related to the crowns.
**Periodontal:** Within normal limits.

**Periapical:** A lateral radiolucency is seen between the roots of teeth 42 and 43 (PAI 4).

![Fig. 3. Periapical radiograph 20.09.2011.](image)

**Diagnosis September 20th 2011**

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<td><strong>Periapical</strong></td>
<td>K04.51 chronic lateral periodontitis</td>
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**Treatment plan**


**Problem list**

Cooperation /anxiety.

**Treatment September 20th 2011**

Two carpules Xylocaine/adrenaline was applied to establish anaesthesia (infiltration). Access opening and localisation of untreated lingual canal orifice (bleeding from canal). Due to challenges with poor anaesthesia and patient hyperventilation (due to anxiety) treatment had to be ended.

**Chemical:** 1% NaOCl, 17% EDTA.

**Intracanal medicament:** Ca(OH)₂.

**Temporary filling:** IRM.

**Treatment October 18th 2011**

Two carpules Xylocaine/adrenaline was applied to establish anaesthesia (mandibular block and infiltration).

**Mechanical:** Bur, NiTi hand files:

- B: #50/0.02/16mm
- L: #40/0.02/16.5mm

**Chemical:** 1% NaOCl, 17% EDTA, 2% chlorhexidine-di-gluconate.

**Intracanal medicament:** Ca(OH)₂.

**Temporary filling:** IRM.

**Treatment November 8th 2011**

No symptoms.

Filled with gutta-percha (0.02 taper) and AH Plus, sealed with IRM.

**Fig. 4. Working-length radiograph.**

**Fig. 5. Master cone radiograph.**
Prognosis

Endodontic: Good.
Tooth: Uncertain due to loss of tooth substance.

Follow-up examination October 15th 2013 (2 years)
No symptoms. A crown has been made.
Lateral radiolucency has healed.

Discussion

One of the most important factors in endodontic therapy is the mechanical preparation of the root canal. Despite the high success rates seen for appropriate endodontic procedures (1, 2), cleaning of complex root canals such as to those with lateral branches or apical ramifications is difficult.

Furthermore, cleaning narrow flattened canals or roots with a high degree of curvature is extremely ineffective (3). If accurate data on the size of the apex of root canals could be obtained, it might provide reliable standards for the amount of instrumentation normally required in this region. In an attempt to provide such data, Kerekes and Tronstad (4, 5, 6) measured the diameter of root canals by taking sections of anterior, premolar, and molar teeth at 1, 2, 3, 4, and 5 mm from the apex. Based on these data, they then estimated the smallest size of instruments that would ensure, with 90% probability for each tooth type, adequate preparation of the circular-shaped canals at the various distances from the apex.

The internal anatomy of the mandibular incisors has been described in several studies that used clearing or cross-sectional methods (7-14). The results of these studies show that mandibular incisors with single canals are the most common reported anatomy. The second most prevalent anatomic variation includes the presence of 2 canals that ends in a single foramen (Vertucci type III) (7, 11, 15).

In their study of one hundred freshly extracted central and lateral incisors, Kartal and Yanikoglo (15) concluded that the chance of a second canal in mandibular incisors is 50%. They also described two additional root canal types that are not defined in Vertucci’s classification (7).

Despite the presence of single canals at the apical third of the mandibular incisors, the prevalence of oval canals is not uncommon (9). Several studies have shown the difficulty to achieve efficient cleaning of the mandibular incisors with oval root canal anatomy by using hand or rotary instruments (16-19).
Miyashita et al. (13) investigated canal configuration, thickness and curvature of the root canals, condition of any accessory canals, and location of the apical foramina in 1085 extracted mandibular incisors with no visual abnormalities. They found that more than 85% of the root canals possessed a single canal (Type I). The majority of the lateral branches were small (>80% <#15 reamer, none >#30 reamer and 50% of apical foramina were located distal to the apex. Based on data on the thickness of the root and main canal in the apical portion and curvature of the root canal the authors suggested that for adequate apical preparation, a #40 reamer must be able to reach the apical constriction.

Milanezi de Almeida et al. (20) analysed root canal anatomy and prevalence of oval canals in 340 mandibular incisors by micro CT scanning. The occurrence of a single canal and Vertucci type III configuration represented 92% of the mandibular incisors studied. Within these anatomic configurations, oval-shaped canals in the apical third were not uncommon and were more prevalent in the type III anatomy.

References
Case 4

Endodontic retreatment of the maxillary right second molar

Patient
56-year-old Caucasian male.

Chief complaint
Non-contributory.

Medical record
Ritalin, Paracetamol/codein due to back pain. Heavy smoker.

Dental history
The patient was referred to the postgraduate clinic from the student clinic for endodontic retreatment of the maxillary right second molar. A post and crown was planned as restoration. The tooth had been treated endodontically for more than 10 years ago.

Clinical tests September 8th, 2010

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Radiographic findings September 8th, 2010

Dental:

Soft tissue: Gingivitis in the region 15 to 17. An aphthous lesion is seen at the buccal aspect between tooth 17 and 15.

Dental:
Tooth 15: MOD amalgam filling. Tooth 16: Missing. Tooth 17: MOD amalgam filling, buccal cuspal fracture (Fig. 2).
**Diagnosis September 8\textsuperscript{th} 2010**

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<tr>
<td>Periapical</td>
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**Treatment plan**
Non-surgical endodontic retreatment. The patient is told that the prognosis for the tooth is uncertain due to considerably loss of tooth substance.

**Problem list**
Proper tooth isolation and aseptic due to severely damaged tooth (Fig. 2).

**Treatment September 8\textsuperscript{th} 2010**
1 carpule of Xylocaine/adrenaline was applied. The access cavity was refined with burs and all the caries and the former amalgam coronal restoration material was removed. Three orifices with gutta-percha were localised (Fig. 4). A pre-endodontic copper ring was adjusted and semented using IRM (Fig. 5).

**Treatment September 15\textsuperscript{th} 2010**
1 carpule of Septocaine was applied. 

*Mechanical*: Burs, prerace and biorace rotary files:
- MB: #50/0.04 (BR6)/18mm
- DB: #50/0.04 (BR6)/18mm
- P: #60/0.02 (BR7)/17mm

*Chemical*: Chloroform, 1% NaOCl, 17% EDTA.

*Intracanal medicament*: Ca(OH)$_2$.  

*Temporary filling*: Cavit, IRM.
Treatment November 17\textsuperscript{th} 2010
No symptoms, filled with gutta-percha and AH Plus, sealed with IRM.

Prognosis
Endodontic: Good.
Tooth: Uncertain.

Follow-up examination November 29\textsuperscript{th} 2011
No symptoms. Radiograph shows evidence of healing of the periapical radiolucency.

Discussion
Endodontic therapy is a predictable treatment, resulting in up to 97% retention rate for the treated teeth (1, 2, 3). However, about 3% of endodontically treated teeth require further treatment, including extraction of the tooth. Long-term predictability of restored endodontically treated teeth is important for the decision of tooth retention versus extraction and implant placement. A distinction has to be made between a general treatment outcome and endodontic treatment outcome. Depending on the evaluation criteria used, a general treatment outcome of either natural tooth or dental implant may address retention, functionality, restorative, and, if applicable, periodontal and endodontic success (4).

Endodontic treatment success is considered to be achieved by its objective of preventing or eliminating apical periodontitis (5, 6). Healing or continuation of periapical disease is widely regarded to be dependent on the absence or presence of microorganisms and thus on the antimicrobial debridement of the root canal system by cleaning, shaping, and subsequent root filling (7, 8). Nevertheless, additional factors have been found to influence the long-term endodontic outcome of a tooth. Sjögren et al. (9) suggested various factors, such
as pre-existing apical periodontitis or adequate length and level of the root canal filling. A variety of other endodontic treatment parameters, restorative factors, and biological variables are considered to influence the endodontic outcome (10).

In a patient cohort with 200 teeth investigated by Chugal et al. (11), preoperative pulp and periapical diagnosis, periapical radiolucency size, and the patient's sex were significantly correlated to the outcome of the endodontic treatment. The strongest influence on postoperative healing was found to be by the presence and magnitude of preoperative apical periodontitis.

The apical limit of the obturation has also been identified as a parameter significantly influencing the true endodontic outcome by Bergenholtz et al. (12).

In terms of the general treatment outcome, according to Ng et al. (10), four variables could improve the survival of endodontically treated teeth: a crown restoration after endodontic therapy, the presence of mesial and distal approximal contacts, that the tooth will not be used as an abutment for removable or fixed partial dentures, and if the tooth itself was not a molar. A definitive restoration is necessary because the root canal filling itself may not provide the necessary coronal seal that can prevent bacterial penetration and the invasion of oral microorganisms into the root canal system (13).

A retrospective investigation of complete-mouth radiographs of patients seen in a university setting found the definitive coronal restoration to be more important for a successful endodontic outcome than the quality of the endodontic filling (14). Nevertheless, different studies showed that both a good coronal restoration and a good endodontic treatment provided the highest endodontic success (15). Hence, an intact coronal restoration has been found indispensable for the long-term general treatment outcome of the endodontically treated tooth (16).

Fuss et al. (17) studied 147 extracted teeth. The most common reason for extraction (44%) was a restorative consideration, with endodontic, endoesthetic, and vertical root fracture (VRF) the next most frequent reasons (21%, 19%, and 11%, respectively).

Vire (18) found that 59% of 116 extractions of endodontically treated teeth were due to prosthetic reasons, 32% to periodontal reasons, and 9% to endodontic failures.

Zadik et al. (19) also analysed factors related to extraction of endodontically treated teeth. In this retrospective study 547 endodontically treated permanent teeth that were extracted in a multidisciplinary clinic in a 2-year period were analyzed. The most common reason for extraction was nonrestorable caries (61.4%). Other reasons were: endodontic failure (12.1%), VRF and iatrogenic perforation or stripping (8.8% each), periodontal disease (4.6%), unrestorable cusp fracture (2.4%), orthodontic (1.3%) and prosthetic (0.2%) reasons, and trauma (0.5%).

Setzer et al. (4) investigated preoperative factors that potentially can provide more information about the long-term survival and predictability of endodontically treated teeth, including age, sex, and restorative, periodontal, and endodontic factors. The authors found that significant positive correlations existed between “untoward events” (any form of retreatment or extraction) and “prognostic value according to periodontal status”. They concluded that the only preoperative factors significant for the prognosis of restored endodontically treated molars.
were related to periodontal prognostic value and attachment loss.

References


16. Iqbal MK, Johansson AA, Akeel RF, et al. A retrospective analysis of factors associated with the periapical status of restored,


Case 5

Endodontic treatment of the maxillary left first molar

Fig. 1. Frontal view.

Patient
57-year-old Caucasian male.

Chief complaint
Non-contributory.

Medical record
Non-contributory.

Dental history
The patient was referred to the post-graduate clinic from the student clinic for endodontic treatment of the maxillary left first molar.

Clinical findings January 19th 2011
Soft tissue: Sinus tract at the buccal aspect of tooth 27, normal findings around tooth 26.
Dental:
Tooth 25: MOD amalgam restoration.
Tooth 26: Fractured composite restoration, caries.
Tooth 27: A mixture of amalgam, composite, and temporary filling material is seen.

Clinical tests January 19th 2011

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Radiographic findings January 19th 2011
Dental: Tooth 27 has a radiopaque MOD restoration, the root canal is filled with a weakly radiopaque filling material. Teeth 25 and 26 have MOD radiopaque filling materials.
Periodontal: Moderate attachment loss.
Periapical: Apical radiolucencies teeth 26 (PAI 3) and 27 (PAI 4). A normal PDL space is seen around the root of tooth 25.

Fig. 2. Buccal view. A sinus tract is seen at the distal aspect of tooth 27.
**Diagnosis January 19th 2011**

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**Problem list**
Obliteration, loss of tooth substance due to caries.

**Treatment plan**
Pre-endodontic treatment restoration and endodontic treatment tooth 26, extraction of tooth 27.

**Treatment January 19th 2011**
1 carpule of Xylocaine/adrenaline was injected. Access opening and removal of caries and former restoration materials. Pre-endodontic composite restoration. Mechanical: Burs, Gates glidden, NiTi handfiles #20, Biorace rotary files: MB: #40/0.04 (Br5) /18mm, MB2: #40/0.04(Br5)/20mm, DB: #40/0.04 (Br5)/19mm, P: #50/0.04 (BR6) /18mm. Chemical: 1% NaOCl, 17% EDTA. Intracanal medicament: Ca(OH)₂. Temporary filling: Cavit, IRM.

**Treatment February 9th 2011**
No symptoms. Obturation tooth 26: Buccal roots filled with gutta-percha and AH Plus; Palatal root filled with MTA plug and thermoplastised gutta-percha and AH Plus. Sealed with IRM.

**Prognosis**
Endodontic: Good.
Tooth: Good.
Follow-up examination January 27th 2012 (1 year)
No symptoms. Tooth 26 has been restored with a post and a dental crown. The patient has postponed the extraction of tooth 27 since he had no subjective complaints. Re-informed about the infection related to tooth 27 and recommended to have it extracted as soon as possible. Periapical radiograph shows no sign of regression of apical radiolucency related to tooth 26.

Fig. 7. Follow-up radiograph 1 year.

Follow-up examination June 24th 2014 (3.5 years)
No symptoms. Tooth 27 was extracted after the last follow-up examination. The apical periodontitis lesion on tooth 26 seems to have healed well.

Fig. 8. Follow-up radiograph 3.5 years.

Discussion
The presence of microorganisms in a root canal is the main etiologic factor in the development and continuation of periapical lesions (1, 2, 3). Immunological reactions, in this case periapical lesions, are established in the periapex to combat the infectious agent and promote the repair of the affected region (4). These pathologies cause bone lysis to make room for their organisation and growth. The differential diagnosis of periapical pathologies is confirmed only by means of histological processing (5). Several authors disagree about the prevalence of these pathologies: the prevalence of cystic lesions ranges from 6% (6) to 54% (7), and that of granuloma, from 45% (8) to 97.0% (6, 9).

A number of chemical mediators of inflammation, including the cytokines IL-1α, IL-1β, TNFα, prostaglandins and LPS, seem to be related to the pathogenesis of periapical lesions (10, 11, 12, 13). These substances may stimulate root resorption in the same way that they stimulate bone resorption (14). Irregular resorbed areas are frequently situated in sites that are not within the reach of root-canal instruments or medication and may act as niches for extraradicular bacterial colonization (15, 16), besides causing technical problems for root canal treatment (17, 18). Radiographic examination is not always helpful in the diagnosis of small areas of external root resorption associated with teeth having apical periodontitis. Vier and Figuereido (19) examined 104 root apices from extracted teeth with periapical lesions by means of hematoxylin-eosin (HE) staining and scanning electron microscopy (SEM). Cysts accounted for 24.5% of the samples, 84% of which were associated with marked inflammation. The most prevalent
Diagnosis was noncystic periapical abscess with varying degrees of severity (63.7%). Periapical granuloma was not a frequent finding. SEM analysis showed that 42.2% of the root apices had periforaminal resorption extending over 50% of their circumference. When the foraminal resorption was evaluated, 28.7% had resorption affecting >50% of the periphery. Only 8.9% of the samples showed no periforaminal or foraminal resorption. In a similar study examining internal apical resorption the authors found that apical internal resorption was present in 74.7% of 75 examined roots associated with periapical lesions (20).

Normally, the failure of root-canal treatment is related to the persistence of infection in the root-canal system (21, 22). The presence of root resorption in teeth with periapical lesions is important for infection control since these areas are niches for bacteria. Moreover, the apical limit of instrumentation may be altered in teeth with widely resorbed apices, since the cementum-dentine junction at the constriction can be missing (17, 18). In such circumstances, sealing the canal may be difficult and overfilling is likely. Bacteria may also be found in the external surface of the root, forming a periapical biofilm (23, 24), thus confirming the importance of appreciating the existence of periforaminal root resorption.

References


Case 6

Endodontic treatment of the maxillary right first incisor

Fig. 1. Frontal view.

Patient
34-year-old Caucasian male.

Chief complaint
He complained about tenderness when chewing and biting on his upper right front tooth. He also had a sensation of slight mobility of this particular tooth. He could not remember any specific trauma to his front teeth.

Fig. 2. Buccal view. Discoloured tooth 11. PPD 6mm.

Medical record
The patient had a pronounced dental anxiety. He was not using any medicaments.

Dental history
The patient was referred to the post-graduate clinic from private practice for evaluation and treatment of the maxillary right first incisor.

Clinical findings November 3rd 2010
Soft tissue: Normal findings
Dental:
Tooth 12: Sound
Tooth 11: Discoloration, incisal composite filling.
Tooth 21: Composite filling ID.
Periodontal: A periodontal pocket of 6mm was probed at the buccal aspect of tooth 11 (Fig. 5).

Clinical tests November 3rd 2010

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Radiographic findings November 3rd 2010
Dental: Tooth 11 has an incisal radiopaque restoration.
Periodontal: Marginal periodontitis.
Periapical: Tooth 11 has a periradicular radiolucency at the midroot to cervical level. Apically there is a continuous PDL space.

Fig. 3. Palatal view.
Diagnosis November 3\textsuperscript{rd} 2010

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Treatment plan

Tooth 11: Endodontic treatment of infected pulp.

Problem list

Calcification.
Root fracture?

Treatment November 3\textsuperscript{rd} 2010

2 carpules of Xylocaine/adrenaline was applied, intrapulpal injection was necessary during the treatment session. Access preparation and localisation of canal orifice, pulp chamber obliteration. Bleeding from canal below the fracture line.

Mechanical: Burs, Gates glidden, NiTi handfiles:

#45/19mm

Chemical: 1\% NaOCl, 17\% EDTA

Intracanal medicament: Ca(OH)$_2$.

Temporary filling: IRM.

Treatment November 24\textsuperscript{th} 2010

No symptoms. Tooth feels different, but is not tender on percussion compared to neighbouring teeth.

Filled with gutta-percha and AH Plus, sealed with composite.
Prognosis

*Endodontic:* Uncertain.
*Tooth:* Uncertain.

**Follow-up examination July 4th 2011 (7 months)**
Asymptomatic. Reduction of periodontal pocket (4mm). Less mobility.

**Follow-up examination March 18th 2013 (2.5 years)**
Asymptomatic. Periodontal pocket unchanged (4mm). Lateral radiolucency is seen in relation to fracture line. Observation.

**Discussion**

An intra-alveolar fracture in the cervical part of the root is a rare injury; reported frequencies vary between 6% and 19% of intra-alveolar root fractures (1-5). The prognosis is considered to be poor due to a short mobile coronal fragment, with less probability of healing with hard tissue, and possible bacterial contamination of necrotic pulp tissue from the gingival crevice (6, 7). However, it has also been shown that cervical fractures may heal and a conservative approach, including a relatively long splinting period, has been recommended (8-11).

Type of fracture healing was classified by Andreasen & Hjörting-Hansen (8): 1) Healing with interposition of hard tissue: healing with hard tissue, fragments are in close contact and the fracture line is not visible or indistinctly outlined; 2) Healing with interposition of bone and soft tissue (PDL) between the fragments: fragments are separated by ingrowth of hard tissue surrounded by periodontal ligament-like tissue; 3) Healing with interposition of soft tissue (PDL): fragments are close but separated by a distinct radiolucent line and there is rounding-up of the fracture edges; 4) No healing: persistent or a widened space between the fragments and the presence of a radiolucency in the alveolar bone adjacent to the root fracture.
Cvek et al. (12) evaluated 94 cervical root fractures. The teeth were divided into two groups according to type of fracture: 1: transverse fractures limited to the cervical third of the root (51 incisors) and 2: oblique fractures involving both the cervical and middle parts of the root (43 incisors). Healing of the fracture with hard tissue formation was observed in 17 teeth (18%), healing with interposition of periodontal ligament (PDL) and, in some cases, hard tissue between the fragments in 62 teeth (66%), and fifteen teeth (16%) showed no healing and a radiolucency adjacent to the fracture. Neither the frequency nor the type of fracture healing differed significantly between the two groups (transverse versus oblique).

Andreasen et al. (13) analysed the long-term tooth loss after root fractures and assessed the influence of the type of healing and the location of the root fracture in 492 root-fractured teeth in 432 patients. The location of the root fracture had a strong significant effect on tooth survival. The 10-year tooth survival of apical root fractures was 89%, of mid-root fractures 78%, of cervical-mid-root fractures 67%, and of cervical fractures 33%. The fracture-healing type offered further prognostic information. No tooth loss was observed in teeth with hard tissue fracture healing regardless of the position of the fracture. For teeth with interposition of connective tissue, the location of the fracture had a significant influence on tooth loss. For teeth with connective tissue healing, the estimated 8-year survival of apical, mid-root, and cervical-mid-root fractures were all more than 80%, whereas the estimated 8-year survival of cervical fractures was 25%. Horizontal root fractures due to dental trauma generally do not result in pulp necrosis (14). The incidence of tooth survival in the cervical third is lower (30%) than the incidence in the middle (86%) and apical thirds (96%) (14).

In the present case, the tooth required endodontic treatment, probably because of infection via the periodontal pocket that resulted in necrosis of the coronal fragment. Clinical examination of root fractures should evaluate tooth colour, sensitivity to percussion, mobility, and sensitivity to thermal stimulation (15).

This case showed slight mobility (grade 1), which can be explained by the cervical location of the fracture line. There was no response to the cold test, one can argue that this could be explained by the obliteration of the coronal pulp space; the dental crown showed yellow discoloration, which also may be a clinical sign of mineralization of the pulp chamber. Although in most cases of horizontal root fracture, testing the pulp elicits a positive response, a negative response may be recorded (16) when there is calcification. This negative response does not necessarily indicate a need for endodontic therapy. However, in this case, a radiolucency in the alveolar bone adjacent to fracture was evident, indicating the need for endodontic treatment.

In the study by Cvek et al. (14) no healing, i.e. pulp necrosis and appearance of radiolucency in the periradicular bone, next to the root fracture, with or without widening of the space between fragments, occurred in 109 (20%) of the 534 intra-alveolar root fractured teeth.

References
2. Austin LT. A review of forty cases of retained fractured roots of

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36


Endodontic retreatment of the maxillary left first molar

Patient
29-year-old Caucasian male.

Chief complaint
Non-contributory.

Medical record
Non-contributory.

Dental history
The patient was referred to the post-graduate clinic from the student clinic for endodontic retreatment of the maxillary right first molar. A crown is planned.

Clinical findings October 25th2011
Soft tissue: normal findings
Dental:
25: Sound.
26: Discoloured and leaking composite filling (ODP) with underlying cavity/caries (Fig. 2).
27: Sound.

Radiographic findings October 25th2011
Dental: Tooth 26 has an MOD radiopaque filling material. The root canals seem poorly filled with a weakly radiopaque material. Periodontal: Within normal limits. Periapical: Widening of PDL space tooth 26, apical radiolucencies mesiobuccal and palatal root (PAI 3). Normal PDL space around tooth 25 and 27.
Diagnosis October 25th 2011

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Treatment plan
Non-surgical retreatment.
A crown is planned after endodontic retreatment.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Treatment November 2nd 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Gutta-percha was removed. Prepared the canals using NiTi hand files and BioRace rotary files:
MB: #40/0.04 (Br5)/19.5mm
DB: #40/0.04 (Br5)/19mm (step)
P: #50/0.04 (Br6)/19.5mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Fig. 4. Working-length radiograph MB2.

Treatment November 2nd 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Gutta-percha was removed. Prepared the canals using NiTi hand files and BioRace rotary files:
MB: #40/0.04 (Br5)/19.5mm
DB: #40/0.04 (Br5)/19mm (step)
P: #50/0.04 (Br6)/19.5mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Fig. 5. Working-length radiograph MB and P canals.

Fig. 6. Working length radiograph DB canal.

Treatment November 2nd 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Gutta-percha was removed. Prepared the canals using NiTi hand files and BioRace rotary files:
MB: #40/0.04 (Br5)/19.5mm
DB: #40/0.04 (Br5)/19mm (step)
P: #50/0.04 (Br6)/19.5mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Fig. 4. Working-length radiograph MB2.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.

Fig. 5. Working-length radiograph MB and P canals.

Problem list
Obliteration.

Treatment October 25th 2011
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access preparation, caries removal and locating the untreated MB canal (MB2). Mechanical: Burs, NiTi handfiles #20, Biorace rotary files:
MB2: #40/0.04 (Br5)/18mm
Chemical: 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)₂.
Temporary filling: Cavit, IRM.
Follow-up examination April 15th 2013 (2 years)
No symptoms. Radiograph shows healing of the periapical radiolucency.

Fig. 9. Follow-up radiograph 1 year.

Discussion
Successful root canal therapy requires a thorough knowledge of root and root canal morphology. Root canal anatomy variations present a constant challenge in successful diagnosis and endodontic treatment, especially the multirooted teeth. A classic study by Hess (1) showed pulp spaces to be complex systems. Numerous studies since then have continued to help define the anatomy, morphology, and dimension of the human dentition, with the common denominator being that certain root systems are more complex than others. One such system is found in the mesiobuccal (MB) root of maxillary molars (2-5).

The broad buccolingual dimension of the mesiobuccal root and associated concavities on its mesial and distal surface is consistent with the majority of the mesiobuccal roots having two canals while there is usually a single canal in each of the distobuccal and palatal roots (6, 7).

In a literature review of the root canal morphology of the human permanent maxillary first molar (8399 teeth from 34 studies) the incidence of two canals in the mesiobuccal root was 56.8% and of one canal was 43.1% in a weighted
average of all reported studies. The incidence of two canals in the mesiobuccal root was higher in laboratory studies (60.5%) compared to clinical studies (54.7%). Less variation was found in the distobuccal and palatal roots and the results were reported from fourteen studies consisting of 2576 teeth. One canal was found in the distobuccal root in 98.3% of teeth whereas the palatal root had one canal in over 99% of the teeth studied (8). The use of operating microscopes has facilitated the localization and handling of additional canals, especially the second mesiobuccal canal (MB2) in maxillary first molars. Buhrley et al. (9) investigated the effect of magnification on locating the MB2 canal in maxillary molars. The participating endodontists documented 312 cases of root canal therapy on maxillary first and second molars. Participants that used the microscope or dental loupes located the MB2 canal with a frequency of 57.4% and 55.3%, respectively. Those using no magnification located the MB2 canal with a frequency of 18.2% (9). Failure to detect and treat the second MB2 canal system will result in a decreased long-term prognosis (10). Stropko (11) observed that by scheduling adequate clinical time, by using the recent magnification and detection instrumentation aids and by having thorough knowledge of how and where to search for MB2, the rate of location can approach 93% in maxillary first molars.

References
Endodontic retreatment of the mandibular left first molar

Patient
34-year-old Asian male.

Chief complaint
Non-contributory.

Medical record
Non-contributory.

Dental history
The patient was referred to the postgraduate clinic from the student clinic for retreatment of the mandibular left first molar prior to prosthetics (crown). The tooth had been root filled approximately 15 years ago. Previous attempts to retreat the tooth had been made at the student clinic.

Clinical findings April 21st 2010
Soft tissue: Normal findings.
Dental: Tooth 35: Occlusal amalgam restoration.
Tooth 36: Leaking amalgam restoration (MODL) with caries and occlusal temporary filling material.
Tooth 37: Composite filling (MO).

Radiographic findings April 21st 2010
Dental: Tooth 36 has an MOD radiopaque filling material. The tooth has an insufficient root filling. The root canals seem to be calcified apically.
Periodontal: Within normal limits.
Periapical: Normal PDL space around tooth 35, 36 and 37.
Fig. 3. Periapical radiograph.

**Diagnosis April 21\textsuperscript{st} 2010**

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<tr>
<td>Periapical</td>
<td>Within normal limits</td>
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**Treatment plan**

Non-surgical endodontic retreatment.

**Problem list**

Negotiation of obliterated root canals.

**Treatment April 21\textsuperscript{st} 2010**

1 carpule of Septocaine was applied to establish anaesthesia. Access preparation and localisation of 3 canal orifices. Partially removing the old gutta-percha. Obliterated canals. 

*Mechanical:* Burs, Gates glidden, Hedstrøm hand files. 

*Chemical:* Chloroform, 1% NaOCl, 17% EDTA. 

*Intracanal medicament:* Ca(OH)$_2$. 

*Temporary filling:* Cavit, IRM.

Fig. 4. Working length radiograph.

**Treatment September 7\textsuperscript{th} 2010**

1 carpule of Septocaine was injected. Access preparation and localisation of D canal, bleeding from canal. Attempt to negotiate mesial canals using ultrasound was unsuccessful. 

*Mechanical:* Burs, NiTi hand files: 

D: #50/0.02 23mm 

*Chemical:* 1% NaOCl, 17% EDTA. 

*Intracanal medicament:* Ca(OH)$_2$. 

*Temporary filling:* Cavit, IRM.

Fig. 5. Working length radiograph. D canal.

**Treatment September 12\textsuperscript{th} 2010**

No symptoms. 

1 carpule of Septocaine was injected. MB and ML canals were filled with ProRoot MTA, D canal was filled with gutta-percha and AH Plus using a cold lateral condensation technique. Moistened cotton pellet applied over MTA. 

*Temporary filling:* Cavit, IRM.
Fig. 6. Master cone radiograph.

Fig. 7. MTA in mesial canals.

Fig. 8. Filled with GP/AH+ distal canal.

Fig. 9. IRM plugs.

Fig. 10. Tooth restored with composite.

Fig. 11. Follow-up radiograph 2 years.

**Prognosis**

Endodontic: Uncertain.
Tooth: Uncertain.

**Follow-up examination February 6th 2012**

No symptoms. A crown with a post was made at the student clinic. No visible apical pathology on periapical radiograph.

**Treatment November 2nd 2010**
IRM plugs mesial canals, tooth filled with composite.

**Discussion**

Strindberg (1) stated in 1956 that the highest success rate is obtained when the root filling is confined to 1 mm from the radiographic apex. In the ideal endodontic case, the root canal is patent from the orifice to the apical foramen. However, this is not always the case. Canals may be obliterated by denticles or secondary dentin formation, or the anatomy of the root may prevent
proper instrumentation. There are various opinions in the literature regarding the prognosis for endodontic treatment of such canals. According to Strindberg (1) the prognosis is good even in teeth with nonvital pulps. Molven (2) studied, in vitro, forty-six root canals in which the pulps had been amputated or partially root filled 5 years or more previously and in which no root canals were visible in intraoral radiographs apical to the amputation or end of the root fillings. On radiographs taken after extraction, twenty-nine canals could be traced partially or for their whole length. When the canals were instrumented in the laboratory, using a standardized procedure, ten canals were found to be penetrable, twenty-six were diagnosed as non-penetrable, and complications occurred in ten canals (breakage of instrument/obstruction caused by filling material). A complete obliteration in the total length was not found in any canal. In a study by Åkerblom et al. (3), looking at the outcome of obliterated root-filled teeth that were root-filled only one third of the root length, clinical and radiographic follow-up examinations were performed for 2 to 12 years. The criteria for obliteration were: (a) The root canal was not patent for more than one-third of the root length, (b) No root canal lumen was visible on the radiographs apical to the instrumented portion. Teeth with obliterated root canals were treated endodontically without any surgical procedure. The overall success rate was found to be 89%. When the preoperative periapical status was taken into consideration, the success rate for roots with an intact periapical contour was 97.9%.

An accessory canal is any branch of the main pulp canal that communicates with the external surface of the root. A lateral canal is an accessory canal located in the coronal or middle third of the root, usually extending horizontally from the main root canal (4). Ramifications can be observed anywhere along the length of the root, but they occur more commonly in the apical portion and in posterior teeth (5). In 73.5% of the cases, ramifications are found in the apical third of the root, in 11% in the middle third, and in 15% in the coronal third (6). Ricucci et al. (7) reviews and reports on the histopathologic and histobacteriologic status of the tissue in lateral canals and apical ramifications (LC/AR) in diverse clinical conditions as well as in response to endodontic treatment. Serial sections from 493 human tooth specimens obtained by extraction or apical surgery. They found that LC/AR were observed in about 75% of the teeth. Chemo mechanical preparation partially removed necrotic tissue from the entrance of LC/AR, whereas the adjacent tissue remained inflamed, sometimes infected, and associated with periradicular disease. In cases in which lateral canals appeared radiographically “filled,” they were actually not obturated, and the remaining tissue in the ramification was inflamed and enmeshed with the filling material.

References

3. Åkerblom A, Hasselgren G. The Prognosis for Endodontic


Case 9

Endodontic retreatment of the maxillary left first incisor

**Patient**
15-year-old Caucasian male.

**Chief complaint**
Non-contributory.

**Medical record**
Non-contributory.

**Dental history**
The patient was referred to the post-graduate clinic from the public dentistry for retreatment of the maxillary left first incisor. The tooth had recently been rootfilled but the referring dentist was unhappy with the result. The patient had a trauma to his upper front teeth 7 years earlier (2004).

**Clinical findings August 24th 2011**
*Soft tissue:* Normal findings.
*Dental:* Teeth 11 and 21 have coronal composite build-ups. Tooth 21 has a palatal temporary filling.

**Clinical tests August 24th 2011**

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**Radiographic findings August 24th 2011**
*Dental:* Tooth 21 has a radiopaque coronal restoration and a radiopaque root filling material.
*Periodontal:* Within normal limits.
*Periapical:* Tooth 21 has an apical radiolucency (PAI 3).
Diagnosis August 24th 2011

<table>
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Treatment plan
Endodontic retreatment.

Problem list
Apical resorption?

Treatment August 24th 2011
Access opening and localization of gutta-percha. Iatrogenic push-out of gutta-percha during removal (Fig. 5).
Mechanical: Bur, Gates Glidden, Hedstrøm handfiles, DeRace rotary files, NiTi handfiles: #60/24mm adjusted to 23.5mm
Chemical: Chloroform, 1% NaOCl, 17% EDTA.
Intracanal medicament: Ca(OH)_2.
Temporary filling: IRM.

Treatment September 28th 2011

Treatment November 11th 2011
Asymptomatic. Filled with gutta-percha and AH Plus, sealed with IRM.
Prognosis

*Endodontic:* Uncertain.

*Tooth:* Good.

**Follow-up examination March 18th 2013 (2 years)**
The patient is asymptomatic.
Radiograph shows uncertain healing.

**Discussion**
Several follow-up studies (1-6) have concluded that apical overfilling is associated with an impaired prognosis. This opinion has been based on studies that include observation periods mostly in the range of 2-4 years. Strindberg (1) however, followed up some cases for up to 10 years, and he occasionally noticed a reduction in the volume of excess fillings over the longer periods.
Halse & Molven (7) re-examined 239 root-filled teeth after 10-17 years and concluded that apical overfilling per se had little influence on the long-term healing result as judged radiographically. In about 80% of the cases of overfilling, no excess root filling material could be traced at the reexamination. In a few cases only, the appearance of the excess material was nearly identical to that at the time of treatment, whereas the remaining overfillings (18%) showed a reduced size. Among the recorded variables only one seemed to have a major impact on the prognosis—namely, the presence or absence of an apical radiolucency at the time of treatment, indicating that infection was the important factor when failures occurred. Yusuf (8) found in his study of periapical granulomas that “foreign” material was present in 96/284 specimens. Whilst dentin and cementum chips often was associated with active inflammation, extruded root-filling materials were generally associated with the formation of scar tissue. Healing of the periapical lesion may occasionally occur by means of fibrous scar tissue, which appears as a periapical radiolucency indistinguishable from that seen in failed endodontic treatment (9). In one study (10) scar tissue healing was observed at the apices of teeth that had previously undergone periapical curettage; it was concluded that a periapical scar develops only after periapical surgery. However, in another histopathologic study, 2.5% of 2308 specimens were diagnosed as periapical scars, most of which occurred at the apices of conventionally root-filled teeth (11). In the study by Nair et al. (9), the observation of scar tissue in 2 specimens indicated that after root canal treatment the periapical lesions healed with soft connective tissue with no signs of inflammation.

References

9. Nair PNR, Sjögren U, Figdor D, Göran Sundqvist G. Persistent periapical radiolucencies of root-


Endodontic treatment of a maxillary anterior tooth

Fig. 1. Frontal view.

Patient
61-year-old Caucasian female.

Chief complaint
Pain in the mucosa above the maxillary left front tooth, sometimes-unprovoked radiating pain.

Medical record
The patient has dental fear. She explains about traumatic experiences related to treatment of the upper front teeth after a trauma in childhood.

Dental history
The patient was referred to the post-graduate clinic from private practice for endodontic treatment of the maxillary left first incisor. She had a trauma (traffic accident) to her anterior teeth as a child and the teeth were restored with aluminium crowns until the age of 18. After that the metallic-ceramic dental crowns (Fig. 1-3) were made.

Clinical findings May 27th 2014
Soft tissue: Normal.
Dental: Teeth 21 and 11 have dental crowns (Fig. 2, 3).

Clinical tests May 27th 2014

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Radiographic findings May 27th 2014
Dental: Teeth 21 and 11 have radiopaque dental crowns.
Periodontal: Within normal limits.
Periapical: Tooth 21 has an apical radiolucency (PAI 3). Widened PDL space around the apex of tooth 11. A continuous PDL space is seen around the root of tooth 22.
Diagnosis May 27\textsuperscript{th} 2014

<table>
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Treatment plan
Endodontic treatment of tooth 21.

Problem list
Dental anxiety.
Pulp canal obliteration in the coronal half of the canal space.

Treatment May 27\textsuperscript{th} 2014
The patient cried during the first visit. She was afraid that the crown would be destroyed, however, she wanted to treat the tooth due to pain. 1 carpule of Xylocaine/adrenaline was injected. Access opening and careful localisation of the canal orifice with the aid of radiographs (Fig. 5).

Mechanical: Burs, LN burs.
Chemical: 17% EDTA.
Temporary filling: IRM.

Treatment June 3\textsuperscript{rd} 2014
1 carpule of Xylocaine/adrenaline was injected. Access opening and relocalization of canal orifice.

Mechanical: Bur, NiTi hand instrumentation #20, RECIPROC\textsuperscript{®} one file endo: #40/0.04/23.5mm
Chemical: 0.5% chlorhexidine, 17% EDTA.
Intracanal medicament: Ca(OH)\textsubscript{2}.
Temporary filling: IRM.
Treatment June 17th 2014
No symptoms.
Filled with gutta-percha and AH Plus, sealed with composite.

Discussion
Crown fractures of the permanent dentition comprise the most frequent form of traumatic dental injuries. Since enamel-dentin crown fractures expose a large number of dentinal tubules, pathways to the pulp are established for a variety of noxious agents present in the oral environment including bacteria and toxins (1-4). Therefore, to prevent pulpal injury, coverage of the exposed dentin would seem important. However, the effect of length of dentin exposure on pulpal response has been controversial. On the one hand this assumption is supported by a clinical study where pulpal necrosis (PN) was significantly increased in untreated crown fractured teeth with extensive dentin exposure (5). But, in teeth with functional, vital pulp tissue, dentin provides considerably resistance to bacterial ingress. Classical studies (6-8) suggest that persistent bacterial provocation of exposed dentin, even in conjunction with resin restoration (9), tends to result in pulpal inflammatory lesions of limited duration.

Cavalleri and Zerman (10) did a follow-up study of 84 crown fractured permanent incisors with incomplete root formation over a 5-year period. Four of 67 teeth (6%) with fracture of the enamel and dentine without pulpal involvement showed PN and 1 tooth showed pulp canal obliteration (PCO) (1.5%). Eight of 14 teeth (57%) with fractures of the enamel and dentine with pulpal involvement showed PN.

Robertson (11) did a retrospective evaluation of patients with uncomplicated crown fractures and luxation injuries. A total of 241 patients with 545 injured teeth were available for clinical examination. In addition, 82 permanent incisors presenting with pulp canal obliteration were followed for a period of 7 to 22 years (mean 16 years). The findings showed little pulpal

Prognosis
Endodontic: Good.
Tooth: Good.

Follow-up examination (phone call)
September 9th 2014 (3 months)
The patient has no symptoms; no longer tender when palpating over the root.
response to crown fracture and subsequent restorative procedures as long as there was no concomitant periodontal injury (15-year follow-up). PCO was found in all luxation categories. According to the survival curve the 20-year pulp survival rate diagnosed radiographically was 84%. Although the risk of PN increased with time, routine endodontic intervention of teeth with on-going PCO of the root canal did not seem justified (11).

Robertson et al. (12) investigated pulp-healing responses following crown fracture in 455 teeth with or without pulp exposure and luxation. The observation period ranged from 6 months to 17 years (mean 2-3 years). Crown fractures without luxation showed pulp survival (PS) in 99 %, PCO in 1 % and PN in 0 % of the cases. With concomitant luxation PS was observed in 70 %, PCO in 5 % and PN in 25 %. Their findings support the idea that in teeth with an intact pulpal circulation, dentin can provide considerable resistance to bacterial invasion (13).

References
Case 11

Patient with persistent pain maxilla left side

Fig. 1. Frontal view.

Patient
32-year-old Caucasian male.

Chief complaint
The patient is complaining about occasional throbbing pain (once a week) in the left side of maxilla. The pain mainly arises after consumption of red wine and the tooth pain often comes with a temporary headache. He describes the pain as "nerve pain". The pain started after a root canal treatment of the maxillary left first molar. The pain persisted after endodontic treatment and the tooth was later retreated two times without any relieve of symptoms. He is not using any pain medications.

Medical record
Non-contributory.

Dental history
The patient was referred to the post-graduate endodontic clinic from private practise for apicoectomy of the maxillary left first molar. Tooth 26 had been treated endodontically several times.

Clinical findings April 11th 2014
Soft tissue: Normal findings.
Dental:
Tooth 25: Composite fillings.
Tooth 26: Large composite restoration (MODP), temporary occlusal filling, chronic caries.
Tooth 27: Composite fillings, chronic caries.

Fig. 2. Occlusal view.

Clinical tests April 11th 2014

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Radiographic findings April 11th 2014
Dental: Teeth 25, 26, 27 have radiopaque restoration materials. Tooth 26 has a radiopaque root filling material.
**Periodontal**: Normal findings.

**Apical**: Teeth 25 and 27 have continuous PDL spaces. Tooth 26 uncertain findings mesial root; flush root canal filling. Based on uncertain clinical and radiographic findings, the patient was referred for cone-beam CT (CBCT).

Based on uncertain clinical and radiographic findings, the patient was referred for cone-beam CT (CBCT).

**Problem list**

Neuropathic pain.

**Prognosis**

Tooth: uncertain

**Radiologic description (in Norwegian)**

From the Department of Maxillofacial Radiology, May 6th 2014

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**Diagnosis April 11th 2014**

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**Treatment plan**

CBCT referral.

Treatment alternative: Surgical retreatment of the mesial root of the

---

Fig. 3. Periapical radiograph.

Fig. 4. Periapical radiograph.
Follow-up examination May 27th 2014
Information about CBCT findings. The patient is advised to have a permanent filling in tooth 26, preferably a dental crown, and a general caries check.

Follow-up examination (phone call) September 30th 2014
Fewer symptoms from the tooth. He feels some “discomfort” approximately once a month. He has not decided if he wants to keep the tooth and have a crown made. At present, he is waiting for his dentist to return after maternity leave.

Discussion
Persistent pain associated with teeth after nonsurgical or surgical endodontic treatment has been used as an indicator of treatment failure (1, 2). However, pain may be experienced in a tooth or adjacent site in the absence of clinical or radiographic signs of dental disease. Failure to detect pathological change on periapical radiographs may reflect limitations of the diagnostic method rather than an absence of an osteolytic lesion (3, 4). Superimposition of adjacent anatomical structures over the suspect tooth may further obscure the view. Conversely, residual periapical disease may be truly absent and the pain may be nonodontogenic. Nonodontogenic dental alveolar pain is often difficult to diagnose because it is poorly understood (5, 6).

Nonodontogenic pain in the dentoalveolar region can arise from four potential processes: 1) referred musculoskeletal pain disorder, 2) neuropathic pain disorder, 3) headache disorders presenting in the dentoalveolar region, and 4) a pathological process outside the immediate dentoalveolar region that refers pain to that area, such as sinus disease, salivary gland disorders, brain tumors, angina, throat cancer, and craniofacial vascular disorders (7, 8).

Pain in a tooth site of neurogenic origin has been reported in the literature (9, 10) but only a few published studies (9-14) have investigated the occurrence of neuropathic pain after dental treatment. Evidence of the association between dental treatment and chronic neuropathic pain has been presented by Marbach et al. (11), Schnurr & Brooke (12) and Vicker et al. (13), who reported that most patients diagnosed with atypical odontalgia related the onset of the pain to dental treatment, dental infection or dental trauma.

Only three epidemiological studies (9, 10, 14) have investigated the prevalence of chronic neuropathic pain after dental treatment. The study by Marbach et al. (9) was conducted by a single endodontist, who mailed questionnaires to patients 1 month following nonsurgical endodontic treatment. Only female patients were included in their analyses because the
female sample was considered too small. Of the 256 female patients assessed, 20 (9%) reported persistent pain during the period of survey but only 11 female patients attended for clinical and radiographic examination to exclude an odontogenic cause of pain. Of the 11 patients, eight (3% of 256 female patients) were diagnosed with "phantom toothache".

Campbell et al. (10) carried out a similar survey of patients who had undergone surgical endodontic treatment 2 years previously and found that 59 (5%) of the 118 patients suffered from chronic pain that divided equally into two groups; post-traumatic stress dysaesthesia (absence of pain preoperatively) and phantom tooth pain (presence of pain preoperatively). In contrast, Berge (14) found none of the 1035 patients in their survey suffered from chronic neuropathic pain following surgical removal of third molars 5–6 years previously.

Polycarpou et al. (15) investigated the prevalence of persistent pain after endodontic treatment and factors affecting its occurrence in cases with complete radiographic healing. 175 patients/teeth were reviewed 12–59 months following treatment. The prevalence of persistent pain after successful root canal treatment was 12% (21/175). A positive history of previous chronic pain experience or painful treatment in the orofacial region, and female gender were important risk factors associated with persistent pain after successful endodontic treatment. Marbach (16) has suggested that a deafferentation pain syndrome may be triggered by pulp amputation. Support for this theory comes from the work of Hu & Sessle (17) who showed that somato-sensory pathways alter as a result of removal of pulp tissue in cats.

Nixdorf et al. (7) conducted a systematic review of prospective studies that reported the frequency of nonodontogenic pain in patients who had undergone endodontic procedures. In their study, 3.4% of patients experienced persistent pain of nonodontogenic origin for 6 months or more after root canal therapy. In rare cases, chronic persistent tooth pain does not respond to dental treatment. Some of these cases might be due to neuropathic pain disorders induced by nerve injuries sustained during endodontic procedures.

Neuropathic pain is defined as a pain initiated or caused by a primary lesion in or dysfunction of the nervous system. Clinically, neuropathic pain is characterized by partial or complete somatosensory change in the innervation territory of a specific part of the peripheral or central nervous system along with the paradoxical presence of pain and hypersensitivity phenomena (18). Several studies have reported that endodontic procedures are related to the development of neuropathic tooth pain (NTP) (9, 10, 19–23). NTP is also known as atypical odontalgia (21) and phantom tooth pain (PTP) (9, 20). Some cases of chronic tooth pain related to endodontic procedures have been reported in which repeated dental treatments failed to provide pain relief (20, 21).

One study reported that the incidence of NTP after endodontic procedures was greater than that after any other dental treatment such as tooth extraction and trauma (23).

Furthermore, 3 retrospective studies have reported that 3%–12% of patients developed NTP after endodontic procedures (9, 10, 15).

Oshima et al. (18) conducted another retrospective study of 271 patients who had chronic persistent tooth pain that did not respond to endodontic procedures despite the absence of
“major pathology”. Pain predominantly occurred in the maxilla (14 patients). In 10 patients (62.5%), NTP developed after retreatment. The majority of patients were female. Daily application of tricyclic antidepressants produced pain relief in 11 patients (68.8%).

References
15. Polycarpou N, Ng YL, Canavan D, Moles DR, Gulabivala K. Prevalence of persistent pain after endodontic treatment and factors affecting its occurrence in cases with complete radiographic


Endodontic retreatment and apical surgery of the maxillary right canine

**Patient**
65-year-old Caucasian female.

**Chief complaint**
Tender to palpation.

**Medical record**
Non-contributory.

**Dental history**
Tooth 13 was endodontically treated by general practitioner 5 years ago (due to apical periodontitis). History of a sinus tract. Tooth 12 is going to be extracted and an implant or a dental bridge is planned. The patient was referred to the post-graduate endodontic clinic for retreatment and complementary apical surgery of tooth 13.

**Clinical findings May 18th 2011**

*Soft tissue:* A sinus tract is evident apically region 13.

*Dental:* Teeth 11, 12 and 13 have dental crowns.

**Radiographic findings May 18th 2011**

*Dental:* Teeth 13 and 12 have radiopaque dental crowns. A radiopaque root filling material is seen in both teeth.

*Periodontal:* Attachment loss.

*Apical:* An apical radiolucency is seen around the root of tooth 13 (PAI 4). Widened PDL space apically around the root of tooth 12.
Diagnosis May 18th 2011

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<td>Chronic marginal periodontitis</td>
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<td>Periapical</td>
<td>K05.40</td>
<td>Chronic apical periodontitis</td>
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Treatment plan
Orthograde retreatment and complementary apical surgery tooth 13.

Problem list
Gingival recession and aesthetics.

Treatment August 31th 2011
The patient is asymptomatic. Access opening and attempt to remove GP in the apical part of the canal. Apical perforation and bleeding at the tip of paper point. Adjustment of working length and enlargement.

Mechanical: Burs, Hedstrøm- and NiTi hand files:
#70/21.5mm
Chemical: Chloroform, 1% NaOCl, 17% EDTA.

Filled with gutta-percha and AH Plus Sealed with IRM plug and composite.

Treatment May 18th 2011
1 carpule of Septocaine was injected. Access opening and localization of gutta-percha (GP). Not able to remove all GP apically.

Mechanical: Burs, Gates glidden, Prerace, NiTi hand files:
#60/23mm adjusted to 22.5 mm
Chemical: Chloroform, 1% NaOCl, 17% EDTA.

Intracanal medicament: Ca(OH)\(_2\).
Temporary filling: IRM.
Surgery September 28th 2011
The patient was given a chlorhexidine mouth rinse and local anaesthetic was injected. A marginal incision was made running from tooth 11 to tooth 14 with a vertical releasing incision on the distal aspect of 14. Elevation of the mucoperiosteal flap revealed pathological fenestration and extruded GP. Osteotomy and curettage of granulation tissue. Biopsy. Root-end resection 3mm and retrograde preparation with ultrasonic instruments. Haemostasis using resorbable surgicel and ferric sulphate. A retrograde filling of white MTA was applied. The operation site was rinsed with sterile saline and the flap sutured in place with supramide 4.0. Administration of Ibux 400mg. Postoperative instructions.
Prognosis
Endodontic/surgery: Good.
Tooth: Good.

Follow-up examination October 11th 2011 (2 weeks)
The patient had no postoperative complaints. Suture removal.

Follow up examination January 26th 2012 (4 months)
Asymptomatic. Healing of apical radiolucency.

Follow up examination May 14th 2013 (2 years)
Asymptomatic. The apical radiolucency seems to have healed well.

Radiograph from general practitioner September 4th 2013
Discussion

Non-surgical endodontic treatment is a predictable and reliable treatment with high success rates ranging from 86%–98% (1, 2). Nevertheless, for a variety of reasons, endodontic failure still occurs, and presence of clinical signs and symptoms along with radiographic evidence of periapical bone destruction indicates the need for retreatment (3, 4). Etiologic factors of endodontic failure can be placed into 4 groups (5): (1) persistent or reintroduced intraradicular microorganism, (2) extraradicular infection, (3) foreign body reaction, and (4) true cysts. Among those, many studies reported that microorganisms in the root canals or periradicular lesions play a major role in the persistence of apical periodontitis after a root canal treatment (6-8). Non-microbial factors have also been suggested as a potential cause of post-treatment disease (9), but evidence is relatively weak as it comes from a few case reports.

Endodontic failure related to microorganisms can be caused by procedural errors such as root perforation, ledge formation, separated instruments, and missed canals, as well as anatomical difficulties such as apical ramification, isthmuses, and other morphologic irregularities (8, 10). Song et al. (11) examined the clinical causes of failure and the limitation of previous endodontic treatment by examining the root apex and resected root surface at 26x magnification during endodontic microsurgery. A total of 493 roots were analysed. The most common possible cause of failure was a leaky canal (30.4%), followed by a missing canal (19.7%), under filling (14.2%), anatomical complexity (8.7%), overfilling (3.0%), iatrogenic problems (2.8%), apical calculus (1.8%) and apical cracks (1.2%).

Post-treatment disease has been demonstrated to be highly associated with intraradicular infection by studies using microscopy (12-14), culture (15, 16) or molecular methods (17, 18, 19). The outcome of treatment has been shown to be poorer when bacteria persist in the root canals at the time of filling (20, 21). This may indicate that residual bacteria can survive in treated canals for many years and induce or sustain periradicular tissue inflammation.

Extraradicular infections are usually associated with acute inflammation, clinically characterised by an abscess with accompanying pain and swelling, or a sinus tract. However, it has been suggested that in some cases an extraradicular infection may be associated with chronic inflammation and lead to endodontic treatment failure. This condition may be associated with a biofilm formation on the external root surface (22), sometimes showing calculus-like calcifications (23), or forming cohesive actinomycotic colonies within the body of the lesion (24).

There are some few case reports that suggest that some lesions may not heal because of endogenous or exogenous non-microbial factors (25). Endogenous causes include cholesterol crystals and true cysts, whereas exogenous causes comprise foreign-body reactions to apically extruded filling materials, paper points or food (14, 26). Nevertheless, in most of these cases it is difficult to rule out the concomitant presence of infection as the cause of the disease.

References


Case 13

Endodontic retreatment in conjunction with apical surgery of the mandibular right first molar with a separated instrument

Fig. 1. Frontal view.

Patient
54-year-old Caucasian male.

Chief complaint
He has no symptoms at present, but he complains about several episodes of pain and swelling in the lower right mandible. His dentist/doctor has prescribed antibiotics (AB) at several occasions due to tooth pain.

Medical record
The patient is diagnosed with Bechterev. He has dental fear.
Medicaments: Celebra, Prednisolone.

Dental history
Concomitant with the last AB regimen the patient was referred to the postgraduate clinic from private practice for retreatment of the mandibular right first molar. Tooth 46 was endodontically treated many years ago. At several occasions the last year, the patient received dental emergency treatment consisting of AB prescriptions for tooth pain related to the specific tooth.

Clinical findings September 28th 2010
Soft tissue: Normal findings
Dental:
Tooth 44 has an occlusal amalgam filling and a buccal composite filling. Buccal caries is noted along the composite margins. A craze line is seen at the buccal aspect, running in an occlusal-cervical direction.
Tooth 45 has a dental crown.
Tooth 46 has a composite restoration with a small buccal amalgam filling, and there is caries along the margins of the restorations.

Fig. 2. Buccal view.

Fig. 3. Lingual view.
Clinical tests September 28th 2010

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<tr>
<td>Biting</td>
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</table>

Radiographic findings September 28th 2010

**Dental:** Tooth 46 has a radiopaque filling material. A radiopaque root canal filling material and a separated instrument in the mesial root is seen. Tooth 45 has a radiopaque dental crown and a radiopaque root filling material.

**Periodontal:** Within normal limits

**Apical:** An apical radiolucency around the root of tooth 46 is seen (PAI 4). A normal PDL space is seen around the root of tooth 45.

![Fig. 4. Periapical radiograph 28.09.2010.](image)

Diagnosis September 28th 2010

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<th>Code</th>
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Treatment plan

Non-surgical retreatment of the endodontically treated right mandibular first molar and observation.

Problem list

Instrument removal and negotiation of apical third.

Treatment September 28th 2010

1 carpule of Septocaine was injected. Access opening and localization of old GP and of untreated DL canal.

**Mechanical:** Burs, Gates glidden, Hedstrøm files, NiTiFlex hand files:

- MB: #40/18.5mm
- ML: #40/20.5
- DB: #40/18.5mm
- DL: #40/21.5mm

**Chemical:** Chloroform, 1% NaOCl, 17% EDTA.

**Intracanal medicament:** CaOH₂

**Temporary filling:** Cavit, IRM

![Fig. 5. Working length radiograph.](image)

Treatment October 26th 2010

**History:** The patient experienced a flare-up three days ago during physical workout.

**Emergency treatment at the student clinic:** Prescription of phenoxybenzylpenicillin and paracetamol/codein.

**At present:** Tooth is tender on biting only.
Mechanical: NiTiFlex hand files, adjusting working lengths according to apex locator:
MB: #40/18.5mm
ML: #40/21mm
DB: #40/21mm
DL: #40/23mm

Chemical: 1% NaOCl, 17% EDTA, 2% chlorhexidine-di-gluconate.

Intracanal medicament: Chlorhexidine-di-gluconate / CaOH₂.

Temporary filling: Cavit, IRM.

Treatment November 23rd 2010
The patient has no symptoms. Tooth 46 filled with gutta-percha and AH Plus. Sealed with IRM.

Prognosis
Endodontic: Uncertain.
Tooth: Uncertain.

Follow-up examination August 23rd 2011 (8 month)
The patient describes another history of flare-up and antibiotic treatment in June 2011 at private practice.
Radiographic findings 23.08.2011:
Radiolucency seemed unchanged from November 2010.
Treatment plan: Surgical retreatment of the endodontically treated mandibular right first molar.
**Surgical treatment September 21\textsuperscript{st} 2011**
The patient was given a chlorhexidine mouth rinse and local anaesthetic was injected. A marginal incision was made running from tooth 43 to tooth 46 with vertical releasing incisions at the distal aspect of 46 and mesial aspect of 43. Elevation of the mucoperiosteal flap. Osteotomy and curettage of granulation tissue. Biopsy. Root-end resection and retrograde preparation with ultrasonic instruments. Fractured instrument in mesial root removed simultaneously with resected root. Adrenalin and ferric sulphate haemostasis. Retrograde filling of IRM was applied. The operation site was rinsed with sterile saline and the flap sutured in place with supramide 4.0 and 5.0. Postoperative instructions.

![Fig. 11. Buccal view of operation site.](image1)

![Fig. 12. Enucleation of lesion.](image2)

![Fig. 13. Root resection 3mm.](image3)

![Fig. 14. Root-end preparation.](image4)

![Fig. 15. Root-end filling with IRM.](image5)

**Prognosis**
Surgery: Good.
Tooth: Good.

**Follow up examination September 27\textsuperscript{th} 2011 (1 week)**
The patient experienced mild post-operative discomfort. Suture removal. A secondary healing pattern was observed in the posterior region and the patient was advised to rinse with chlorhexidine for another week.
Follow up examination October 8th 2013 (2 years)
Asymptomatic, a crown is now planned. Radiograph shows healing of apical radiolucency.

Fig. 16. Periapical control radiograph 2 years.

Discussion
Procedural accidents have a negative effect on healing and might contribute to the persistence of infections in inaccessible apical areas, requiring surgical intervention.
The failure of nonsurgical root canal treatment is commonly related to the presence of residual bacteria (persistent infection) or the reinfection of a previously disinfected root canal environment (secondary infection) (1).
Unsuccessful outcomes can be attributed to persistent intraradicular infections found in previously uninstrumented canals, dentinal tubules, or the complex irregularities of the root canal system (2, 3, 4). The extraradicular causes of endodontic failures include periapical actinomycosis, a foreign-body reaction caused by extruded endodontic materials, the accumulation of endogenous cholesterol crystals in the apical tissues, and an unresolved cystic lesion (5-8). Previous procedural accidents may have a negative effect on healing. Besides, they might contribute to the establishment of infections at inaccessible apical areas, requiring a surgical intervention (9).
In different European countries, epidemiological studies have shown an elevated number of teeth to be retreated resulting in periapical radiolucencies from poor root canal therapies (10).
Gorni & Gagliani (11) studied 254 molars, 107 premolars, and 91 single-root anterior teeth and found that the success rate was significantly lower in teeth with altered root canal morphology (47%) compared with teeth in which no significant anatomical changes were made by the former endodontic treatment (86.8%).
Formerly treated teeth with persistent periapical lesions might be preserved with nonsurgical retreatment, assuming the tooth is restorable and periodontally sound. Bergenholtz et al. (12) reported a success rate of 78% in teeth with periapical pathologies and 94% in teeth without.
Sundqvist et al. (13) reported an overall success rate of 74% of 50 cases examined after retreatment. They found that the success rate in bacteria-free canals was almost 80%; whereas in teeth with particular bacterial species the outcome was significantly lower (66%). In a study by Sjögren et al. (14), similar results were achieved and further considerations were made regarding the size of the lesions: the greater the lesion, the lower the success rate. Chugal et al. (15) confirmed these results.
Some authors have reported better clinical results with surgical procedures compared with orthograde retreatment (16), although others have reported similar clinical outcomes using both techniques with slight differences related only to the time element. Kvist & Reit (17) did a randomized clinical study comparing surgical and nonsurgical procedures. They failed to show any systematic difference in the outcome of surgical and nonsurgical endodontic retreatment. Surgical retreatment seemed to result in more rapid periapical bone fill, but also might imply a higher risk of “late failures”.

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Torabinejad et al. (18) performed a systematic review to compare the outcomes of nonsurgical and surgical retreatment. They concluded that while endodontic surgery demonstrates more favourable initial healing, this declines with increasing recall periods. Conversely, nonsurgical retreatment shows improved outcomes with increasing recall time.

References


Case 14

Explorative surgery of the maxillary left second incisor with sinus tract

Patient
72-year-old Caucasian male.

Chief complaint
The patient complains about spontaneous pain and tenderness when chewing in the front region of the upper left maxilla. The pain is worse in the morning.

Medical record
Non-contributory.

Dental history
The patient was referred to the postgraduate clinic from a specialist in endodontics for apicoectomy of the maxillary left lateral incisor. The tooth was root filled one year ago (2010) by the referring specialist due to apical periodontitis. One year later (2011) the patient presented with pain and a sinus tract was evident.

Clinical findings October 19th, 2011
Soft tissue:
A draining sinus tract was evident at the distal aspect of tooth 22.
Dental:
Tooth 22 had a distopalatal composite filling.

Clinical tests October 19th, 2011

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Radiographic findings October 19th, 2011
Dental: Tooth 22 has a non-radiopaque distal filling and a radiopaque coronal filling material. The root canal is filled with a homogeneous radiopaque material.
Periodontal: Moderate attachment loss.
Periapical: Tooth 22 has an apical circumferential radiolucency (PAI 5).

Fig. 1. Periapical radiograph 19.10.2011.
Diagnosis October 19th 2011

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Treatment plan
Explorative surgery tooth 22.

Problem list
Root fracture?

Surgery October 19th 2011
A sinus tract draining through the alveolar bone incisally between tooth 22 and tooth 23 was evident (Fig. 3).

An incomplete vertical root fracture was evident in the apical part of the root; resection was done at the mid-root level (Fig. 3.). Tooth 22 was kept in place as temporary restoration and the tooth was stabilized with a dentine adhesive and a composite restoration to the neighbouring teeth.
Follow-up treatment October 25th 2011
Suture removal. The patient was asymptomatic.

Prognosis
The tooth has to be extracted.

Follow-up examination August 29th 2014
The patient has a well-functioning bridge replacing tooth 22.

Bacteriological findings (with DNA-DNA hybridization); Diagnostic service, Institute of Oral Biology
- *Porphyromonas gingivalis* in high concentrations.
- Gram-negative enteric bacilli in high concentrations
- Additional findings:
  - *Treponema socranski* subsp. *socranski*
  - *Eubacterium saburreum*
  - *Prevotella nigrescens*
  - *Fusobacterium nucleatum* subsp. *vincentii*
  - *Campylobacter rectus*
  - *Actinomyces viscosus*
  - *Actinomycis gerenceriae*
  - *Streptococcus intermeduius*
  - *Fusobacterium nucleatum* subsp. *polymorphum*
  - *Porphyromonas endodontalis*
Results SEM (scanning electron microscopy); Institute of Oral Biology, Steinar Stølen

Fig. 8. SEM photo shows Gram-negative bacilli on root cementum.

Fig. 9. SEM of cut surface of sulphur granule. The granule consists of an abundance of bacteria. Rod-like organisms are prominent.

Discussion

Microorganisms are able to survive and induce persistent infection in extraradicular areas (1, 2). The endodontic treatment of teeth with periapical lesions is less successful than that of teeth with vital pulp or with pulp necrosis without radiographically visible periapical lesions (3). Some studies have revealed that bacteria can form a biofilm surrounding the apical foramina and external root surfaces that is associated with persistent periapical infections (4).

Wang et al. (5) evaluated the presence of extraradicular biofilm on the external surface of the root apex in teeth with different pulp and periapical pathological conditions. They found that teeth with vital pulp and pulp necrosis without radiographically visible periapical lesions did not have exposed apical root cementum or extraradicular bacteria. The detection rates of extraradicular biofilm in teeth with primary chronic periapical periodontitis and persistent periapical periodontitis were 30% and 100%, respectively.

Actinomycosis is a chronic, granulomatous infectious disease characterized by suppuration, abscess formation, and draining sinus tracts. In tissues, Actinomyces species grow in microscopic or macroscopic clusters, that sometimes exude from soft tissues through sinus tracts, and because of their yellowish appearance, they are commonly referred to as sulphur granules, even though there is no clear evidence that they contain sulphur at all (1, 6). It has been recognized that granules can provide the bacteria with protection against phagocytosis or other immunologic mechanisms.

The patient in the present case had a persistent sinus tract. A sinus tract is defined as a passage of pus from an abscess cavity to and external environment through a tissue membrane such as the oral mucosa or the skin. The reason that a sinus tract develops is not fully understood.

Mortensen et al. (7) investigated 1600 teeth with periapical lesions; 136 (9.0%) teeth had sinus tracts. They found that the size of the radiolucency seemed to matter, because teeth with periapical lesions smaller than 5 mm had sinus tracts in 5% of cases, whereas teeth with periapical lesions greater than or equal to 5 mm had sinus tracts in 19%.
Some studies have suggested that the odontogenic sinus tract is lined with epithelium (8, 9). Valderhaug (10) studied experimentally induced sinus tracts in monkeys. He found that most of the sinus tracts were completely or partly lined with epithelium. However, studies by Grossman (11) and Bender and Seltzer (12) state that the sinus tract is not lined with epithelium, but lined with granulation tissue. According to Grossman (11) sinus tracts can heal and closure occur after root-canal treatment. In this case the sinus tract persisted after treatment of the tooth. It was an indication of treatment failure and a surgical approach had to be done. For non surgical endodontic treatment, it has been shown that the presence of a sinus tract will not influence the long-term outcome of endodontic treatment (13-17). However, another study found that the presence of a sinus tract was found to be a significant prognostic indicator (18). In surgical endodontic, studies have reported a comparable treatment outcome (19, 20).

**References**


Case 15

Endodontic retreatment of the maxillary left first molar and surgical retreatment of the maxillary left first and second premolar

Fig. 1. Frontal view.

Fig. 2. Buccal view.

Patient
66-year-old Caucasian female.

Chief complaint
The patient reported of previous pain and antibiotic regiments related to tooth 25. She also complains that several teeth in the left maxilla are tender when biting.

Medical record
The patient was diagnosed with fibromyalgia and was medicated with Ibuprofen.

Dental history
The patient was referred to the postgraduate clinic from the student clinic for apicoectomy of the maxillary left second premolar.

Clinical findings November 16th 2010
Soft tissue: Normal findings.
Dental: Teeth 24, 25 and 26 have dental crowns.

Radiographic findings November 16th 2010
Dental: Teeth 24 and 25 have radiopaque dental crowns, a post in the canal and radiopaque root filling materials. Tooth 26 has a radiopaque dental crown and a radiopaque root filling material.
Periodontal: Moderate attachment loss.
Periapical: An apical radiolucency is seen around the root of tooth 25 (PAI 4). Widened PDL space around the root of tooth 24, flush root filling. Discontinued lamina dura around the buccal roots of tooth 26; apical radiolucency MB root (PAI 3).
Diagnosis November 16th 2010

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Treatment plan
Endodontic retreatment of tooth 26.
Surgical retreatment of tooth 25 and inspection of tooth 24.

Problem list

Treatment November 16th 2010
1 carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access opening and localization of gutta-percha and a post in the palatal root canal. Mechanical: Burs, Gates Glidden,

NiTiFlex hand files:
MB: #45/18mm
DB: #45 /18.5mm
P: no treatment
Chemical: 1% NaOCl, 17% EDTA, 2% clorhexidine-di-gluconate.
Intracanal medicament: CaOH₂
Temporary filling: Cavit, IRM.

Treatment December 14th 2010
Filled with thermoplasticized gutta-percha (Beefill) and AH Plus. Sealed with IRM.
**Prognosis:**

*Endodontic:* Good.

*Tooth:* Good.

**Surgery April 6th 2011**


**Histologic findings (Laboratorium of pathology, HS Koppang)**

Granulation tissue with moderate to intense chronic inflammation.
**Prognosis**

*Surgery:* Good.
*Teeth:* Good.

**Follow-up examination April 13th 2011 (1 week)**

Few post-operative complaints. Suture removal.

![Fig. 14. One week post-operatively.](image)

**Follow-up examination September 21th 2011 (5 month’s)**

The patient is asymptomatic. No pain to percussion. The radiograph shows that the lesion is healing.

![Fig. 15. Periapical control radiograph 5 months post-operatively.](image)

**Discussion**

Surgical endodontic treatment has historically been considered as an alternative to root canal treatment, or the preferred choice when root canal treatment is difficult or impossible (1). However, unless the root canal space is effectively cleaned, shaped and filled during preliminary root canal treatment or root-end preparation, it remains as a source of infection that may allow inflammation to continue after surgical endodontics. The surgical intervention aims thus to remove the infected root-end and seal any remaining bacteria in the root canal system from the periradicular tissues. It has been discussed whether a root-end filling after root-end resection is necessary, or if the root canals are sufficiently filled with GP (2, 3). Some studies have found that healing occurs whether or not a root-end filling is placed (2, 4). However, ex vivo studies have suggested that a root-end filling is necessary to prevent leakage from the root canal and dentinal tubules (5, 6).

In the last 10 years, mineral trioxide aggregate (MTA) has received special attention. MTA was introduced in the early 1990s as a new root-end filling material (7). MTA has showed in leakage studies that the material provides a remarkable seal (7, 8) and a favourable endodontic response with the potential to induce or attach to the newly regenerating periodontal ligament (8,9).

Two randomized clinical trials (RCTs) comparing MTA and intermediate restorative material (IRM) have reported success rates of 84–92% for MTA and 76–86% for IRM after 1 year (11, 12) and 92% for MTA and 87% for IRM after 2 years (11).

Christiansen el al. (13) performed a randomized clinical to compare healing after root-end resection with a root-end filling of mineral trioxide aggregate (MTA) or smoothing of the orthograde gutta-percha (GP) root filling. Teeth treated with MTA had significantly better healing (96%) than teeth treated by smoothing of the orthograde GP root filling only (52%).

Wälivaara el al. (14) investigated the periapical tissue response of 4 different retrograde root-filling materials: intermediate restorative material (IRM), thermoplasticized gutta-percha,
reinforced zinc oxide cement (Super-EBA), and mineral trioxide aggregate (MTA), in conjunction with an ultrasonic root-end preparation technique in an animal model. New root cement on the resected dentin surfaces was seen on all sections regardless of the used material. The IRM and MTA produced fewer signs of leakage, less unhealed periapical tissue, and a concomitant decreased inflammatory infiltration. New hard tissue formation, directly on the surface of the material, was seen only in the MTA sections. There was, however, no statistical difference in outcome among the tested materials.

References
13. Christiansen R, Kirkevang LL, Hørsted-Bindslev P, Wenzel A. Randomized clinical trial of root-end resection followed by root-end filling with mineral trioxide aggregate or smoothing of the orthograde gutta-percha root
Case 16

Endodontic treatment and apical surgery of the mandibular left first molar

Patient
70-year-old Caucasian male.

Chief complaint
The patient complains about occasional, sporadic pain in the posterior region in lower left mandible. The posterior molar tooth is tender when biting.

Medical record
Non-contributory.

Dental history
The patient was referred to the postgraduate clinic from private practice for endodontic treatment of the mandibular left first molar.
Tooth 35 was treated 2 years earlier (2009) at the Department of Oral and Maxillofacial Surgery; apicoectomy without root-end filling.

Clinical findings January 12th 2011
Soft tissue: Normal findings.
Dental: Tooth 34 is sound. Tooth 35 has a MODL composite restoration. Tooth 36 has a dental crown (Fig. 2).

Radiographic findings January 12th 2011
Dental: Tooth 36 has radiopaque coronal restoration. Tooth 35 has a radiopaque MOD restoration and a radiopaque root filling material.
Periodontal: Moderate attachment loss.
Apical: Tooth 46 has an apical radiolucency mesial root (PAI 3). Tooth 35 has an apical radiolucency (PAI 3).

Clinical tests January 12th 2011

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Fig. 3. Periapical radiograph 12.01.2011.

**Diagnosis January 12th 2011**

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**Treatment plan**

Non-surgical endodontic treatment of tooth 36.

**Treatment January 12th 2011**

2 carpules of Xylocaine/adrenaline was applied to establish anaesthesia. Access opening, bleeding from DB and MB canal, ML necrotic.  
*Mechanical*: Burs, NiTiFlex hand files #20, Biorace  
MB: #40/0.04 (BR5)/18mm  
ML: #40/0.04 (BR5)/18mm  
D: #50/0.04 (BR6) /19mm  
*Chemical*: 1% NaOCl, 17% EDTA.  
*Intracanal medicament*: CaOH$_2$.  
*Temporary filling*: Cavit, IRM.

**Treatment February 2nd 2011**

No symptoms. Tooth filled with gutta-percha and AH Plus. Sealed with IRM.

**Fig. 5. Master cone radiograph.**

**Fig. 6. Post-obturation radiograph.**

**Prognosis**

*Endodontic*: Good.  
*Tooth*: Good.

**Follow-up examination February 29th 2012 (1 year)**

Control at 1 year with x-ray indicated that the tooth was healing.

**Fig. 7. Periapical control radiograph 1 year.**
Follow-up examination April 2\textsuperscript{nd} 2014 (3 years)
The patient contacted the clinic due to a small discomfort and swelling of the gingiva next to tooth 36 (Fig. 8).

Clinical examination revealed a buccal swelling over the mesial root of tooth 36. Normal probing depths.

X-ray showed apical radiolucency. An OPG was ordered.

Medications: 8 months ago the patient started taking Calcigran Forte 1000mg/day and Alendronat 70mg once a week.

Treatment plan:
Apical surgery tooth 36.

Surgery April 22\textsuperscript{nd} 2014
5 carpules of Xylocaine/adrenalin was applied to establish anaesthesia. Marginal incision from 34-36 with vertical releasing incisions 34 mesially and 36 distally. Enucleation of granuloma overlying mesial root /surgical curettage. Detection of a vertical root fracture (VRF) mesial root. Discussion of treatment alternatives. The patient is reluctant upon extracting the tooth immediately. Root resection of mesial root was discussed as a treatment alternative with the conclusion that unfavourable occlusal loading could weaken the prognosis of the remaining distal root. It was decided to postpone the extraction and leave the tooth until symptoms.

Wound closure using non-absorbable suture material in sizes 4-0.
Postsurgical care.
Follow-up examination April 29th 2014 (1 week)
No symptoms. Suture removal.

Follow-up examination May 13th 2014 (1 month)
Recurrent swelling at the buccal aspect over the mesial root. Tender on biting. Referred to Department of Maxillofacial Surgery, Ullevål hospital the same day for removal of tooth 36.

Discussion
Vertical root fracture (VRF) is a longitudinally oriented fracture of the root that originates from its apical end and propagates coronally and is defined as one of the crack types (1). The prevalence of VRFs is reported to range from 11%–20% in extracted endodontically treated teeth (2). According to the literature, vertical root fracture is the third most common reason for extraction of an endodontically treated tooth (3). The final diagnosis of VRF can be complicated due to lack of specific signs, symptoms, and/or radiographic features and because several etiologic factors might be involved. Thus, the differential diagnosis from other pathologic entities might be difficult (4, 5, 6, 7, 8, 9, 10, 11). Tamse et al. (4) did an evaluation of 92 endodontically treated VRF teeth. They found that premolars were the predominant group (52%), and the maxillary second premolar accounted for 27%. In the mandible, the fracture was found in the mesial root in 17 of 22 molars (77%), whereas the distal root was fractured in only five teeth. In the maxillary molars, the fracture was in the mesiobuccal root (55.5%) and palatal root (33.3%). Only one distobuccal root was fractured. Pain (51%) or abscess (31%) was the major complaint. The most predominant clinical sign was deep pockets in 62 cases (67.4%), usually located at the buccal side of the tooth or the root involved. Other signs and symptoms were sensitivity to percussion, mobility, and a coronally located fistula. There was a combination of both a deep pocket and a fistula in 22 cases (23.9%). The most significant finding of bone rarefaction was that a lateral radiolucency plus the combination of periapical and lateral radiolucency was present in 58 cases (63%). Radiographic features of vertical root fractures vary widely. These may be observed on radiographs as diffuse widening of periodontal ligament, dislodgement of retro-filling material, vertical bone loss, separation of root fragments or displacement of apical portions of root. Presence of “radiographic halo” has been shown as a major finding in cases of vertical root fractures (12). A VRF might also be observed directly on a conventional radiograph in the event the x-ray beam is in the same plane as the fracture to be observed (13, 17).

In a systematic review by Tsesis et al. (14), the authors concluded that evidence-based data concerning the diagnostic accuracy and clinical effectiveness of clinical and radiographic dental evaluation for the diagnosis of VRF in endodontically treated teeth are lacking. Often, exploratory surgery is resorted in order to visualize the fracture. Raising a full thickness flap to directly visualize the root(s) under light, magnification, and with methylene blue staining does this. There is no substitute for direct visualization if the diagnostic and prognostic assessments remain questionable (15). The inability of conventional imaging techniques to consistently visualize VRFs precisely necessitates the development of alternative imaging...
modalities to improve their detection (16). Cone-beam computed tomography (CBCT), also called digital volume tomography (DVT), is a relatively new imaging modality in maxillofacial imaging, which involves three-dimensional (3D) slice acquisition at significantly reduced radiation doses. Presently CBCT has been shown to be promising in the early detection of vertical root fractures. Edlund et al. (17) designed a clinical pilot study to determine the diagnostic accuracy of CBCT for detection of suspected VRFs in endodontically treated teeth by using exploratory surgery to confirm the presence or absence of a fracture. Thirty-two teeth in 29 patients with clinical signs and symptoms suggestive of VRF were included in the study. Sensitivity of CBCT for detection of VRF was 88%, and the specificity was 75%. Positive predictive value (PPV), the proportion of teeth with fractures that were correctly diagnosed, was determined to be 91%, and negative predictive value (NPV), the proportion of teeth with no fractures that were correctly diagnosed, was 67%. The overall accuracy was 84%. Similar findings have been published in a few case reports (18, 19, 20). It has been shown that the presence root canal filling does not significantly influence the accuracy but reduces specificity in detection of vertical root fracture by CBCT (21, 22).

References
Surgical retreatment of the maxillary right first incisor

**Patient**
18-year-old Asian female.

**Chief complaint**
Non-contributory.

**Medical record**
Non-contributory.

**Dental history**
A specialist in pedodontics endodontically treated tooth 11 in 2009 due to a large apical radiolucency. There was a trauma in childhood. The tooth had a crown cemented soon after finishing of the root filling. The patient was referred to the postgraduate clinic from the public dentistry for surgical retreatment due to a persisting apical lesion.

**Clinical findings February 2\textsuperscript{nd} 2011**
*Soft tissue:* Gingivitis.
*Dental:* Tooth 11 has a dental crown. Teeth 12 and 21 have palatal erosive tooth loss, otherwise sound.

**Clinical tests February 2\textsuperscript{nd} 2011**

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Radiographic findings February 2\textsuperscript{nd} 2011
\textit{Dental}: Tooth 11 has a radiopaque dental crown and a radiopaque root-filling material.
\textit{Periodontal}: Gingivitis.
\textit{Apical}: Tooth 11 has an apical radiolucency (PAI 4), and overfilling of gutta-percha is suspected. Normal PDL space around teeth 12 and 21.

Diagnosis February 2\textsuperscript{nd} 2011

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Treatment plan
Apicoectomy with retrograde filling of tooth 11.
\textit{Treatment alternative}: non-surgical retreatment and observation.

Problem list
Thin gingival biotype.
Gingival recession and aesthetics.

Surgical treatment May 25\textsuperscript{th} 2011
At the day of surgery, clinical inspection showed a sinus tract tooth 11.

Fig. 5. A sinus tract was present apically around tooth 11, 25.05.2011.

The patient was given a chlorhexidine mouth rinse and local anaesthetic (Xylocaine/adrenaline) was injected. A papilla-base incision was made running from tooth 22 to tooth 13 with a vertical releasing incision on the distal aspect of 13. Elevation of the mucoperiosteal flap revealed pathologic fenestration and extruded gutta-percha. Osteotomy and curettage of granulation tissue. Biopsy. Root-end resection and retrograde preparation with ultrasonic instruments. Haemostasis with ferric sulphate. A retrograde filling of white MTA was applied. The operation site was rinsed with sterile saline and the flap sutured in place with supramide and dafilon 5.0 and 6.0. Prescription of Apocillin 660mg x4 for 7 days.
Postoperative instructions.

Complications during surgery: Flap-tearing and difficulties in suturing.
Fig. 6. Photo after root-end preparation.

Fig. 7. Photo showing retrograde filling with MTA.

Fig. 8. Post-operative radiograph before suturing.

Fig. 9. Suturing.

Fig. 10. Photo 2 weeks post-operatively.

Prognosis
Endodontic: Good.
Tooth: Good.
Surgery: Unpredictable tissue healing.

Follow-up examination May 31\textsuperscript{th} 2011 (one week)
Suture removal. The patient had not experienced any postoperative problems. The sinus tract was closed but secondary healing was observed in the midline.

Follow-up examination June 8\textsuperscript{th} 2011 (2 weeks)
The wound healing was good. There was a small gingival recession. The patient had not noticed any changes in gingival levels.

Follow-up examination January 19\textsuperscript{th} 2012 (7 months)
No further gingival recessions. The tooth was asymptomatic. Radiographic signs of healing with a continuous PDL space surrounding the apex.
Discussion
When designing a tissue flap, various modes of incision can be selected, including horizontal, sulcular, submarginal, and vertical releasing incisions. The tissue flap in its entirety can be a full-thickness or a combination of a full- and a split-thickness flap (1). Certain basic principles must be considered before deciding on the type of incision and the flap design: regional anatomy, proper access to the periapical pathosis, periodontal conditions, state of coronal tooth structure, the nature and extent of coronal restorations and operators choice.

The papilla base incision (PBI) for the marginal mucoperiosteal flap was suggested to prevent loss of interdental papilla height. This incision allows the preservation of the entire papilla, thus eliminating any substantial loss of height as a result of the surgical or healing process (2).

In 2003 Velvart et al. (3) investigated papilla healing in twelve patients after apical surgery in anterior and molar teeth using the PBI and sulcular full-thickness flap. After 1- and 3-months the PBI allowed recession-free healing whilst complete mobilization of the papilla led to a marked loss of the papilla height. Velvart et al. (4) compared the long-term loss of papilla height when using either the PBI or the standard papilla mobilization incision in marginal full thickness flap procedures. They found a significant difference between the two incision techniques for all recall appointments (1-, 3-, and 12-months). Von Arx et al. (5) evaluated gingival recession following apical surgery of 70 anterior teeth (central and lateral incisors, canines, and first premolars). They concluded that gingival biotype, pre-treatment periodontal pocket, and type of incision might significantly influence changes in gingival margin (GM) and clinical attachment level (CAL). In their study the submarginal incision showed significantly less gingival recession compared with the intrasulcular incision, papilla-base incision or papilla-saving incision.

In a study by von Arx et al. (6) long-term changes in periodontal parameters were evaluated after apical surgery of 186 teeth. Significant changes in GM and CAL were observed at facial sites during the first year after surgery. However, none of the periodontal parameters changed significantly between 1 and 5 years after apical surgery. The type of incision technique was found to be the major factor affecting changes in GM and CAL between baseline and 1 year after surgery. Age, smoking, and type of periapical healing were the variables influencing the periodontal parameters.
over the longer observation period of up to 5 years. 
It has been demonstrated that the gingival biotype could be related to complications following flap-procedures. The thin biotype is more prone to gingival recession and an unpredictable tissue healing should be expected (7). The type of incision may be a predictor for complications following surgery of a tooth with a thin biotype: higher probability of recession for intra-sulcular incision, more scarring for submarginal incision, more complications during flap elevation such as flap tearing, and dehiscence and difficulties in suturing (8).

References
Case 18

Evaluation of a root-filled mandibular right first molar and surgical retreatment of the maxillary left first molar with a sinus tract.

Patient
45-year-old Asian male.

Chief complaint
The patient complains about previous pain and sinus tract related to a mandibular left molar tooth. He tells that the tooth was root-filled in 2012 and that his dentist has prescribed antibiotics at several occasions after finishing the root filling. At present the tooth is tender when chewing. He also complains about tenderness when chewing in the posterior region in the upper left maxilla. He has noticed a draining sinus tract in this area.

Medical record
Podagra (hyperuricaemia), allergy (pollen), sleeping disorder. He has mild dental fear.
Medications: Ritalin, Zyrtec.

Dental history
The patient was referred to the postgraduate clinic from private practice for endodontic evaluation and treatment of the mandibular right first molar and the maxillary left first molar.

Tooth 46 was root-filled by the referring dentist 2 years ago and has a history of pain, swelling and sinus tract. Tooth 26 was root-filled by a specialist in endodontics 4 years ago and a crown has recently been made.

Clinical findings February 7th 2014
Soft tissue: Sinus tract region 26.
Dental: Tooth 46 has an ODL composite restoration. Tooth 26 has a dental crown, tooth 27 has a composite restoration with poor margins and caries.
Generalized erosive tooth surface loss.

Fig. 1. Frontal view.

Fig. 2. Occlusal view tooth 46.

Fig. 3. Buccal view tooth 26; sinus tract.
Clinical tests February 7th 2014

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Radiographic findings February 7th 2014

*Dental*: Tooth 46 has a radiopaque MOD filling and a radiopaque root filling material. Tooth 26 has a radiopaque dental crown and a radiopaque root-filling material.

*Periodontal*: Chronic marginal periodontitis.

*Apical*: Tooth 46 has apical radiolucencies mesial and distal root (PAI 4) and a lateral radiolucency distal root.

Tooth 26 has apical radiolucencies mesial and distal root (PAI 3) and an interradicular radiolucency.

Diagnosis February 7th 2014

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Treatment plan

Access preparation and visual inspection with magnification of tooth 46; longitudinal fracture?

Surgical retreatment of the buccal roots of the endodontically treated maxillary left first molar.
Problem list
Anxiety.
Longitudinal fracture tooth 46?
Interradicular radiolucency tooth 26.

Treatment February 7th 2014
Rubberdam was applied. Access preparation and identification of a crack affecting the distal marginal ridge of the mandibular right first molar; the crack has propagated into the distal root. The patient is told that the prognosis is poor and removal of the tooth is recommended.

Follow-up April 29th 2014 (by phone)
The patient postponed the removal of tooth 46 and sent a photo showing a fracture of the tooth (Fig. 9). He was advised to contact his dentist for removal of 46.

Surgery March 25th 2014
The patient was given a chlorhexidine mouth rinse and local anaesthetic was injected. A marginal incision was made running from tooth 27 to tooth 25, with vertical releasing incisions 25 mesially and 27 distally. Elevation of the mucoperiosteal flap. Osteotomy and curettage of granulation tissue. Adrenaline and ferric sulphate haemostasis. A retrograde filling of white MTA was applied. The operation site was rinsed with sterile saline and the flap sutured in place with supramide 4.0 and 5.0. Postoperative instructions. Paracetamol.

Complications during surgery: Large defect in furcation area. Limitations to visibility and accessibility of the root tips.

Prognosis
Endodontic: Uncertain.
Tooth: Uncertain.
Follow-up examination March 27th 2014 (2 days)
The patient experienced post-operative discomfort; swelling and mild pain/malaise and fever. He contacted us due to a planned flight abroad the same day.
Clinically: heat, pain, redness, and swelling are noted in the cheek at the operation site. Secondary healing region 25.
Prescription of phenoxymethylpenicillin (660mgx4 for 7 days).

Follow-up examination April 1st 2014 (1 week)

Follow-up examination April 11th 2014 (10 days)
No swelling. Satisfactory healing at the operation site.

Follow-up examination June 17th 2014 (3 months)
The patient has no complaints. Radiograph shows initial healing of apical radiolucencies. Interradicular radiolucency seems unchanged.

Discussion
The persistence of microorganisms plays a significant role in endodontic treatment failures (1). Although several factors might be involved with endodontic treatment failure, this usually results from the presence of bacteria in the apical portion of the root canal (2-4). The absence of coronal sealing, micro leakage, failures in chemo mechanical preparation, and limit and quality of root filling favour the survival of microorganisms after endodontic treatment or reinfection of the canal and may lead to endodontic treatment failure (2, 4, 5).
There is great variation in the composition of the microbiota.
associated with endodontic failure and the levels of the bacterial species detected in root canals, which may occur as a result of the different diagnostic techniques used (6-10). This microbiota has been described as being mainly composed of facultative anaerobic gram-positive species. *Enterococcus* is the genus most frequently described, and *Enterococcus faecalis* is the species more commonly found in these lesions (6-10).

However, recent studies have questioned the hypothesis that *E. faecalis* is the main species associated with endodontic failures (11-16). Murad et al. (17) investigated the composition of the root canal microbiota from 36 root canals with persistent endodontic infection. The presence, levels, and proportions of 79 bacterial species were determined by checkerboard DNA-DNA hybridization. The highest mean levels were found for the following species: *E. faecium*, *Dialister pneumosintes*, *Staphylococcus epidermidis* and *Helicobacter pylori*. No correlation was found between any of the species tested and clinical findings; however, periapical lesions with the largest areas presented higher counts of gram-negative and rod species. The levels of gram-negative species were statistically significantly higher than those of the gram-positive species.

Sodium hypochlorite (NaOCl) is the main irrigating solution used in root canal preparation to dissolve vital and necrotic tissue and eliminate the bacteria of instrumented root canals (18, 19). Concomitant with the focus on *E. faecalis* as a key organism in persistent infections, modifications like the addition of chlorhexidine (CHX) were introduced. Many authors have stressed the importance of using antimicrobial irrigants during chemomechanical preparation to ensure complete disinfection when this particular organism is suspected. CHX is a broad-spectrum antimicrobial agent that has been reported to be an effective medicament in endodontic therapy. It has been recommended as a final irrigating solution in view of its antimicrobial action (20), proven substantivity (21), and capacity to inhibit the adherence of certain bacteria to dentin (22).

Basrani et al. (23) studied the efficacy of CHX and calcium hydroxide (Ca(OH)\(_2\))-containing medicaments against *E. faecalis* in vitro. They concluded that CHX was significantly more effective against *E. faecalis* than Ca(OH)\(_2\).

In another study by Zamany et al. (23), the authors demonstrated that an additional rinse with 2% chlorhexidine resulted in enhanced disinfection of the root canal system.

**References**


21. Mohammadi Z, Abbott PV. Antimicrobial substantivity of


Case 19

Endodontic retreatment of the maxillary right first molar with a sinus tract

Fig. 1. Frontal view.

Fig. 2. Photo showing sinus tract tooth 16.

**Patient**
60-year-old Caucasian female.

**Chief complaint**
She had noticed a swelling on the gingiva in the molar region in the right maxilla.

**Medical record**
*Medical condition:* Hypothyroidism.
*Medications:* Esidrex, Levaxin.

**Dental history**
Tooth 16 had been treated endodontically more than 10 years ago. In 2012 she had a bridge made at the student clinic, keeping the pre-existing casted conus tooth 16. The patient was referred to the postgraduate clinic from the student clinic for endodontic retreatment of the maxillary right first molar.

**Clinical findings January 31st 2014**

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**Radiographic findings January 31st 2014**

*Dental:* A radiopaque dental bridge abutment teeth 14 and 16, and replacement tooth 15 is seen. Tooth 16 has a radiopaque root filling material.

*Periodontal:* Attachment loss.

*Apical:* An apical radiolucency is seen surrounding the mesial root of tooth 16. Normal PDL space around the root apex of tooth 14 (Fig. 3). The radiopaque gutta-percha point in the sinus tract can be seen in Fig. 4.

**Soft tissue:** A sinus tract in relation to tooth 16 was observed (Fig. 2).

*Dental:* A dental bridge restoration comprising teeth 14, 15, and 16.
Fig. 3. Periapical radiograph 31.01.2014.

Fig. 4. The sinus tract originates from tooth 16.

Fig. 5. Working length radiograph.

**Diagnosis January 31st 2014**

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<th>Code</th>
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<td>Chronic marginal periodontitis</td>
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<tr>
<td>Apical</td>
<td>K04.62</td>
<td>Chronic apical periodontitis with sinus tract</td>
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**Treatment plan**

Non-surgical retreatment of the mesial root of the endodontically treated maxillary right first molar
Observation of sinus tract.
If no healing apicoectomy is planned.

**Problem list**

Previous transportation of mesiobuccal canal.
Negotiating the apical third beyond the curvature.
Sinus tract.

**Treatment January 31st 2014**

Access opening and localisation of MB canal orifice with the old GP.
Mechanical: Burs, NiTiFlex hand files
MB: #55/18mm
Not able to negotiate beyond the curvature. Unable to localize a second MB canal.

*Chemical:* 2% Chlorhexidine, 17% EDTA.

*Intracanal medicament:* Ca(OH)$_2$.

*Temporary filling:* IRM.

**Treatment February 18th 2014**

Asymptomatic. Regression of sinus tract is seen (Fig. 6).

The tooth was filled with gutta-percha and AH Plus. Sealed with composite.

**Fig. 6. Photo showing recession of sinus tract.**

**Fig. 7. Master cone radiograph.**
Fig. 8. Post-obturation radiograph.

Prognosis
*Endodontic*: Uncertain.
*Tooth*: Good.

Follow-up examination May 6\textsuperscript{th} 2014 (3 months)
No symptoms but the patient noticed that the sinus tract is still there. Surgery is planned.
*Problem list*: Reduced bone level.

Fig. 9. Periapical radiograph 06.05.2014.

Fig. 10. Persisting sinus tract 3 months.

Surgery May 13\textsuperscript{th} 2014
The patient was given a chlorhexidine mouth rinse and local anaesthetic was injected. A marginal incision was made running from pontic 25 to tooth 17 with a vertical releasing incision on the mesial aspect of tooth 25. Elevation of the mucoperiosteal flap. Osteotomy and curettage of granulation tissue. Small sinus perforation. Gauze sponge sutured in place before root-end resection and retrograde preparation with ultrasonic instruments. Haemostasis using Xylocaine/adrenaline. A retrograde filling of white MTA was applied. The operation site was rinsed with sterile saline and the flap sutured in place with supramide 4.0 and 5.0. Postoperative instructions.

Fig. 11. Gauze sponge sutured in place to protect sinus.

Fig. 12. Root resection.

Prognosis
*Surgery*: Good.
*Tooth*: Good.

Follow-up examination September 5\textsuperscript{th} 2014 (4 months)
No symptoms. Closed sinus tract.
Discussion

When planning periapical surgery in maxillary premolars and molars, the proximity of the maxillary sinus has to be considered. The maxillary sinus is an osseous cavity with the shape of a pyramid, the base being the nasal antral wall and the rounded tip lying in the zygomatic bone (1). The maxillary sinus is lined by a ciliary epithelium containing beaker cells. This lining transports bacteria and other possible foreign material toward the maxillary ostium on a thin mucous layer. The maxillary ostium represents the opening to the nasal cavity, lying below the middle nasal concha. A healthy maxillary sinus is aseptic in 80 to 100% of the population, containing neither bacteria nor any other foreign material (2). The main purposes of the maxillary sinus have been postulated as a space for conditioning of the breathing air, a means of reducing the weight of the skull, and a resonance chamber for the human voice (1). It also functions as an immunologic barrier (2).

There is a very close anatomic relationship between the root tips of the maxillary posterior teeth and the sinus floor. Eberhardt et al. (3) measured the distances between maxillary molar and premolar roots and the maxillary sinus. Their findings showed that the mean distance of the maxillary posterior teeth to the floor of the maxillary sinus is 1.97 mm. Thus, endodontic surgery of premolars and molars can produce an accidental oroantral communication (2, 4, 5, 6, 7 and 8) referred to as OAC. The OAC may result in acute or chronic sinusitis through displacement of bacteria from the infected periapical tissue, resected root tips, or bony drilling dust into the sinus (2).

Hauman et al. (9) addressed anatomic and clinical aspects of the maxillary sinus in their review article. A key finding was that the borders of the maxillary sinus are projected as a thin radio-opaque line on periapical radiographs. In some cases with chronic periapical periodontitis, this line can be well-defined and easy to trace, although in others the radio-opaque line appears less defined or blurred.

Oberli et al. (2007) attempted to find out whether conventional periapical radiographs can be used to determine the risk of creating an oroantral communication (OAC) while performing periapical surgery on maxillary premolars and molars. Perforation of the sinus membrane (also referred to as the Schneiderian membrane) occurred in 12 cases (9.6%). Exposure of the membrane without rupture occurred in 15 cases (12%). It was found that the distance between the apex or the apical lesion and the sinus floor did not serve as a predictor of a possible sinus membrane rupture. On the other hand, if the radiograph showed a distinct distance between the lesion and the sinus floor, there was an 82.5% probability that OAC would not occur.
Additionally, a blurred radiographic outline of the periapical lesion did not indicate an increased risk of sinus membrane rupture. They concluded that conventional periapical radiographs couldn’t be used as predictors for perforation of the maxillary sinus during periapical surgery. However, radiographs with a specific distance between the periapical lesion and the sinus floor point toward a very low risk of accidental sinus perforation during periapical surgery (10).

Another issue is whether an OAC must be considered a “surgical accident” (6). A review article of the literature on periapical surgery by Garcia et al. (11) confirms that none of the included studies found a significant difference in the healing outcome or the postoperative sequel when accidental OAC had occurred. However, the importance of prevention of introduction of foreign bodies, drilling dust, or bacteria into the maxillary sinus during the surgery is emphasised. In case of OAC, Jerome and Hill (12) suggested protecting the OAC with a gauze pad once the root tip had been resected. Furthermore, magnifying surgical aids such as loupes, endoscopes, and microscopes permit the surgeon to make a precise diagnosis and perform minimally invasive low trauma surgery (13, 14).

The occurrence of intraoperative OAC during periapical surgery is not a severe surgical accident. A proper operation technique avoiding dislocation of drilling dust, root tips, infected tissue, and haemostatic and filling material into the maxillary sinus will allow healing without complications even if OAC should occur.

References

9. Hauman CHJ, Chandler NP, Tong DC. Endodontic implications of


Treatment of multiple idiopathic cervical root resorption

**Patient**
51-year-old Russian male.

**Chief complaint**
Firstly, he complains about lots of past problems with his teeth in the left maxilla that finally had to be extracted. At present he feels discomfort in the gingiva around tooth 14 as well as sensitivity to cold in this area. He thinks the problems started when a crown was made 4 years earlier, and that the gingival discomfort got worse as time went by. Secondly, he complains of sensitivity to cold in the posterior left side of the mandible. He further tells that he is grinding his teeth and that his dentist told him that he is a bruxist.

**Medical record**
Non-contributory.

**Dental history**
The patient was referred to the post-graduate endodontic clinic from private practise because of suspicion of a resorption (internal) on tooth 14 below a crown made 4 years earlier. It was observed on a routine x-ray. There was no history of trauma or orthodontic treatment.

**Clinical findings August 30th 2013**

*Soft tissue:* An aphthous lesion was observed at the buccal aspect between tooth 13 and tooth 14. A gingival pocket of 5mm was probed at the mesiopalatal aspect of tooth 14. Sensitivity to airspray and explorer was noted on the mesiobuccal side of tooth 37 and palatal side of tooth 15.

*Dental:* Tooth 13 has a composite filling. Tooth 14 has a dental crown and a mesiopalatal subgingival cavity. Tooth 15 has a composite filling. Tooth 37 has an occlusal amalgam filling and a small mesiobuccal.
Clinical tests August 30th 2013

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Radiographic findings August 30th 2013

Dental: Tooth 14 has a dental crown and a radiolucency is seen in the cervical area of the tooth. Tooth 15 has a MOD composite filling. Tooth 37 has an occlusal radiopaque filling and a possible pathologic radiolucency is seen at the mesial aspect of the tooth.

Periodontal: Chronic marginal periodontitis.

Apical: Tooth 14 has a lateral radiolucency, mesial aspect, in the coronal third of the root. Teeth 15 and 37 have a continuous PDL space.

Based on clinical and radiographic findings, and with the suspicion of an additional resorptive lesion on tooth 37, the patient was referred for cone-beam CT. In addition to cervical resorption on teeth 14 and 37, a cervical resorption on tooth 15 was identified on the CT scans.

Fig. 4. Periapical radiograph with gutta-percha inserted in the periodontal pocket.

Fig. 5. Bite-wing to visualize suspected cavity 37m.

Fig. 6. Orthopantogram.

Radiologic description (in Norwegian) from the Department of Maxillofacial Radiology

Radiologisk rapport av Tegneparapet med radiologisk diagnosi (R).

1. Det var et trekk på periodontal pocket i coronal third, ca 2 mm i bredden.
2. Det var en fremstøtt resorpsjon i koronal third, ca 2 mm i bredden.
3. Det var en radiopak filling i koronal third, ca 2 mm i diameter.
4. Det var en lateral radiolucency i mesial aspect, coronal third, ca 2 mm i diameter.
5. Det var en radiolucency i coronal third, ca 2 mm i diameter.
6. Flere krenker med tap av kraniumhette i coronal third, ca 2 mm i diameter.
Diagnosis

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**Treatment plan**
Flap-elevation to fill the defects in teeth 37 and 15 externally with composite Surgical extraction of tooth 14. Treatment alternatives were thoroughly discussed: pulpectomy tooth 37 before surgery? Root canal treatment and filling of resorption defect tooth 14?

**Problem list**
Extension of lesion tooth 37. Preservation of bone tooth 14 prior to implant therapy.

**Surgery November 19th 2013**
Surgery tooth 37:
Marginal incision from 37 to 35. Cleaning of resorption lacunae: topical application of a 90% aqueous solution of trichloroacetic acid and curettage. Placement of a composite restoration. Suturing. The lesion was more advanced in apical direction than observed on CT scans, displaying fibro-osseous characteristics with deposition of ectopic bone-like calcifications both within the resorbing tissue and directly on the dentin surface. No pulpal perforation.

**Prognosis**
Tooth: Uncertain.

**Follow-up examination November 26th 2013 (1 week)**
The patient is having pain. He describes increased sensitivity to cold and warm drinks region 37. Clinically there is drainage of pus from a periodontal pocket at the buccal aspect. Tooth 37 is sensitive to percussion. Treatment: Sterile saline rinse, observation.

**Follow-up and treatment December 6th 2013**
The patient complains about intense pain and increased sensitivity region 37. The pain is worse in the evening; jaw pain that is radiating to the ear. He uses paracetamol/codein at a daily basis. Clinically tooth 37 is hypersensitive to cold stimulus (endo ice), lingering pain. Optimal healing is noted after surgery. Diagnosis: K04.01 acute irreversible pulpitis. The patient is not interested in a root filling. It was decided to extract the tooth non-surgically (Fig. 10, 11).
Histological findings tooth 37
(Laboratorium of pathology, AK Goplen)
*Diagnosis*: “Changes consistent with resorption of cementum and with virtually empty pulp”.

**Surgery February 4th 2014**
Surgery teeth 14 and 15:
A palatal marginal incision was made from the canine to the molar region (13-16). *Tooth 15*: Small resorption defect, minimal osteotomy required, cleaning of resorption lacunae and placement of composite filling.

**Prognosis**
*Tooth 15*: Uncertain.

**Follow-up examination February 11th 2014 (1 week)**

**Follow-up examination May 27th 2014**
The patient describes mild sensitivity to cold in the right maxilla. Two implants are placed in region 14 and 36.
*Clinically*: Teeth 15 and 16 are sensitive to air spray, more pronounced on tooth 16. PPD 4mm tooth 15, palatal aspect. No symptoms on palpation and percussion.
A new recall is planned in 6 months.
**Discussion**

Invasive cervical resorption (ICR) is defined as ‘a localized resorptive process that commences on the surface of root below the epithelial attachment and the coronal aspect of the supporting alveolar process, namely the zone of the connective tissue attachment’ (1). Characterized by its cervical location and invasive nature, this resorptive process leads to the progressive and usually destructive loss of tooth structure. The resorbed tissue is replaced by highly vascular tissue that may become visible through thin residual enamel as pinkish discoloured tooth (2).

Clinically, invasive external resorption is associated with inflammation of the periodontal tissues and does not have any pulpal involvement (3). The pulp remains protected by a thin layer of predentin until late in the process and it has been postulated that bacteria in the sulcus sustain the inflammatory response in the periodontium (1, 4).

This feature differentiates cervical external resorption from another type of inflammatory resorption called external inflammatory resorption, which is continued by necrotic pulp tissues and an infected root canal content (5). The aetiology of invasive cervical resorption is inconclusive, however, several potential predisposing factors have been identified (1):

A. Physical trauma
   a) Orthodontic treatment
   b) Orthognathic surgery
   c) Transplanted teeth
   d) Trauma
   e) Bruxism
   f) Guided tissue regeneration

B. Chemical Agents
   a. Intracoronal bleaching
   b. Secondary bone grafting in unilateral complete cleft palate patient.
   c. Tetracycline conditioning of root

The clinical presentation of invasive cervical resorption varies considerably depending on the extent of the resorptive process. The condition is usually painless and while a pink discoloration of the crown indicates the resorptive process, some teeth give no visual signs and diagnosis is usually the result of a routine or sometimes a chance radiologic examination. Multiple resorptions can occur, particularly when there has been a history of orthodontic treatment and a full mouth radiographic examination should follow the identification of any tooth showing evidence of invasive cervical resorption.

Based on the invasiveness of the lesion, Heithersay (4) introduced a clinical classification of invasive cervical resorption (6):

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

Class 2- Denotes a well-defined resorptive lesion that has penetrated close to the coronal pulp chamber but
shows little or no extensions into the radicular dentine
Class 3- Denotes a deeper invasion of dentine by resorbing tissue, not only involving the coronal dentine but also extending into the coronal third of the root
Class 4- Denotes a large invasive resorptive process that has extended beyond the coronal third of the root

Early defects are commonly detected as chance findings on radiographs. The severity of the lesion determines its radiographic appearance. The lesion classically presents as an asymmetrical radiolucency with ragged or irregular margins in the cervical region of the tooth. Early lesions might be radiolucent; however, more advanced lesions might have a mottled appearance caused by the osseous nature of the advanced lesion. The outline of the root canal should be visible and intact, indicating that the lesion lies on the outer surface of the root (7).

It has been shown that conventional radiographic techniques reveal limited information on the true extent and nature of the resorptive lesion (8). In recent literature, cone beam computed tomography (CBCT), has been used to assess ICR lesions. The position, depth in relation to the root canal, and ultimately the restorability of the tooth can be assessed objectively before any treatment is carried out (8, 9).

Heithersay (10) reported on a non-surgical treatment regime that were applied to 101 teeth from 94 patients displaying varying degrees of invasive resorption and followed up for a minimum of 3 years. It involved the topical application of a 90% aqueous solution of trichloroacetic acid to the resorptive tissue, curettage, endodontic treatment where necessary, and restorations with glass-ionomer cement. The result was complete success in Class 1 and Class 2 resorption. Of the 63 teeth classified with Class 3, 61 (96,8%) showed resorption control. When all factors (resorption control, angular bone loss, periapical changes and extraction) were included in the assessment, the overall success rate of Class 3 treatment was 77,8%. In Class 4 resorption 16 teeth were treated and the results showed a survival rate of 50% and a success rate as judged above 12,5%. This represents an unsatisfactory outcome for this treatment regimen when applied to Class 4 resorption, and alternative prosthodontic replacement is generally suggested (2).

Multiple idiopathic cervical root resorption (MICRR) is an uncommonly reported phenomenon that may affect varying numbers of teeth. The condition was first identified 80 years ago by Mueller who reported the first case of idiopathic cervical root resorption in 1930 (11), and since that time approximately 30 cases have been reported (12-25); the number of involved teeth ranges from three to more than 20 per subject (13). The distribution varies from a single region (e.g. mandibular incisors) to most teeth within one arch or more generally distributed throughout the entire dentition. A similar condition involving apical resorption has also been described (26).

Most affected individuals are healthy, with non-contributory medical histories. A predilection for young females has been reported (12, 27).

An attempt has also been made to link multiple idiopathic cervical root resorption to feline invasive cervical resorption (14, 28). These studies raised the question of a possible role of a feline virus as an etiologic co-factor in MICRR.
Liang et al. (12) reviewed the literature on MICRR. They reported the history, clinical findings and radiographic appearance of four unreported cases of multiple idiopathic cervical root resorption and did a systematic literature review of this condition. MICRR was an incidental finding on routine clinical and radiographic examination. No correlation was seen between this type of resorption and any medical or dental finding. Radiographically, the lesions were found to begin at the cemento-enamel junction and then either progress to involve the entire cervical region or, at some point, spontaneously arrest. Those cases that progressed to involve the entire cervical region required extraction. The number of teeth that demonstrated this condition ranged from 5 to 24 per patient. More teeth became involved as the condition was followed in time. There was no detectable frequency of occurrence for any particular dental region or tooth among the involved teeth. Of a total of 18 patients, 13 were females whose ages ranged from 7 years to 68 years. Ten of the 18 patients were Caucasian.

In the present case, there was no obvious etiologic factor identified, and the lesion was considered to be idiopathic form.

References
12. Liang H, Burkes EJ, Frederiksen NL. Multiple idiopathic cervical...


