UNIVERSITY OF OSLO
Dental Faculty

Department of Endodontics

Postgraduate Program in Endodontics

Case Book
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Endodontic Treatment Guidelines

1. Treatment of Tooth without Apical Periodontitis:

- Preoperative radiograph
- Anaesthesia
  - Removal of plaque, caries and leaking fillings
  - Tooth build-up if required for isolation
- Access cavity preparation
- Localization of canal openings
- 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
  - Goal: 1mm short of the anatomic apex
- Instrumentation to desired apical length and size
  - Frequent irrigation with 0.5% sodium hypochlorite (NaOCl)
  - Final irrigation with 17% ethylenediamine tetraacetic acid (EDTA) and NaOCl
- Drying of the canals with paper points
- Master point radiograph
- Root filling:
  - Obturation techniques:
    - Lateral compaction
    - Continuous wave compaction
  - Sealers: AH Plus, Epiphany/Real Seal
  - Core materials: Gutta-percha, Resilon

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

2. Treatment of Tooth with Apical Periodontitis:

First Visit:

- Anaesthesia
  - Building up the tooth if required for aseptic reasons
  - Removal of plaque, caries and leaking fillings
- Application of rubber dam
  - Disinfection of the working field with 0.5% chlorhexidine in 70% ethanol
- Access cavity preparation
  - Localization of canal openings
- Measurement of working length, using apex locator & working length radiograph
Goal: 1mm short of the anatomic apex
- Instrumentation to desired apical size
- Frequent irrigation with 0.5% sodium hypochlorite (NaOCl)
- Final irrigation with 17% ethylenediamine tetraacetic acid (EDTA) and NaOCl
- In retreatment cases: Final irrigation with 17% EDTA and 2% chlorhexidine digluconate
- Drying of the canals with paper points
- Intracanal dressing: calcium hydroxide (Ca(OH)$_2$)
- Cleaning the pulp chamber
- Two-layered temporary top filling: Cavit G and IRM
  In special situations topped by a temporary composite filling
- Removal of rubber dam

Second Visit:
- As described for treatment of tooth without apical periodontitis

Time Plan:
Tooth without Apical periodontitis:
- One-appointment treatment is the standard (goal)
- When time does not allow or there are other reasons, e.g. difficulty in controlling bleeding in the canal, the canal is filled with Ca(OH)$_2$ and the treatment will be finished at the second appointment, preferably 1 – 2 weeks later.

Tooth with Apical Periodontitis:
- Two-appointment treatment is the standard (goal)
- 2 – 3 weeks between 1$^{st}$ and 2$^{nd}$ appointment is the standard (this is mainly for practical reasons: minor after-treatment symptoms usually gone after 1 – 2 weeks)
- Long-term Ca(OH)$_2$ treatment (first for 2 – 3 weeks, then radiographic and clinical control every 3 months) is to be considered when:
  o A large lesion is present
  o Sinus tract does not close
  o Other symptoms continue

NB: Surgery may be an alternative to long term Ca(OH)$_2$ treatment

3. Emergency Treatment:

Acute Pulpitis:
- Eugenol pulpotomy
  - ZOE filling in a deep cavity
  - Eugenol pellet in pulp chamber + IRM top filling
  - No studies published of the effectiveness of Ca(OH)$_2$
  - IRM only without eugenol pellet has not shown to be effective
- Systemic medicaments
  - NSAID prescribed when pain is a problem
  - Systemic antibiotics not recommended
Acute Apical Periodontitis:

- Incision of abscess and drainage, if applicable
- In some cases 1 – 2 mm overinstrumentation with #10 K-file to release pus
- Ca(OH)₂ dressing:
  - Preparation of canals and Ca(OH)₂ treatment is the optimal treatment
- Eugenol pulpotomy:
  - Used only if preparation of canals not possible (e.g. time limitation)
- Systemic medicaments
  - NSAID prescribed when pain is a problem
  - Systemic antibiotics when general indications present

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

- All relevant radiographs mounted on viewer or screen
- Anaesthesia
- 1 minute mouth rinse with Corsodyl® (Chlorhexidine 2mg/ml)
- Incision:
  To provide a clearly defined opening to bone for maximum tissue thickness reflection, and to establish an easily identifiable and accessible border for reapproximation and reattachment.
- Elevation:
  To gain access to bone by separating a full mucoperiosteal flap of tissue and raising it from its underlying hard tissue attachment. The periosteum must be reflected as an integral part of the flap.
- Retraction:
  To hold the flap away from the surgical site, providing maximum access and visibility, without causing harm to the flap or the surrounding tissues.
- Flap design:
  1. Intrasulcular flap:
     - Mainly indicated for treatment of cervical resorptions, perforations, and resections of short roots, and mainly used in posterior apical surgery.
     - Comprises a horizontal incision extending 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.
     - If the access is too limited, the triangular flap can easily be converted into a rectangular flap by placing an additional releasing incision at the distal end of the horizontal incision.
2. Submarginal flap:
   - Fear of even small recessions is the driving force for considering the submarginal flap.
   - When properly planned and performed, the submarginal flap will leave the marginal gingiva untouched and does not expose restoration margins.
   - The submarginal flap design also referred to as an Ochsenbein–Luebke flap is similar to the rectangular flap, with the difference that the horizontal incision is placed within the attached gingiva.
   - The two vertical incisions are connected by a scalloped horizontal incision, performed roughly parallel to the marginal contour of the gingiva.
   - The submarginal incision should only be used when there is a broad zone of attached gingiva with a minimum of 2mm.

![Submarginal Flap Diagram]

- Osseous entry or osteotomy:
  Involves removal of cortical and cancellous bone to gain direct access to the apical portion, and the lateral aspects if necessary, of the root or roots of a tooth where periradicular periodontitis is present. There may be fenestration of through the buccal cortical plate, thus providing instant access to the root tip. A periradicular soft tissue lesion may have perforated the cortical plate, in which case curettage of the lesion permits access to the root either without bone removal or minimal extension of the borders of the defect for improved access. Frequently, however, there will be an intact cortical plate that requires removal to expose the surgical site. This is achieved routinely by using rotary instruments.
• 3–4 mm of the apical portion of the root should be clearly exposed, at least to the buccal, mesial and distal. Following resection of the required 3 mm of root tip, there should be good visibility of the resected root surface for the next stage of the procedure.

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

• Biopsy:
  Although there is unanimous agreement that the vast majority of soft tissue lesions are either granulomas or radicular cysts, any soft tissue lesion removed during the surgical procedure should be submitted for biopsy.

• Root end resection:
  To expose the foramen/canal for inspection, by sectioning the apical segment of the root and/or bevelling it to the line of sight.

• Ultrasonic root end preparation:
  To provide a clean, well-shaped class I cavity in an apically resected root that is parallel to the long axis of the root, sufficiently centred to offer adequate root wall thickness, and deep enough to receive and retain a non-toxic, biocompatible filling material.

• Haemorrhage control:
  To maintain a clean, dry and highly visible surgical site, and spontaneously manage and control any abnormal bleeding. This is achieved through use of:
  - Local anaesthetic solutions possessing vasoconstrictor properties
    - Xylocain-Adrenalin® 10mg/ml + 5µg/ml
    - Stryphnon gauze (Adrenalonchlorid 0,33 mg/cm2)
    - Ferric sulfate (Fe2[SO4]3 with 15.5% astringent and 21% stasis)

• Root-end filling using either IRM or MTA:
  - The surgical site must be aspirated of all fluids and bleeding controlled.
  - The cavity preparation is flushed clean and thoroughly dried with short-cut segments of sterile paper points.
  - The IRM or MTA is carried to the preparation in small semisolid increments with plastic instruments or carvers.
  - Use of the MAP system (Micro-Apical Placement) or the MTA pellet forming block will ease the application of MTA.
  - Pluggers of various sizes and angles are used to effectively condense the material to the depth of the preparation.
Prior to wound closure, the surgical site is irrigated with saline solution to remove debris, and tissue edges are re-approximated in their correct position to promote healing by primary intention. Compression of the repositioned tissue with a saline-moistened 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 non-absorbable suture material in sizes 4-0 and 6-0.
- Postoperative radiograph is taken for control of procedures and as reference for follow-up.
- Postsurgical care:
  A disposable ice pack is covered with soft towelling, 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 600 mg every 4 to 6 hours for the first 48 hours.
  The patient is advised to rinse with Corsodyl® twice daily until suture removal.
- Suture removal:
  The epithelial seal at the wound edges is evident within 2 days; suture removal can take place earliest after 48 h but not later than 4–5 days.

Standard prescription of:
- Analgesics:
  IBUPROFEN 400 mg. NO 30. Every 6 hours in 3 days.
- Antibiotics:
  APOCILLIN 660 mg. NO 30. 1+1+2 in 7 days
Irreversible Pulpitis

Patient
34-year old North European woman, referred from the student clinic, 15th of January 2009 for endodontic treatment of the upper left first molar.

Chief-complaint
The patient was troubled with symptoms from the left maxillary first molar.

History
- **Medical**
  She was hospitalised in 2008 because of blood cloth.
  Allergies: Latex and penicillin
  Medication: Marewan.

- **Dental**
  She is afraid of needles and has postponed dental treatment for many years because of fear of treatment.
  Several teeth have been extracted during the years.

**23.12.08:** The tooth had earlier been restored with a composite filling at the student clinic. Because of acute pulpitis the patient received emergency treatment at the dental clinic at UiO. The tooth was accessed and a Eugenol pellet was placed.
Clinical Findings 15th of January 2009

- **Soft tissue**
  The left second premolar was extracted before Christmas and the wound was healing otherwise normal findings.

- **Dental**
  24: OD composite filling
  25: Extracted
  26: M and D composite filling, Occlusal IRM
  27: MO amalgam filling
  36, 37: Missing

Clinical Tests 15th of January 2009

<table>
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<tr>
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<td>5 mm mesial aspect</td>
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Table 1 Clinical tests

Radiographic findings 15th of January 2009

- **Dental**
  24: OD radiopaque restoration
  25: Remnant of the root, root filled.
  26: MOD radiopaque restoration.
  27: MO radiopaque restoration.
  28: Impacted

- **Periodontal**
  Marginal bone loss especially on the mesial aspect of tooth 26. This is probably because of the remnants of tooth 25

- **Apical**
  No apical pathology
Diagnosis

- **Pulpal Diagnosis tooth 26**
  - Irreversibel Pulpitis K04.01
- **Periapical Diagnosis tooth 26**
  - Normal findings
- **Periodontal Diagnosis**
  - Marginal Periodontitis K05.3

Treatment Plan tooth 26

- Non surgical endodontic treatment with root canal disinfection and obturation of a vital tooth.

Problem list

- Locating the fourth canal.
- Keep the treatment sessions short

Progress notes 15\(^{th}\) of January 2009

Access preparation was made. There were bleeding from the canals and the MB2 canal was located.

Root canal disinfection and instrumentation

1. **Mechanical**
   - Bur
   - NiTi Hand instrumentation, BioRace
   - MB  \#40/17 mm
   - MB2  \#35/16, 5 mm
   - DB  \#40/18 mm
   - P  \#55/21 mm

2. **Chemical**
   - NaOCl
   - EDTAC

3. **Intracanal dressing**
   - Ca(OH)\(_2\)

4. **Temporary filling**
   - IRM
Progress notes 12th of February 2009.
The patient returned to the next appointment. The tooth was free of symptoms and was obturated.

Root canal instrumentation and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
     - MB #40/17 mm
     - MB2 #35/16, 5 mm
     - DB #40/18 mm
     - P #55/21 mm

2. **Chemical**
   - NaOCl
   - EDTAC

3. **Obturation**
   - Resilon®/Epiphany®

4. **Temporary filling**
   - IRM

![Fig 7](image1)

![Fig 8](image2)

![Fig 9](image3)

![Fig 10](image4)
Follow-up

- The patient has not yet been back for a follow-up.

Prognosis

- **Endodontic** Treatment of a vital pulp has a good prognosis.
- **Tooth** Uncertain long term prognosis.

Evaluation

- A tooth with a pulpitis can be treated in one session but since the patient wanted short treatment sessions, it was decided to use two appointments.
- This is a young patient and the tooth has reduced bone support around the mesial root. It is important that the patient maintains good oral hygiene to reduce further bone loss and to continue dental treatment and follow-ups.
- The tooth also needs a good coronal restoration possibly a crown.

Discussion

Irreversible pulpitis implies that the pulp is still vital, but so inflamed that it will not be able to heal again. Therefore the pulp needs to be removed and root canal therapy done. If the pulp is left alone it will eventually become necrotic, and the bacteria will have easy access to the apex and periapical tissues.

Endodontic treatment of the vital pulp has a very good prognosis because the pulp tissue and the surrounding dentine walls are not infected. It is important in this kind of treatment to have optimal aseptic conditions so no new bacteria are introduced into the canals. Aseptic procedures involve the use of rubberdam, disinfection of the surgical field, mechanical and chemical preparation with, and the use of sterile instruments.

The prognosis of initial root canal treatment in teeth without apical periodontitis varies in different studies. The long-term results are ranging from 93-97%.

Resilon® is a thermoplastic synthetic polymer-based root canal filling material. It has the same handling properties of gutta-percha. Based on polymers of polyester, Resilon® contains bioactive glass, bismuth oxychloride, and barium sulfate. The overall filler content is approximately 65% by weight. Epiphany® sealer is a dual curable dental resin composite sealer. The resin matrix is a mixture of BisGMA, ethoxylated BisGMA, UDMA, and hydrophilic difunctional methacrylates. It contains fillers of calcium hydroxide, barium sulfate, barium glass, and silica. The total filler content in the sealer is approximately 70% by weight. Forty seconds of light will cure the coronal 2 mm of the canal, whereas the entire filling will self-cure in approximately 15 to 30 min. Resilo®n can be softened and dissolved like gutta-percha with solvents like chloroform.

Different studies have compared GP and Resilon® to see if one material is superior to the other. A comparison of gutta-percha and Kerr Pulp Canal Sealer or Resilon® and Epiphany® sealer, showed no detectable difference in the outcome of endodontic treatment assessed by PAI radiographic scoring and clinical symptoms.

The bacterial micro-leakage test using Resilon® and Epiphany® sealer showed similar results to the root canals sealed with GP and Roth root canal cement, when using either the Cold Lateral condensation technique or the System B technique. These new materials also allow
similar amounts of dye penetration to occur regardless of whether the Cold Lateral condensation technique or the System B technique was used\textsuperscript{8}.

References
Endodontic treatment of a mandibular left second molar with long standing pain

Patient
51 year old North European female referred to the Post Graduate clinic, 7th of January 2008, because of persisting pain for the last two years.

Chief-complaint
She came to the clinic because of persisting pain for the last 2-3 years in left mandibular molar region. She was referred from her doctor.

History
- **Medical**
  Non-contributory
- **Dental**
The prosthodontic treatment on tooth 36 and 37 was performed approximately 3 years ago and the pain started some time straight after that.
Endodontic treatment was initiated in tooth 36 without any relieve of pain.
The pain starts in region around 36 and spreads backwards to the temporo-mandibular joint and sometimes forward to the incisors. The pain has an increasing nature but by taking 1-2 tablets of 400 mg Ibux she was able to control the pain. The pain usually wakes her up during the night and she has to take a painkiller.
She avoids using her left side when chewing food.
She has earlier had physiotherapy because of muscle pain from the neck and shoulders. There were tender facial muscles, neck and shoulders when palpating.
She works in a hospital kitchen with stressful periods.
Clinical Findings 7\textsuperscript{th} of January 2008

- **Extra-orally**
  Tender muscles in face, neck and shoulders when palpating. No other pathology was found.

- **Soft tissue**
  Normal findings

- **Dental**
  34: OD composite filling
  35: PFM Crown
  36: PFM Crown
  37: PFM Crown

![Fig 2 Lateral view](image)

Clinical Tests 7\textsuperscript{th} of January 2008

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![Fig 3 Occlusal view after adjusting occlusal prematurities](image)

Tabel 1  Clinical Tests
Radiographic findings 7th of January 2008

- **Dental**
  34: OD radiopaque filling
  35: PFM crown
  36: PFM crown, root filled
  37: PFM crown
- **Periodontal**
  Within normal limits
- **Apical**
  No sign of apical pathosis
  37: Fused mesial and distal roots.

**Diagnosis**

- **Pulpal Diagnosis tooth 37**
  Irreversibel pulpitis (K04.3)
- **Periapical Diagnosis tooth 37**
  Normal findings
- **Periodontal Diagnosis**
  Within normal limits

**Treatment Plan**

- Occlusal adjustment tooth 37, TMJ home-exercises.
- Non-surgical endodontic treatment of a vital tooth 37, with canal instrumentation and disinfection

**Problem list**

- Preserve the crown

**Progress notes 7th of January 2008**

The patient was very uncertain if she wanted to start treatment. She has had the pain for the last 2-3 years and endodontic treatment of tooth 36 did not help. When the tooth was tested with ice she got a strong reaction and recognised the pain she usually had. Because of occlusal prematurities on the mesio-lingual cusp the crown was adjusted. She got the same pain sensation in the tooth from the water cooling of the bur. Information was given to the patient that it was probably tooth 37 that was the cause of the problem. It was agreed to wait and see until the next appointment. The patient was also instructed in exercises for TMJ, neck and shoulders to do at home.

**Progress notes 5th of February 2008**

The patient returned and it was less painful than earlier. She still had pain but it did not last as long as it did before and she was no longer up during the night. The tooth was still very sensitive to cold and the reaction to ice lasted for almost a minute before it went away. She was still not sure what to do, and wanted to wait. The next appointment was in 5 weeks, if she did not want further she would cancel. Information about different prognosis on endodontic treatment was given.
Progress notes 4\textsuperscript{th} of Mars 2008

The patient returned and the symptoms were the same. She wanted to try endodontic treatment on tooth 37. Access preparation was made and vital pulp tissue was found. Extensive bleeding from the pulp almost made it difficult to see. A large pulp-stone almost occluding the pulp chamber was removed with bur and ultrasound.

Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     - MB #45/19 mm
     - ML #40/18 mm
     - DB #55/18 mm
     - DL #50/17 mm

2. **Chemical**
   - NaOCl
   - EDTAC

3. **Intracanal dressing**
   - Ca(OH)$_2$

4. **Temporary filling**
   - IRM
Progress notes 25\textsuperscript{th} of Mars 2008
The patient is asymptomatic and the tooth is obturated

Root canal disinfection and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     - MB #45/19 mm
     - ML #40/18 mm
     - DB #55/18 mm
     - DL #50/17 mm

2. **Chemical**
   - NaOCl
   - EDTAC

3. **Root-filling**
   - GP, AH+ and IRM

4. **Permanent filling**
   - Composite

Fig 11

Fig 12 Sealer out of a lateral canal in the distal root

Fig 13 The DL canal looks a bit short, but the length was adjusted with an Apex locator.

Prognosis

- **Endodontic**: assumed good
- **Tooth**: assumed good
Follow-up 17th Mars 2009 – 14 months

Evaluation

- This treatment could have been preformed in one visit but since the patient had had pain for the last 2-3 years it was decided to treat the tooth in two sessions to be sure that the pain disappeared.
- Neuropathic pain was after the examination and clinical tests ruled out, since the symptoms and pain the patient described did not match the clinical picture of a neuropatic patient. Tooth 37’s reaction to ice was typical of irreversible pulpitis.

Discussion

Before treatment starts a pulpal and periapical diagnosis has to been established. The clinical diagnosis should be based on history of symptoms, presenting symptoms, diagnostic tests, and clinical findings.

Irreversible pulpitis; the pulp is still vital but is severely inflamed so that healing is an unlikely outcome with conservative pulp therapy. Without treatment the pulp will undergo necrosis and apical periodontitis will be the final outcome\(^1\).

Symptoms can be very misleading. In most cases a pulp that is irreversibly inflamed is asymptomatic. It has been reported that dental pulps can progress from vitality to necrosis without pain in 26–60% of all cases\(^1\).

Teeth with symptomatic pulpitis is often very sensitive to thermal changes, and it is often an exaggerated response, which quickly turns into a dull aching pain that strongly indicates a pulpal inflammation, most likely irreversible. In a healthy pulp only very intense stimuli will activate the more centrally located C-fibers, while, however when bacteria or their products starts to affect the pulp and lower the threshold to the C-fibers and increase the receptive field\(^1\).

It has also been shown that the more severe the pain and the longer it has been symptomatic, the more likely it is irreversibly inflamed. Probably though the clearest sign of irreversible
inflamed pulp is the history of spontaneous pain, which will ‘hit’ the patient without any thermal stimulation to the teeth and even wake the patient from sound sleep\(^1\).

Karlsson\(^8\) found that 10% of vital teeth submitted to fixed prosthodontic treatment are expected to need endodontic treatment over a 10-year period. Cheung et al\(^9\) found even lower survival rates for vital teeth undergoing fixed prosthodontic therapy; 15% of crowns and 30% of abutments in fixed bridges needed root canal treatment after ten years, after fifteen years 20% and 35%, respectively.

The outcome of endodontic treatment of the vital pulp is very successful, this is due to the fact that the vital pulp and the dentin are not initially infected, and treated under favourable aseptic conditions a pulpectomy with a subsequent root canal filling has a success rate of 90-96%\(^3\). Failures in these teeth may be caused by pulpal infection, even though it is initially absent. The canals may be contaminated during treatment, with bacteria from carious lesion or with saliva\(^4\), through coronal leakage\(^5\) and through exposed dentinal tubules communicating with periodontal defects\(^6\). The peak incidence of emerging apical periodontitis seems to be at one year, with no added risk after that\(^3\).

References
9. Cheung GSP, Lai SCN, Ng RPY. Fate of vital pulps beneath a metal-ceramic crown or a bridge retainer. IEJ 2005;38:521-530
Re-treatment of maxillary right first and second molar

Patient

33 year old North European male referred to the Post Graduate, 1st of October 2008 clinic for endodontic treatment of maxillary right first and second molar.

Chief-complaint

The patient had no symptoms from the teeth at the time of consult. His main problem was the upper right lateral incisor. This tooth was mobile and there was pus drainage from a buccal and palatal sinus tract when palpating. He is a patient at the undergraduate clinic and the need for treatment was discovered during screening radiographs. Tooth 12 is treated by the student. He was referred for endodontic treatment of tooth 16, 17 because of asymptomatic apical periodontitis.

History

- **Medical**
  Allergy to penicillin

- **Dental**
  He has not been to the dentist for
  For the last 3 years. A lot of dental work have been done during the years:
Clinical Findings 1st of October 2008

- **Soft tissue**
  Normal findings. Good oral hygiene.

- **Dental**
  17: MOBP amalgam
  16: O IRM
  15: MOD amalgam
  Missing: 13, 22, 26 and 27
  Endodontic treatment: 17, 16, 12, 11, 23 and 25
  Crowns: 12, 11, 21, 23, 25
  Post: 12, 11 and 23
  Filling: 17, 15, 24, 37, 36, 44, 45, 46 and 47
  Impacted 34 and a root fracture 12 (this tooth is going to be extracted)

Clinical Tests 1st of October 2008

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Tabel 1 Clinical tests
Radiographic findings 1st of October 2008

- **Dental**
  17: MOD radiopaque filling
  Root filled, instrument fracture mesial root
  16: O radiopaque filling, inadequate root-filling

- **Apical**
  17: Circumscribed radiolucency around the roots.
  16: Circumscribed radiolucency around the mesial root

- **Periodontal**
  Within normal limits

**Diagnosis**

- **Pulpal Diagnosis teeth 16 and 17**
  17: Root filled (K04.19)
  16: Root filled (K04.19)

- **Periapical Diagnosis**
  17: Asymptimatical apical periodontitis (K04.5)
  16: Asymptimatical apical periodontitis (K04.5)

- **Periodontal Diagnosis**
  Within normal limits

**Treatment Plan**

- Non surgical endodontic re-treatment tooth 16 and 17.
- Review the treatment after one year to see if the apical lesions have healed. If not consider apical surgery.

**Problem list**

- Remove or bypass the fractured instrument
- Locate the MP canal

**Progress notes 1st of October 2008 tooth 16**

Access preparation was made and the MP canal was located. It was difficult to retrieve accurate working length in the P canal because of obliteration.

**Root canal instrumentation and disinfection**

1. **Mechanical**
   - Bur, Gates-glidden
   - NiTi Hand instrumentation and BioRace
     MB: 16 mm/45
     MB2: 15 mm/40
     DB: 15 mm/45
     P: 19 mm/60
2. Chemical
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate 2%

3. Intracanal dressing
   - Ca(OH)\(_2\)

4. Temporary filling
   - IRM

Progress notes 29\(^{th}\) of October 2008 tooth 16
The patient experienced a flare-up after the last appointment and had to contact the emergency dental clinic in the weekend. They had opened the tooth and placed paper points into the canals probably with Eugenol. It was therefore decided to place a new intra-canal dressing. By the help of Endolift and rotary instruments it was possible to instrument the P canal to full length.

Root canal instrumentation and disinfection
1. Mechanical
   - Bur and Rotary instruments
   - NiTi Hand instrumentation
     MB: 16mm/45
     MB2: 15mm/40
     DB: 15mm/45
     P: 21mm/60

2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate 2%

3. Intracanal dressing
   - Ca(OH)\(_2\)

4. Temporary filling
   - IRM

Progress notes 6\(^{th}\) of January 2009 tooth 16
The tooth was symptom free and obturated

Root canal instrumentation and obturation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur, Irrisafe®
     MB: 16mm/45
     MB2: 15mm/40
     DB: 15mm/45
     P: 21mm/60
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate 2%
3. Obduration
   - GP and AH+
4. Temporary filling
   - IRM

Progress notes 17th of February 2009 tooth 17
Access preparation was made and MP canal located. The fractured instrument was bypassed.

Root canal instrumentation and obturation
1. Mechanical
   - Bur, Gates-glidden and Rotary instruments
   - NiTi Hand instrumentation
     MB: #45/16mm
     MB2: #35/16.5mm
     DB: #45/15mm
     P: #60/21mm
2. Chemical
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate 2%
3. Intracanal dressing
   - Ca(OH)$_2$
4. Temporary filling
   - IRM

Fig 8
Fig 9
Fig 10 Access preparation and located MB2 (arrow)
Fig 11 Calcium hydroxide
Progress notes 31\textsuperscript{st} of March 2009 tooth 17
The tooth was free of symptom and obturated.

Root canal instrumentation and obturation

1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Irrisafe®

2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate 2%
     MB: #45/16mm
     MB2: #35/16.5mm
     DB: #45/15mm
     P: #60/21mm

3. Obduration
   - GP and AH+

4. Temporary filling
   - IRM

Prognosis

- Endodontic: Good
- Tooth: Good

Follow-up 31\textsuperscript{st} of March 2009 - 6 months tooth 16
- Signs of healing at the apex of the MB root tooth 16
- It may be some sign of healing tooth 17

Evaluation

- The preoperative radiograph shows endodontic treatment of very poor quality in both teeth.
- Re-treatment of the teeth should therefore result in a root filling of better technical quality, and thereby healing of the periapical lesion.
- MB2 canal was located in both teeth and by instrumentation and disinfection raises the probability of healing.
- The instrument in the MB canal in tooth 17 was by-passed.
- This patient need crown therapy and to restore the vertical dimension between the upper and lower jaw.
- Warm GP, the System B/Obtura was used to fill tooth 17 (only to get the practice).

Discussion

Bacteria are the number one cause of apical periodontitis\(^1,^2\). The major goal in endodontic therapy is elimination of the bacteria in the root canals. This is accomplished through mechanical instrumentation and irrigation with antibacterial solutions. This method is supported by different studies, but still after thorough irrigation, half of the canals harboured bacteria after the first appointment\(^3\).

Study by Sjögren\(^4\) et al showed that a seven-day dressing with calcium hydroxide effectively eliminated bacteria which survived the biomechanical instrumentation of the canal.

Sodium hypochlorite has a potent antibacterial effect and dissolves necrotic organic material. Higher strengths have not showed to have a better antibacterial effect than lower concentrations, but the toxic effect increases\(^5,^6\).

EDTA is a chelating agent and is able to soften the dentine to depths of 20-50 µm. It removes the smear layer created by the mechanical instrumentation and opens the dentine tubuli so full effect of sodium hypochlorite and calcium hydroxide are possible. EDTA by itself has little if any antibacterial effect.

Chlorhexidine digluconate of varying concentrations has been introduced as an alternative antibacterial irrigation and intracanal dressing. It acts by adsorbing onto the cell walls of microorganisms causing leakage of intracellular components. Chlorhexidine has a strong antibacterial activity against a wide range of Gram-positive, Gram-negative, facultative anaerobe, aerobe bacteria and yeast\(^11\). By adding chlorhexidine irrigation as a second antibacterial irrigation additional reduction in bacteria will be achieved\(^7\). Chlorhexidine also has the potential to effectively reduce or completely eliminating E. faecalis from the root canal and dentinal tubules\(^8,^9\).

Calcium hydroxide maintains its antibacterial effect over a long period of time because of slow release of hydroxyl ions. The pH range is high 12, 5-12, 8 and is used in dentistry to facilitate mineralization, dissolve tissue and as a antimicrobial agent. The hydroxyl ions produce a pH over 11, which prevent growth and survival of oral bacteria by destruction of cell membranes and protein structures. It also alters the biological properties of bacterial lipopolysaccarides and interfere with membrane transport mechanisms\(^10\).

The function of root canal obturation is to fill the root canal space and eliminate all portals of entry between the canal and the periodontium. The better the seal, the better the prognosis for the tooth. An ideal filling should be well condensed, seal all foramina leading to the
periodontium, adapt to the instrumented canal walls, and end at the apical seat. In a meta-
analysis by Peng et al\textsuperscript{13} they locked through the literature to compare cold lateral condensation and warm GP obturation. The result demonstrated that a greater incidence of overextension was seen in the warm GP obturation group than in the CLC group. But there were no statistical difference in the obturation quality, long-term outcome, and postoperative pain between these two groups.

Re-treatment cases have a significantly higher incidence of flare-ups than initial treatment\textsuperscript{12}. This may be because re-treatment cases are more difficult to treat, and there is a tendency to push remnants of gutta-percha, solvents, and debris and bacteria into the periapical tissues. According to the literature there is no association between the occurrence of midtreatment flare-ups on the outcome of treatment, in either initial treatment or in retreatment cases\textsuperscript{10}.

References
Apical periodontitis lower left and right central incisor with extra-oral sinus tract

Patient 24 year old Norwegian male referred to the Post Graduate clinic, 21st of November 2006, for endodontic treatment of the mandibular central incisors.

Chief-complaint
The patient has had a persisting pimple on the chin with continuous draining of pus for the last two years. There is no pain, but he feels it a bit embarrassed.

History
- **Medical**
  Non contributory
- **Dental**
The patient went to the doctor because of a pimple on the chin that would not heal and there was continuous draining of pus. He was sent to a dermatologist for treatment. Because of unsuccessful result of the surgical treatment the patient was referred to the Surgical Department at UiO. He was then referred to the Post Graduate Endodontic Clinic for further treatment.

The patient has had orthodontic treatment for two years and removed the appliance 6 months ago and can not recall any trauma to the lower front teeth.
Clinical Findings 21\textsuperscript{st} of November 2006

- **Extra oral**
  Sinus tract at the chin and it was possible to provoke drainage of pus in an area of 3-4 cm radius of the sinus tract. There was no sign of tumour.

- **Soft tissue**
  Normal findings
  Poor oral hygiene with approximal and gingival plaque.

- **Dental**
  The patient has a deep vertical occlusion with signs of incisal damage to the upper and lower front. Incisal enamel fracture and exposed dentine 31 and 41.
Clinical Tests 21st of November 2006

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Tabel 1 Clinical tests

Radiographic findings 21st of November 2006

- **Dental**
  - 42: Sound tooth
  - 41: Sound tooth, Incisal enamel fracture
  - 31: Sound tooth, incisal enamel fracture
  - 32: Sound tooth
- **Periodontal**
  - Within normal limits
- **Apical**
  - Circumscribed apical radiolucency centered around the root of 31 but also around the root of 41.

Diagnosis

- **Pulpal Diagnosis teeth 31 and 41**
  - 31: Necrotic tooth (K04.5)
  - 41: Necrotic tooth (K04.5)
- **Periapical Diagnosis**
  - Chronic apical periodontitis with an extra oral sinus tract (K04.63)
- **Dental**
  - 31: Enamel fracture (S02.50)
- **Periodontal Diagnosis**
  - Within normal limits

Treatment Plan

- Non surgical endodontic treatment with root canal disinfection and obturation of necrotic teeth, 31 and 41.
Problem list

- Succeeding in eliminating the infection and closure of the sinus tract

Progress notes 21st of November 2006

It was decided to start treatment with Ca(OH)$_2$ of tooth 31 to see if this tooth was the cause of the problem, since the sinus tract was traced to the root of 31 and this tooth had the largest incisal enamel damage.

Root canal disinfection and instrumentation

1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
   - 1 canal #40/23 mm

2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. Intracanal dressing
   - Ca(OH)$_2$

4. Temporary filling
   - IRM

Fig. 9

Progress Notes 12th of December 2006

when the patient returned, the sinus tract had "closed" for a few days, but then reopened again. It was decided to reopen 31 to see if a second canal had been missed. The canal had time-glass cross section but there was no lingual canal. Because of limited time treatment of 41 was postpone to the next appointment. (Followed standard procedures)

Progress Notes 13th of February 2007

The patient returned with a persisting sinus tract and instrumentation of tooth 41 was initiated. The canal was empty and dry.

Root canal instrumentation and disinfection

1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
   - 1 canal #40/22.5 mm

2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. Intracanal dressing
   - Ca(OH)$_2$

4. Temporary filling
   - IRM

Fig 10
Progress notes 16th of May 2007
The patient returned and the sinus tract had closed just a few day after the last treatment. The opening of the extraoral sinus tract had healed with scar tissue.

The endodontic treatment of 31 and 41 were completed.

Root canal disinfection and obturation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     31: #40/23 mm
     41: #40/22.5 mm
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Obturation
   - GP and AH+
4. Temporary filling
   - IRM

Prognosis
- Endodontic: assumed good
- Tooth: assumed good
Follow-up 20th June 2008 - 13 months

Evaluation

- The origin of the sinus tract should have been found sooner, and then unnecessary antibiotic therapy and surgical procedures would have been avoided.
- Instrumentation and location of root canals in 41 should have been completed in the first visit.

Discussion

Sometimes a chronic endodontic infection will drain through an intraoral communication to the gingival surface. This pathway extends directly from the source of infection to the surface opening and dead and dying microbes and polymorphonuclear cells follow the path of least resistance. Why a sinus tract develops is not fully understood. It may be the body’s mechanism of controlling the infection or indicate a specific infection of some volume/number/virulence of the bacteria. A sinus tract can open in the alveolar mucosa, in the attached gingival, through the furcation, gingival crevice and even drain onto the face or neck. Where the sinus tract will penetrate depends on the location of the root apices to the lingual or buccal cortical plate, and the relationship of the apex to the attachment of the muscles.(Fig 17)
Pus travels via the route of least resistance along facial planes until exiting cutaneously. These tracts tend to occur more frequently from infected mandibular teeth (80%) than maxillary teeth (20%). Openings in the skin will generally close once the infected tooth is treated and healing occurs in a few days often leaving a visible scar.

Harrison and Larson found that most sinus tracts are not lined with epithelium throughout their entire length. Baumegartner et al also found that 20 of 30 specimens did not have epithelium that extended beyond the level of the surface mucosa rete ridges.

The root of the lower central incisor is usually narrow mesiodistally and wider labiolingually. It is important to remove the lingual shoulder since this tooth often has two canals that are buccolingually oriented. It is usually the lingual canal that is missed. Most mandibular incisors have a single root that on x-rays appears to be a long narrow canal. But there is often a dentin bridge present in the pulp chamber that divides the root into two canals. They usually join and exit through a single apical foramen, but may also persist as two separate canals. Occasionally one canal branches into two canals, which can rejoin into a single canal.

According to the study of apical canal configuration by Vertucci, approximately 97% of the teeth have one canal and 3% two canals.

Possible explanations for necroses in 41 and 31 are trauma, orthodontic treatment, traumatic occlusion and invasion of microorganism through the exposed dentine. There was no recollection of any trauma to the teeth but if there had been a lateral luxation or an intrusion injury the frequency of pulpal necrosis would be between 80-100% in teeth with mature roots.

He underwent orthodontic treatment for approximately two years and both human and animal studies have confirmed that both lateral and intrusive forces result in alteration in pulpal blood flow. If orthodontic forces are extreme, circulatory interruptions can occur, resulting in pulpal necrosis. Apoptosis and necrosis of pulpal cells also increase subsequent to movement. These changes are transient provided that the movement forces are not excessive.

It was difficult to find literature on the issue traumatic occlusion and pulp necroses. But some authors suggest that some failures of root canal treatment may be due to the presence of occlusal trauma.

Enamel-dentine fracture of the incisal edge may open dentine tubuli and are probably the entrance port to the bacteria. Unusually large dentinal tubules have been described and they are often present in cuspal and incisal areas. Openings of dentinal tubules give the bacteria and their by-products easy access to the pulp resulting in necrosis and apical periodontitis.

References
5. Cohen s. and Hargreaves KM Pathways of the pulp. 9th Edition
Symptomatic apical periodontitis in a transplanted premolar and maxillary left lateral incisor

Patient 14 year old Norwegian boy referred to the Post Graduate Endodontic, 16th of June 2007 for treatment of maxillary left and right central incisor.

Chief-complaint
The patient came to the clinic because of acute pain and abscess formation in the upper front. He received acute treatment at the Surgical Clinic and was later referred to the Endodontic Clinic for treatment of the right and left maxillary central incisor.

History
- Medical
  31.10.01: The patient had a trauma to the head/face witch resulted in a jaw fracture and a possible fracture of prosc.alveolaris in the lower jaw. He was hospitalized for several weeks because of the head trauma. He still gets easily tired and has problems with headaches.
- Dental (Chart notes from the general practitioner)
  31.10.01: 11, 21 and 12 were exarticulated and not replaced. 22 and four of the lower incisors were luxated.
  09.01.02: Negative sensibility test 22 and the incisors in the lower jaw.
  30.10.02: Auto-transplantation of 35 to area 11 at the UiO.
  19.05.03: Orthodontic treatment 35 because of little change in eruption. Different percussion sound was noted.
  09.05.06: 22 was instrumented and Ca(OH)\(_2\) was placed.
Jan/Feb 2007: 35 was instrumented and Ca(OH)$_2$ was placed.

11.05.07: Abscess formation in area 35-22 with mobility of the teeth. Ca(OH)$_2$ was changed in 22 at UiO.
Clinical Findings 16th of June 2007

- **Soft tissue**
  The gingiva was oedematous and tender to palpation. There was a sinus tract in the midline between 35 and 22. Edges around the composite build-up accumulated plaque and resulted in BOP.

- **Dental**
  13: No fillings
  12: Missing
  11: Transplanted 35 with a composite buildup. IRM on the palatinal side.
  21: Missing
  22: Moved orthodontically to area 21, composite buildup. P composite filling.
  23: No fillings
  Retainer from 14 to 24.

Clinical Tests 16th of June 2007

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Tabel 1 Clinical Tests

Radiographic findings 16th of June 2007

- **Dental**
  13: Sound tooth, radiopaque filling fixating the retainer.
  35: Obliterated pulp. Radiopaque filling in the coronal part of the crown.
  22: Radiopaque filling in the crown that seems to go down into the root canal.
  23: Sound tooth, radiopaque filling fixating the retainer.

- **Apical**
  13: Continuous PDL can be followed around the root.
  35: Diffuse radiolucency around the apical part of the root.
  22: Circumscribed radiolucency around the root and apical resorption.
23: Continuous PDL can be followed around the root.

- **Periodontal**
  Some loss in marginal bone height.

**Diagnosis**

- **Pulpal Diagnosis teeth 35 and 22**
  
  35: Necrotic pulp (K04.5)
  22: Necrotic pulp (K04.5)

- **Periapical Diagnosis**
  
  35: Apical periodontitis with a sinus tract (K04.62)
  22: Chronical apical periodontitis (K04.5)

- **Marginal Diagnosis**
  Within normal limits

**Treatment Plan**

- Non-surgical endodontic treatment of necrotic teeth with root canal disinfection and obturation

**Problem list**

- Locate the canal in tooth 35.
- Persisting apical periodontitis in 22 despite of Ca(OH)$_2$ treatment.

**Progress notes 16$^{th}$ of June 2007**

The GP had started instrumentation of 35 but had only succeeded in locating the buccal canal and not been able to instrument to full length, because of obliteration. Access preparation was done and the buccal canal was located. Further preparation was made with ultrasound and the palatinal canal was found.

**Root canal disinfection and instrumentation**

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     B#40/13 mm
     P#35/18 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Intracanal dressing**
   - Ca(OH)$_2$

4. **Temporary filling**
   - IRM
Progress notes 30th of October 2007
The patient returned and the sinus tract had closed. The gingiva had a normal appearance. 35 was obturated and the Ca(OH)$_2$ in 22 was changed and IRM placed.

Root canal disinfection, instrumentation and obturation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     35: B#40/13 mm
     P#35/18 mm
     22: #60/18 mm
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Obturation/Intracanal dressing
   - 35:GP and AH+
   - 22:Ca(OH)$_2$
4. Permanent/Temporary filling
   - 35: Composite
   - 22: IRM
Progress notes 22\textsuperscript{nd} of November 2007

The patient had no symptoms and tooth 22 was obturated.

Root canal disinfection and obturation

1. Mechanical
   - NiTi Hand instrumentation
     22: #60/18 mm

2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. Obturation
   - 22:GP and AH+

4. Permanent filling
   - 22: Composite

Prognosis

- **Endodontic** 35 and 22: assumed good. Endodontic treatment was performed according to standard clinical procedures
- **Tooth** 35 and 22: assumed good

Follow-up 15\textsuperscript{th} of September 2008 – one year

Evaluation

- Endodontic treatment was performed according to standard clinical procedures.
- 35 was not instrumented to full length, because of obliteration but healing has taken place.
- There has been some loss of marginal bone. It is important for the patient to maintain good oral hygiene.
- With a proper coronal restorations or porcelain crown whit a smooth marginal adaption, good esthetical and gingival results would be achieved.
- Transplanted teeth usually obliterate during the first 6 months, but remain vital. There is no indication for endodontic treatment. Can only speculate why this tooth became necrotic, but the tooth probably anckylosed and the success rate is not always a 100%.

Discussion
Luxation injury is a combined periodontal and pulpal injury. A horizontal impact forces the crown in a palatal direction and the apex in a labial direction. This kind of injury represents a rupture of the PDL and the pulp as well as injury to the alveolar socket walls. Lateral luxation creates a complex of compression and rupture zones in the periodontal ligament, pulp and bone. Healing is dependent upon the healing pattern resulting from the combined pulpal and periodontal injuries. The final outcome can range from pulpal, and periodontal regeneration/repair to infected pulp necrosis, and external root resorption, and loss of gingival attachment. The prognosis for laterally luxated teeth depends upon the stage of root development at the time of injury. Pulp necrosis in mature teeth is about 80% while in immature teeth only 10%.

Autotransplantation leads to an almost identical healing situation, as a luxated and displaced tooth. Subsequent healing processes usually restore the content of the pulp canal including the nervous supply.

Missing teeth in children are a particular challenge because the replacement should adapt to growth and developmental changes and have the potential for long-term survival. Autotransplantation of developing premolars are an alternative replacement. Transplanted teeth have the capacity for functional adaptation and preservation of the alveolar ridge.

The method for autotransplantation of immature premolars was developed by Slagsvold and Bjercke and they reported successful results in publications from the University of Oslo. A follow-up study, of teeth transplanted by Bjerke until 1980 were examined by Czochrowska et al. They found the survival rate to be 79%. Andreasen et al found that 86% of the mature teeth were diagnosed with pulp necrosis within 6 months, while 95% of the immature teeth responded positive after one year. Pulp obliteration was usually first noted 8 weeks after transplantation and was almost always present 6 months. It normally progressed until the root canal was no longer visible. Ninety per cent of these cases still reacted positively to electrometric pulp testing and only six per cent became negative.

Hard tissue apposition along the root canal walls is a slow, normally occurring physiological aging process that usually progresses at a slow pace. The rate of hard tissue deposition acceleration may seem to be uncontrolled after dental trauma, autotransplantation, and orthodontic therapy, leading to rapid partial or total obliteration of the root canal space. The precise mechanism of obliteration is unknown, but some speculate that uncontrolled sympathetic response, reduced vascular flow or deposited tissue in areas of coagulated blood could result in a pathological mineralization.

Experimental replantation studies in humans, have shown that extraction and immediate replantation of premolars leads to pulpal revascularization in almost all cases. Odontoblasts in all parts of the pulp can survive the trauma of the replantation.
Histological studies\textsuperscript{10} have shown reparative dentine in the apical parts of replanted teeth from the second postoperative week. Six months after replantation reparative dentine was observed in all teeth. The first-formed dentine was generally very irregular in structure, but the reparative dentine matured with time. It was also found that the degenerative processes were less pronounced and the regenerative processes more extensive in immature than in mature teeth.\textsuperscript{10}

References
Retreatment of maxillary right second premolar with a Carbone post

Patient 35-year old East European woman referred to the Post Graduate Clinic, 25th of October 2007, because of apical periodontitis.

Chief-complaint
The patient has no symptoms from the tooth, and was referred for endodontic treatment of the upper right second premolar from her general practitioner, because of persisting apical periodontitis, that was discovered during routine radiographs.

History
- **Medical history**
  Non-contributory
- **Dental history**
  Endodontic and crown therapy of the upper right second premolar for 2-3 years ago. The patient has no symptoms.
Clinical Findings 25th of October 2007

- **Soft Tissue**
  - Normal findings

- **Dental**
  - 14: OD composite
  - 15: PFM crown
  - 16: OP composite
  - Good oral hygiene

Clinical Tests 25th of October 2007

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Tabel 1  Clinical tests

Radiographic findings 25th of October 2007

- **Dental**
  - 14: OD radio opaque filling
  - 15: Metal-porcelain crown
    - Prior endodontic treatment that is 4 mm short of the radiological apex.
  - 16: O opaque filling

- **Apical**
  - 15: Circumscribed periapical radiolucency 5 mm in diameter.
  - PDL can be followed around the roots of the neighbouring teeth.

- **Periodontal**
  - Within normal limits
Diagnosis

- **Pulpal Diagnosis tooth 15**
  Root filled tooth (K04.19)
- **Periapical Diagnosis tooth 15**
  Asymptomatical apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  Within normal limits

Treatment Plan

- Non-Surgical Endodontics
  Conventional retreatment with root canal disinfection and instrumentation

Problem List

- Locate the canals
- Retrieve instrumentation length
- Preserve the crown

Progress notes 25\textsuperscript{th} of October 2007

Access preparation through the crown reviled a carbon post in the palatinal root and the core material looked like a composite. I started removing the core material with diamond burs and when the post was free, the crown fell off. With a closer view at the radiograph it is possible to see that there might be something in the canal. Rubberdam was applied and the post was removed with a long diamond flame bur and a ultrasonic K-file. It was very time consuming to use ultrasound and it produced a lot of black dust. The crown was re-cemented with IRM and Ca(OH)\textsubscript{2} in the canal.

Progress notes 30\textsuperscript{th} of October 2007

The patient returned the next week. The crown was removed, rubberdam placed and retreatment with Gates-glidden bur, Chloroform and hand files.
Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur
     - B #45/17 mm
     - P #45/18 mm

2. **Chemical**
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Intracanal dressing**
   - Ca(OH)$_2$

4. **Temporary filling**
   - IRM

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**Progress notes 20$^{th}$ of November 2007**

The patient returned after 3 weeks and there had been no problems and the tooth was symptom free.

Root canal disinfection and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur
     - B #45/17 mm
     - P #45/18 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Obturation**
   - GP and AH+

4. **Temporary filling**
   - Cavit G in the palatinal canal and IRM topp filling

---

**Fig. 7**

**Fig. 8**

**Fig. 10 Radiograph taken 20.11.2007**
Prognosis

- **Endodontic**: assumed good
- **Tooth uncertain**: the tooth has to be restored with a post, which compromised the prognosis of the tooth. It is shown that 3 to 10% of root fractures are due to post and cores.⁷

Follow-up 12th of December 2008 – 14 months

- The lesion has healed and the tooth is restored with a new post and crown

![Radiograph taken 25.10.2007](image1)

![Radiograph 20.11.2007](image2)

![Radiograph 12.12.2008](image3)

Evaluation

- It was difficult to diagnose this kind of post preoperatively because of low contrast on the radiograph.
- The patient needs to be informed before treatment of the possible extra costs of a new crown if a crown has to be redone. In this case the patient needs a new post and crown and results in higher costs.
- In this case there was a leakage under the crown.
- Outcome of treatment is assumed to be good since the instrumentation length was increased.

Discussion

Apical periodontitis is caused by bacterial presents in the root canal. The most commonly found bacteria in a primary intraradicular infection are dominated by anaerobic bacteria, particularly Gram-negative species like Tannerella, Dialister, Porphyromonas, Fusobacterium and Prevotella but also Gram-positive anaerobes rods and cocci, and some facultative are commonly found.² Secondary intraradicular infection is caused by microorganisms that were not present in the primary infection, but has been introduced during treatment, between appointments or after completion of endodontic therapy through leakage. Species associated with this kind of infection are Pseudomonas, Staphylococcus, E. coli and E. Faecalis.²
Persistent intraradiculare infection is caused by microorganisms that manage to survive our attempt to disinfect the canal. Bacteria associated with this kind of infection are Gram-positive facultative bacteria particularly E. Faecalis and sometimes fungi\(^3\).

The root canal system is a selective habitat that allows the growth of certain bacteria. In a study by Möller et al they showed that a shift in the root canal takes place with time, from facultative bacteria to almost strict anaerobic bacteria\(^6\).

The major factor that influences the outcome of endodontic treatment is the presence of bacteria in the canal at the time of filling\(^4\).

The former endodontic treatment of the tooth was of poor quality and too short of the radiographic apex. The microbiology in the uninstrumented part of the canals may be the same as in a tooth with initial apical periodontitis and not the microbiology associated with retreatment cases, which can be more treatment-resistant. The treatment outcome in this case can be compared with a tooth with a periapical lesion receiving initial treatment, and this has a 94% success\(^5\) in outcome.

References
Retreatment of the mandibular right first molar obturated with silver cones

Patient
63-year old North European male referred to the Post Graduate Clinic, 30th of September 2008, because of apical periodontitis in lower right second molar.

Chief-complaint
Non from the tooth in question, instead he complained about other teeth were fillings had been lost. The patient was referred from the student clinic for re-treatment of tooth 46 because of asymptomatic apical periodontitis. He was scheduled for treatment in September 2008, but cancelled because of financial reasons and since he did not have any symptoms from the tooth.

History
- **Medical**
  Non-contributory
  Regular smoker
- **Dental**
  Endodontic and prosthodontic treatment were performed many years ago.
  Poor oral hygiene
  He did not attend a dentist regularly and was advised to contact one for further treatment.
Clinical Findings 3\textsuperscript{rd} of March 2009

- **Soft tissue**
  Normal findings
  Gingival plaque

- **Dental**
  47: PFM crown
  46: PFM crown
  45: MO composite,
    fracture of D filling, B caries
  44: MODL composite,
    grey discoloration

Clinical Tests 3\textsuperscript{rd} of March 2009

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Table 1 Clinical tests

Radiographic findings 3\textsuperscript{rd} of March 2009

- **Dental**
  47: PFM crown
  46: PFM crown, root filled with a
    material with less radiopacity in the
    distal canal compared to the mesial
    canals – which probably are silver cones.
    Short root filling in the distal and mesial
    canal.
  44: MO radiopaque filling, fractured D filling
    M and D Caries

- **Apical**
  47, 45, 44: Continous PDL can be followed around the roots
  46: Sign of apical pathology at the mesial and distal root, a circumscribed
    radiolucency starting some mm before the apex.

- **Periodontal**
  Within normal limits
Diagnosis

- **Pulpal Diagnosis tooth 46**
  Root filled tooth (K04.19)
- **Periapical Diagnosis tooth 46**
  Asymptomatic apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  Within normal limits

Treatment Plan

- Non surgical endodontic re-treatment with disinfection and instrumentation

Problem list

- Removal of the silver points
- Retrieve instrumentation length in both roots
- Preserve the crown

Progress notes 3\textsuperscript{rd} of March 2009

Access preparation was made and Rubberdam placed. Careful removal of the filling material inside the crown to prevent cutting the silver cones. Burs and ultrasound (K-file) were used. Temporary filling Cavit-G placed until the next session.

Progress notes 12\textsuperscript{th} of March 2009

Several attempts were made to remove the silver cones with the use off the IRS system, but the cones fractured several times. The distal canal was re-treated and a new attempt was going to be made at the next appointment with different types of instruments. Retreatment of the distal canal was done with Gates-Glidden, Chloroform and NiTi handfiles.

Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
   - D #40/18 mm
2. **Chemical**
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. **Intracanal dressing**
   - Ca(OH)$_2$
4. Temporary filling
   - IRM

Progress notes 26\textsuperscript{th} of March 2009

Ultrasound K-files were used to prepare the points free from the surrounding dentine. New attempts were made with the use of IRS system, different pliers and a microtube system from Sybron Endo. With the help of superglue and Gilberto Deblian the ML silverpoint was finally removed with the microtube. The MB point was pulverized with the use of Ultrasound K-file (Satelec\textregistered).

![Fig 7 Removed silver point](image1)
![Fig 8 Different sizes of Microtubes](image2)
![Fig 9 Closer view of the silver point](image3)
![Fig 10](image4)

Root canal disinfection and instrumentation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
   - ML: #40/20 mm
     MB: #45/17 mm
   - D: #60/18 mm

2. Chemical
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. Intracanal dressing
   - Ca(OH)\textsubscript{2}

4. Temporary filling
   - IRM
Progress notes 16\textsuperscript{th} of April 2009

The patient has not experienced any symptoms, and the tooth is obturated.

Root canal disinfection and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Irrisafe®

2. **Chemical**
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Obturation**
   - GP, AH+ and IRM

4. **Permanent filling**
   - Composite

Prognosis

- **Endodontic**: uncertain
- **Tooth**: assumed good

Follow-up

- No follow up
Evaluation

- It was possible to instrument the canals closer to the apex than the previous root-filling, but some length are still missing.
- It was time consuming to remove the silver points.
- Attempts to remove them with different pliers, Masseran-kit or the IRS system failed, because the silver was soft, thin and fragile they broke several times.
- Ultrasound (K-file) was used to expose the points, and this resulted in dentine loss in the coronal part of mesial root and weakening of the root.
- Apicoectomy of the mesial root can be considered if there is no healing at one year follow-up.

Discussion

Silver points were widely used in the 1930s to the 1960s, particularly in smaller canals. They were prefabricated to the same size as the instruments used for the preparation of the canals. The advantage of the silver points, were that they were easy to handle and to insert to proper length in the root canals. The drawback was that they did not seal laterally or apically because their lack of plasticity. Too much space were left to be filled by the cement or sealer and leading to leakage\(^1\).

Seltzer et al in 1972 removed 25 silver cones in teeth which had bee treated endodontically from 3 months to 20 years previously. Examination of these cones by the scanning electron microscope revealed that they were moderately to severely corroded ranging from pitting to deep crater formation. The main areas of corrosion of silver cones are the apical and coronal portions. Both regions may be in contact with fluids, either periapical exudates or saliva, in the event of leakage. Defects in the cones by cutting it, or even just placing them in the canals enhance corrosion even more\(^2\).

Fractured instruments or in this case silver points that block the canal for proper cleaning and shaping should be removed if possible. If not remnants of bacteria and necrotic pulp tissue may remain and compromise the outcome of root canal treatment\(^3\).

It is not always successfully to remove fractured instruments; it may lead to ledge formation, over-enlargement and transportation of the prepared root canal, or root perforations. Sometimes if it is not possible to remove the instrument, attempts to bypassing or leaving the fractured portion in the root canal should be considered. Studies on treatment outcome indicate that the fractured instrument has an impact on prognosis only in cases with apical periodontitis\(^3,4\).

There are several methods for removing fractured instruments. Ultrasound is often used, it is important to create a straight line access to the coronal end of the instrument under microscope (modified Gates-Glidden burs or other alternatives). Then create a groove around the coronal end of the instrument using ultrasound (size 25 K-file tip or small burs) around the instrument until movement. Loosened instrument can then be removed by flushing with irrigation, Hedstrom-file, different pliers, Masseran-kit or the IRS system.
In this case an attempt to remove the silver cones, were made, because the mesial canals had not been properly cleaned, and had a small dimension and probably harboured a lot of bacteria.

References
Irreversible pulpitis in the mandibular right first molar with an iatrogenic perforation

Patient
35 year old male from the Middle East referred to the Post Graduate Clinic because of an iatrogenic perforation during access preparation.

Chief complaint
The patient has symptoms from the tooth when he drinks hot and cold. He was referred from the student clinic because of an accidental perforation during access preparation.

History
- **Medical history**
  Non contributory
- **Dental history**
  Endodontic treatment was started because of a deep caries lesion in 46. During access preparation the student perforated the tooth in the furcal area.

Clinical Findings 2\textsuperscript{nd} October 2008
- **Soft tissue**
  Normal findings
- **Dental**
  45: OD amalgam
  46: MO IRM , BD amalgam
  47: O amalgam
Clinical tests 2\textsuperscript{nd} October 2008

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Table 1 Clinical tests

Radiographic findings 2\textsuperscript{nd} October 2008

- **Dental**
  45: OD radiopaque filling
  46: MOD radiopaque filling, radiolucency between the mesial and distal root extending in an apical direction between the roots.
  47: O radiopaque filling, caries
  48: O radiopaque filling

- **Apical**
  No sign of apical pathosis. Continuous PDL can be followed around the roots.

- **Periodontal**
  Within normal limits

Fig 2 Lateral view

Fig 3 Occlusal View

Fig 4
Diagnosis

- **Pulpal Diagnosis tooth 46**
  Irreversible pulpitis (K04.03)
- **Periapical Diagnosis**
  Normal findings
- **Periodontal Diagnosis**
  Within normal limits

Treatment plan

- Locate and repair the perforation.
- Non-Surgical Endodontics whit root canal disinfection and obturation

Problem list

- Extent of the perforation

Progress Notes 2\textsuperscript{nd} October 2008
Removal of temporary filling revealed a large perforation through the pulpal floor. The access preparation was drilled through the pulpal floor and further down the distal root, so the entrance to the distal canal was at the level with the perforation. The mesial canals were located higher up in the mesial wall of the pulp chamber. (Fig 8) There was some bleeding and seeping of tissue fluid from the perforation. Ca(OH)\(_2\) was placed over the bone during instrumentation of the canals and until the next appointment.

Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. **Intracanal dressing**
   - Ca(OH)\(_2\)
4. **Temporary filling**
   - IRM
Progress Notes 14th October 2008

The patient was free of symptoms and the tooth obturated. A GP point was placed in the distal canal during placement of Plaster of Paris and MTA.

Root canal disinfection and obturation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Obturation
   - Plaster of Paris, MTA
   - GP and AH+
   - Moist cotton pellet
4. Permanent filling
   - Composite

The tooth was obturated with GP and AH+. A moist cotton pellet was placed over the MTA so the cement could set.

Progress notes 21st of October 2008

The patient returned and the IRM and cotton pellet was removed. The MTA had set and a composite toppfilling was placed.
Prognosis

- **Endodontic**: assumed good
- **Tooth**: uncertain long term prognosis

Follow up 14\textsuperscript{th} of April 2009 – 6 months

- Satisfying clinical conditions and the patient has no symptoms. Clinical probing depth 2 mm and there was no bleeding on probing
Evaluation

- Care must be taken when access preparation is performed.
- The tooth strength is very reduced, and can fracture during occlusion.

Discussion

Endodontic treatment is sometimes challenging and root perforation is an undesirable incident that can occur at any stage of root canal treatment. Caries or resorptive processes may cause perforations but most perforations are induced iatrogenically. Perforation in the pulp floor is an artificial opening in the tooth and results in the destruction of the dentine floor and cement. It creates a pathological communication between the supporting periodontal apparatus and the root canal system. A furcation perforation created by the clinician during entry to the canal system is an undesirable damage and furcation or root perforations are responsible for endodontic failure. According to the Washington study, root perforations resulted in endodontic failure in approximately 10% of all failed cases. The long-term prognosis of a perforated tooth is dependent upon the location of the perforation, how long the perforation is exposed to oral contamination, and the ability to seal the perforation.

Experimental studies of periodontal tissue reaction after perforations in monkeys and dogs teeth, together with some clinical investigation of perforation in human teeth, suggest that perforation in the floor of the pulp chamber have the least favourable prognosis after treatment, this is because of the close proximity to the oral environment and a higher risk of periodontal defect.

Seltzer et al made artificial perforations in the pulp chamber floor in monkeys’ teeth. One group of the perforations were sealed immediately, some left open for a while before they were sealed and some not sealed at all. The tissue reactions ranged from mild to severe, where the most severe reactions occurred when the perforated regions were not sealed immediately.

In a study by Balla et al they found that the degree of tissue response to experimentally created furcation perforations treated with various materials depended upon several factors: the severity of initial damage, size and location, sealing ability or cytotoxicity of the repair material and bacterial contamination. Extensive injury may cause irreversible damage to the attachment apparatus at the furcal area. They also found in several cases that epithelium surrounded the perforation area. Once the periodontal pocket was formed, persistent inflammation in the furcal area was maintained by irritants from the pocket. Peterssons et al showed that pocket formation increased with increasing observation time.

MTA has been recommended as a repair material for root perforations because it has been shown to be biocompatible to the surrounding tissue and has a good sealing ability. Torabinejad et al found the presence of cementum growing on the surface of the MTA and regeneration of the periradicular periodontium. Also in a study by Yaltirik et al they found the presence of dystrophic calcification in connective tissue adjacent to MTA when the material were implanted into albino rats.

In this case the perforation was sealed with MTA and calcium sulphate as an internal matrix. This was done to prevent overfilling of MTA into the alveolar bone and to reduce the need for MTA. Zou et al evaluated the effect of matrix on MTA in an in vitro study. They found no overfilling in the group with calcium sulphate, but that group had the most leakage because of calcium sulphate debris remaining on the walls. Al-Daafas et al looked at the histological
healing response of furcal perforations repaired with calcium sulphate as an internal matrix in dogs’ teeth. They found that calcium sulphate did not help bone regeneration or prevent epithelium migration into the defected area and caused more inflammatory reaction 12.

This patient had an accidental perforation during access preparation at the student clinic. There was a large perforation in the furcal area almost separating the two roots. By placing MTA in the perforation one can hope for a hard tissue formation. But according to the literature a perforation this size and location has a poor prognosis. It will with time produce a communication with the oral environment and result in a periodontal lesion. The tooth is also very weekend by the loss of tooth substance and might fracture.

References
5. Al-Daafas A and Al-Nazhan S. Histological evaluation of contaminated furcal perforation in dogs’ teeth repaired by MTA with or without internal matrix. OOOOE 2007;103:e92-e99.
Endodontic treatment of a mandibular right second molar with C-shape anatomy

Patient
32 year old North European female with Norwegian mother and African father. She was referred to the Post Graduate Clinic, 3rd of October 2007 because of C-shape anatomy.

Chief-complaint
The patient had no pain, but some of the temporary filling had fallen out and was irritating.

History
- Medical
  Non contributory
- Dental
  Endodontic treatment was started in February 2007 at the student clinic, because of a deep caries lesion in the lower right second molar. Because of difficult root anatomy the patient was referred to the postgraduate clinic.

Clinical Findings
- Soft tissue
  Normal, darker pigmentation of the gingiva
- Tooth
  46: Normal tooth with no fillings
  47: mesial and lingual composite filling.
  Occlusal IRM filling
  48: Normal tooth with no fillings
Clinical Findings 3rd October 2007

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Table 1 Clinical tests

Radiographic findings 3rd October 2007

- **Dental**
  45: no fillings
  46: no fillings
  47: loss of tooth structure M, radiopaque occlusal filling
  48: no fillings

- **Apical**
  46: sign of apical periodontitis on the distal root.
  Continuous PDL can be followed around the roots of the other teeth

- **Periodontal**
  Within normal limits

Diagnosis

- **Pulpal Diagnosis tooth 47**
  Pulpal necrosis (K04.1)

- **Periapical Diagnosis**
  Asymptomatical apical periodontitis (K04.5)

- **Periodontal Diagnosis**
  Normal

Treatment Plan

- Non surgical endodontic treatment with of a necrotic tooth with canal disinfection and obturation
Problem list
- The root anatomy was not recognized at first, but by closer viewing of the radiograph a different anatomy was found. C-shaped roots can be difficult to instrument and obturate.

Progress notes 3\textsuperscript{rd} October 2007
Access preparation was done and four canals were located. There was no bleeding from the canals.

Root canal disinfection and instrumentation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     MB #35/18 mm
     ML #35/20 mm
     DB #40/18 mm
     DL #50/20 mm
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Intracanal dressing
   - Ca(OH)\textsubscript{2}
4. Temporary filling
   - IRM
Progress notes 11th of March 2008
The patient had no symptoms from the tooth when she returned. The tooth was reopened, with the use of burs and ultrasound two more canals were located.

Root canal disinfection and instrumentation
1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     - MB  #35/18 mm
     - MB2 #35/19,5 mm
     - ML  #35/20 mm
     - DB  #40/18 mm
     - DB2 #40/18 mm
     - DL  #50/20 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Intracanal dressing**
   - Ca(OH)$_2$

4. **Temporary filling**
   - IRM

Progress notes 26$^{th}$ of March 2008
The patient was free of symptoms and the tooth was obturated.

Root canal disinfection and obturation
1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Ultrasound
     - MB  #35/18 mm
     - MB2 #35/19,5 mm
     - ML  #35/20 mm
     - DB  #40/18 mm
     - DB2 #40/18 mm
     - DL  #50/20 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Obturation**
   - GP and AH+

4. **Temporary filling**
   - IRM
Prognosis
- **Endodontic** assumed good
- **Tooth** assumed good

Follow-up
- The patient has not been back for a follow-up. She has moved to another part of the country.

Evaluation
- The treatment was preformed according to procedure guidelines.

Discussion
Mandibular second molars differ from the first molars in a greater variation in the crown and root anatomy. The two roots often sweep distally in a gradual curve with the apices often close together. The pulp chamber and the canal orifices are generally not as large as in the first molar and the roots are closer together. The canals can therefore be fused to a single
conical root with varying internal root anatomy or often a C-shaped canal system\(^1\). The first to report C-shaped configurations were Cooke and Cox in 1979.

The variation appears to be genetically determined, and different studies indicate that C-shaped canals are more frequent in some populations\(^4\) than others. Yang et al\(^5\) reported the incidence of C-shape root anatomy in the second lower molars in a Chinese population to be 31.5\%, and a true C-shape was reported in 14\% of the material. Ahmed et al\(^2\) found 10\% in a Sudanese population. These studies indicate that a C-shaped canal are more frequent in Asians, especially from the Far East\(^4\), and is much more common in Asians than in Caucasians.

Failure of the Hertwig’s epithelial root sheath to fuse on the lingual or buccal root surface is the main cause of C-shaped roots, which always contain a C-shaped canal. This fusion remains irregular, and the two roots stay connected by an interradicular ribbon. The floor of the pulp chamber is deep and has an unusual anatomic appearance\(^1\). This kind of root anatomy is so named because of the cross-sectional morphology of the root and root canal. Instead of having several discrete orifices, the pulp chamber of the C-shaped canal is a single ribbon-shaped orifice with a 180\° arc. Two or three canals may be found in the C-shaped groove, or the C-shape may be continuous throughout the root length\(^3\).

Below the orifice level, the root structure can harbour a wide range of anatomic variations. These can be classified into two basic groups: (1) those with a single, ribbon-like, C-shaped canal from orifice to apex and (2) those with three or more distinct canals below the C-shaped orifice\(^3\).

This variation may occur in mandibular first molars, maxillary molars, mandibular first premolars, and even in maxillary lateral incisors, but it is most commonly found in mandibular second molars\(^4\). When present on one side, a C-shaped canal may be found in the contra lateral tooth in over 70\% of individuals\(^6\).

Melton and co-workers\(^7\) proposed a classification of C-shaped canals based on their cross-sectional shape. This shape can vary along the length of the root (fig 13).

<table>
<thead>
<tr>
<th>Category</th>
<th>Cross-sectional Shape</th>
</tr>
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<tbody>
<tr>
<td>I (C1)</td>
<td>an ellipse interrupted</td>
</tr>
<tr>
<td>II (C2)</td>
<td>a semicolon</td>
</tr>
<tr>
<td>III (C3)</td>
<td>2 or 3 separate canals</td>
</tr>
<tr>
<td>IV (C4)</td>
<td>a single round or oval</td>
</tr>
<tr>
<td>V (C5)</td>
<td>no canal lumen could be</td>
</tr>
</tbody>
</table>

1. Category I (C1): the shape was an interrupted “C” with no separation or division (Fig. 1A).
2. Category II (C2): the canal shape resembled a semicolon resulting from a discontinuation of the “C” outline.
3. Category III (C3): 2 or 3 separate canals.
4. Category IV (C4): only one round or oval canal in that crosssection.
5. Category V (C5): no canal lumen could be observed (which is usually seen near the apex only).

Fig 13
Irregular areas in a C-shaped root canal system may house soft tissue remnants or infected debris, so thorough cleaning, shaping and a intracanal dressing with Ca(OH)$_2$ is recommended. These teeth pose a considerable technical challenge but by the use of microscopy, ultrasonic instrumentation, and plasticized obturation techniques have made treatment successful\textsuperscript{1}.

References
Internal resorption of the maxillary left lateral incisor

Patient  
28-year old North African male referred to the Post Graduate Clinic, 7th of October 2008 for endodontic treatment of the right maxillary lateral incisor.

Chief-complaint
The patient has no symptoms or pain. He needs endodontic treatment of the upper left lateral. He was referred from the Student Clinic because of an resorption in the maxillary left lateral.

History
- Medical history
  Non contributory
- Dental history
  He visited the dental emergency clinic 4 year ago because of pain and a palatal abscess. Endodontic treatment was then initiated. The symptoms disappeared and he did not seek dental treatment until 2008. He is now a patient at the Student Clinic.

Clinical Findings 7th October 2008
- **Soft tissue**
  Normal, a more greyish colour on the buccal surface of the gingiva tooth 22
- **Dental**
  21: D composite
  22: M and D composite, P IRM
Clinical Tests 7\textsuperscript{th} of October 2008

<table>
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</table>

Table 1 Clinical tests

Radiographic findings

- **Dental**
  - 21: Radiopaque D filling
  - 22: Radiopaque MP filling, radiolucent filling distal
    Circumscribed lucency in the coronal third of the root projecting over the root canal
  - 23: Normal tooth, no fillings

- **Apical**
  - 22: Signs of apical periodontitis
    Continuous PDL space around the other roots

- **Periodontal**
  - Normal
Diagnosis

- **Pulpal Diagnosis tooth 22**
  - Necrosis (K04.1)
- **Periapcal Diagnosis**
  - Chronical apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  - Within normal limits
- **Tooth Diagnosis**
  - Patological tooth resorption (K03.3)

Treatment Plan

1. Locate the resorption.
2. Non-Surgical Endodontics with root canal disinfection and obturation

Problem list

- Extent of the resorptive cavity
- Cleaning and shaping
- Obturation

Progress notes 7th October 2008

Access preparation was made and the resorption defect located in the buccal front of the rootcanal. Osteode tissue was removed with burs, ultrasound and hand instruments. There was no bleeding.

Root canal disinfection and instrumentation

1. Mechanical:
   - NiTi Hand instrumentation
   - Bur and Ultrasound
   - #60/23 mm
2. Chemical:
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Intracanal dressing:
   - Ca(OH)2
4. Temporary filling:
   - IRM

Fig 7
Progress notes 21\textsuperscript{st} October 2008

The patient has not experienced any pain and the tooth is symptom free. MTA in the resorption defect and a wet cotton pellet until the next appointment.

Root canal disinfection and obturation
1. **Mechanical**
   - NiTi Hand instrumentation
   - Ultrasound
   - #60/23 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Obturation**
   - GP/AH+
   - Grey MTA
   - Moist cotton pellet

4. **Temporary filling**
   - IRM

Progress notes 11\textsuperscript{th} of November 2008

Removal of IRM and cotton pellet after the placement of rubberdam. The MTA had set and a top-filling of composite was placed.
Prognosis

- **Endodontic**: assumed good
  University based studies on teeth with apical periodontitis have shown that the overall healing rate to be around 90%
- **Tooth**: Good
  Teeth with internal resorption have shown high survival rate as long as the resorption has not penetrated the root surface.

Evaluation

- Good clinical conditions at five months follow-up
- No signs of further development of the resorption

Follow-Up 21\textsuperscript{st} of April 2009, 5 months

![Fig 12 11.11.2008](image1)
![Fig 13 Clinical photo](image2)
![Fig 14 21.04.09](image3)

Discussion

Internal resorption is a rare finding in permanent teeth. It affects approximately 2 \% of the teeth and is caused by trauma and infection of the pulp. Internal resorption is characterized by an oval-shaped enlargement of the root canal space\textsuperscript{1}.

The protection of the internal dentine wall from mechanical trauma, compared with the external root surface lower the incidence of internal resorption in traumatized teeth. Resorption is only found in areas where the dentine wall was denuded of odontoblasts and predentin. In these areas they found spreading of macrophage-like cells. This indicates that initiation of internal resorption requires the removal of odontoblasts and predentin\textsuperscript{2}.

Trauma and infection may be regarded as two important etiological factors in internal resorption. Based on the findings in the study of Wedenberg et al internal resorption may be
divided into 2 types. A transient type, which is developed in the absence of pulpal infection, and a progressive type, which requires continuous stimulation by a bacterial inflammation².

The loss of the protective odontoblast layer exposes the mineralized dentine, which then becomes colonized and resorbed by osteoclasts. The pulp tissue coronal to the lesion has to become necrotic and infected because this sustain the resorptive lesion. For the lesion to progress the apical part of the pulp has to be vital³.

Diagnose is usually made from radiographs. The defect appears as a smooth and almost spherical radiolucency in the roots. The root canal below the resorption defect commonly appears narrow. The lesion has often bees confused with external resorption. The parallel technique can be used to confirm whether the lesion is within the outer or inner aspect of the canal. External resorption defects will move in the same or in the opposite direction of the second radiograph, and the root canal can be seen as an uninterrupted canal. Internal resorption will on the other hand appear to stay in the same position¹.

Internal inflammatory resorption is rare and often detected after its activity has ceased. Clinical symptoms and signs are usually not identified until the internal resorption is advanced. The tooth may be discoloured and respond negatively to sensitivity testing with advanced lesions¹.

The lesion contains granulomatous tissue and osteoclastic cells adjacent to the dentine. This dentine frequently contains bacteria that stimulate the osteoclasts. The coronal part of the lesion contains necrotic tissue. The resorptive process will continue while the pulp has blood supply. Infection may ultimately lead to the necrosis of the remaining pulp⁴. While there is an active lesion prompt endodontic treatment is required to remove the remaining vital apical pulp tissue that is sustaining the lesion. In some cases if the lesion has progressed to far the root wall may become perforated³. Endodontic filling of this irregular root canal anatomy is best achieved by using warm gutta-percha obturation system⁵.

It was difficult to determine if this resorption was internal or cervical. On the radiographs it has a typical appearance of an internal resorption because of its spherical shape, but on the other hand the original outline of the root canal was not distorted. There was also increased probing debt at the buccal aspect of the tooth, but the lesion could not be probed. After access preparation the resorbtion was located. It appeared to originate from the root canal because the buccal front of the canal was destroyed. There was no bleeding from the resorbtion tissue and this would have been expected if it had been a cervical resorbtion. The resorptive defect had probably arrested in development since the pulp was necrotic. There was no sign of perforation of the buccal root wall, but MTA was chosen because in rare occasions the internal resorption can penetrate the root and this resorbtion was large in the buccal direction.

References
2. Wedenberg C, Lindskog S. Experimental internal resorption in monkey teeth
3. Caliskan MK and Turkun M. Prognosis of permanent teeth with internal resorption: a
   clinical review. Endod Dent Traumatol 1997;13:75-81

Endodontic treatment of the mandibular teeth in a medically compromised patient

Patient
62-year old Norwegian male referred to the Post Graduate clinic, 5th of December 2006, for endodontic evaluation and treatment of the mandibular teeth.

Chief-complaint
The patient was referred for an examination and to evaluate the need for endodontic treatment in the lower jaw. The patient had no pain from his teeth.

History
- **Medical**
  2004: Stroke
  2005: Tung cancer. This was treated with radiation therapy. The distal part of the lower jaw got a dose of 70 Gy, the middle part a lower dose of 46 Gy while the central part of the mandible received an insignificant dose.
  As a result of radiation therapy he has lost the tong reflex, atrophic gingiva and fibrosis of the fascial muscles. He has constant pain in the jaw muscles and a reduced sensation in the area. There is also a dramatical reduction in the salivary flow.
- **Medication**
  Albyl E 75 mg one tablet a day.
- **Dental**
  Before the radiation the patient a good functional dentition with, normal dental status compared to others his age. (Fig 2) After the radiation therapy caries lesions developed at an increasing speed. (Fig.3)
Clinical Findings 5th of December 2006

- **Extra orally**
  The skin of his face is thin and soft and the facial hair is lost in the right and left side of the face where he has received radiation. Candidiasis in the lip corners (Fig 3).

- **Soft tissue**
  Atrophic mucosa, tong and the hole mouth that are very sore and sensitive. There is almost no saliva.
• Dental
  Mandibular right side
  47: PFM crown
  46: PFM crown
  45: PFM crown
  44: MLD composite, M caries

Mandibular front
  43: Mesial and distal caries
  42: Mesial and distal caries
  Temporary composite bridge
  fixated to 42 and 32.
  32: Mesial and distal caries

Mandibular left side
  33: Mesial and distal caries
  34: MLD composite
  35: MLD composite
  36: MODL composite
  37: Missing
  38: O composite, MBDL caries
  Aproximal plaque

Clinical Tests 5th of December 2006

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</table>
Radiographic findings tooth 47- 41

- **Dental**
  - 47: PFM crown
  - 46: PFM crown
  - 45: PFM crown, root filled
  - 44: Composite build-up
  - 43: Mesial and distal caries
  - 42: Mesial and distal caries
  - 41: Fracture of the crown, the root is still in place, composite bridge fixated to 42-32

- **Periodontal**
  - Within normal limits

- **Apical**
  - 41: signs of apical pathosis
  - 47, 46, 45, 44, 43, 42: Lamina dura can be followed without disruption.

Radiographic findings tooth 38- 31

- **Dental**
  - 31: Fracture of the crown, the root is still in place, composite bridge fixated to 32
  - 32: Mesial and distal deep caries
  - 33: MBD composite
  - 34: MBD composite
  - 35: MBDOL composite
36: MBDOL composite
37: Missing
38: O composite, mesial and distal caries

- **Periodontal**
  Within normal limits

- **Apical**
  32, 33, 34, 35, 36: Lamina dura can be followed without disruption.
  31, 38: Signs of apical periodontitis

**Diagnosis**

- **Pulpal Diagnosis**
  Vital pulp: 47, 46, 44, 43
  Root filled (K04.19): 45
  Necrotic pulp (K04.1): 42, 41, 31, 32, 33, 34, 35, 36, 38

- **Periapical Diagnosis**
  Asymptomatic apical periodontitis (K04.5): 41, 31, 38

- **Periodontal Diagnosis**
  Within normal limits

**Treatment Plan**

- Non surgical endodontic treatment of necrotic teeth with disinfection and instrumentation, and pulpectomy of teeth 43 and 44.
  Endodontic treatment was first only planned in teeth 38, 36, 35, 34, 33, and 43 because of deep caries, and 44 since this tooth was tender to percussion and had a deep restoration. But because of the rampant caries development in the lower jaw it was also decided to treat tooth preventively 47, 46, and 43 while the pulps were still vital. The endodontic treatment was done by to Post Graduate students.

- Further treatment of this patient was preformed by the referring dentist, and the plan was to remove the crowns of the teeth that were destroyed the most, and replace them with partial dentures. Teeth 42, 41, 32, 31 were planed for extraction and replaced possibly by a bridge from 43-33.

- He was instructed in exercises for the oral muscles and informed and instructed in oral home care.

**Problem list**

- Antibiotic prophylaxis: Apocillin 660 mg 2+2+2 tablets, a day before treatment, during treatment and the day after treatment (Recommended by his treating doctor at hospital)
- Try to keep the treatment sessions as short as possible and two appointments in one week, to reduce the use of antibiotics
- Reduce the number of radiographs
- Treatment has to be preformed under Rubberdam because of reduced tong reflex.
- Dryness of the mouth
- Rubberdam placement on tooth 38
- Soar and tender oral mucosa
- Difficult to place the X-ray holder.
- Use the Apex-locator during treatment to prevent over-instrumentation.
Progress notes 5\textsuperscript{th} of December 2006 teeth 34 and 35
The patient started taking antibiotics the day before treatment. It was impossible to treat the patient without the Rubberdam during access preparation because of lost tongue reflexes. The mouth, the lips, cheeks and gingival were covered in Vaseline because of dryness. Access preparation of tooth 34 and 35 were started without anaesthesia, but the teeth gave a vital response before entering the pulp. Eugenol and IRM were placed in tooth 34 and 35.

Progress notes 6\textsuperscript{th} of December 2006 tooth 33
Treatment of tooth 33 was started. This tooth was also vital.

Root canal disinfection, instrumentation and obturation
1. Mechanical
   - NiTi Hand instrumentation, Bur
     1 canal: #60/24 mm
2. Chemical
   - NaOCl
   - EDTAC
3. Obturation
   - GP and AH+
4. Temporary filling
   - IRM

Progress notes 12\textsuperscript{th} of December 2006 tooth 38
The crown had fractured and it was impossible to place a rubberdam. This tooth was in the middle of the radiation field so subgingival placement of a copper ring was not allowed. The tooth was treated without rubberdam and irrigated only with Chlorhexidine Digluconate 2%. This tooth was also vital.

Root canal disinfection, instrumentation and obturation.
1. Mechanical
   - NiTi Hand instrumentation
   - Bur
     M: #45/10 mm
     D: #50/9,5 mm
2. Chemical
   - Chlorhexidine 2% Digluconate
3. Obturation
   - GP, AH+ and IRM plugs
4. Permanent filling
   - Glass-ionomer

Progress notes 13\textsuperscript{th} of December 2006 teeth 34 and 35
Endodontic treatment of tooth 34 and 45: Treatment was preformed according to guidelines for treatment of vital pulp and obturated with AH+ and GP.

   - Tooth 34
     #45/20 mm
Tooth 35  
#55/18 mm

Progress notes 7th of Mars 2007 tooth 44
After the last treatment session the patient experienced severe muscle pain and trismus, and was not able to open his mouth properly in a week. He wanted a pause before he continued treatment.

Endodontic treatment of tooth 44:  
He received 400 mg Ibux before treatment to reduce muscle pain postop and it helped. The diagnosis on 44 was on the day of treatment was partial necrosis. It was decided to obturate in one session because there was no sign of apical periodontitis and to reduce treatment sessions for the patient. Treatment was preformed according to guidelines for treatment of vital pulp and obturated with AH+ and GP. Additional irrigation with Chlorhexidine 2% Digluconate. Obturation: GP, AH+ and IRM

• Tooth 44  
#50/14,5 mm

Progress notes 29th of May 2007 tooth 43
Treatment was preformed according to guidelines for treatment of vital pulp and obturated with AH+ and GP. (Fig 10)

• Tooth  
#50/25 mm

Progress notes 20th of June 2007 tooth 36
Treatment was preformed according to guidelines for treatment of vital pulp and obturated with AH+ and GP. The PFM-crown had been removed because of caries and replaced with temporary crown.

• Tooth 36  
MB: #40/19 mm  
ML: #40/19 mm  
D: #55/19 mm
Progress notes 19th of February 2007 tooth 46
The patient wanted a new break from further endodontic treatment. He completed prosthetic treatment in the upper jaw and had returned to work. He was much more content and there was also some improvement in the oral health. The mucosa was not as tender as before, and the numbness in his face had improved. There was also an improvement in oral hygiene and no further progression of caries.

![Fig 12 New crowns in the upper jaw](image)

![Fig 13](image)

![Fig 14](image)

Treatment was performed according to guidelines for treatment of vital pulp and obturated with AH+ and GP.

- Tooth 36
  - MB: #40/18 mm
  - ML: #40/18 mm
  - D: #50/17 mm

![Fig 15](image)
Progress notes 5\textsuperscript{th} of Mars 2008 tooth 47

Treatment was performed according to guidelines for treatment of vital pulp and obturated with AH+ and GP

- Tooth 47
  MB: #45/16,5 mm  
  ML: #45/16,5 mm  
  D: #60/16,0 mm

Follow-up

One year on teeth 33, 34, 35, 36, 38 and 44. The patient has not been available for further follow-up.
Prognosis

- **Endodontic** assumed good.
- **Teeth**: assumed good. Oral hygiene has improved and there has been an arrest in caries development.

Evaluation

- The treatment could have been completed a lot sooner, but the patient got tired of dental treatment and needed pauses. He was unmotivated and would not realise that oral home care was important.
- All the teeth that were diagnosed as necrotic, except tooth 44, were vital. Why there was no reaction when these teeth were tested with ice and electricity are difficult to say.
- The prognosis on teeth with vital pulps are 96%.\(^1\)
- Treatment of tooth 38 was not optimal
- His dental status should have been evaluated before radiation, and teeth with a poor prognosis extracted.
- This kind of patient should be followed up by a team, where oral health and oral rehabilitation are focused on, and maintained.
- Antibiotic prophylaxis
Discussion

Radiotherapy (RT) induces damage in normal tissues that may result in additional oral problems such as mucositis, hyposalivation, radiation caries, taste loss, trismus, soft-tissue necrosis, and osteoradionecrosis. These sequelae may be dose-limiting and have a tremendous effect on the patient’s quality of life. When the salivary glands are in the radiation field, particularly the parotids, the resultant decrease in salivary flow leads to an increased risk of caries and periodontal disease.

The bulk of saliva, particularly under conditions of stimulation by eating or drinking, comes from the parotids. It is purely a serous gland which is very sensitive to radiation. The rampant development of caries in these patients are thought to be due to “loss of the buffering, antibacterial, lubricating and cleansing properties of saliva” resulting in a shift in the oral bacterial flora towards cariogenic organisms (especially Streptococcus mutans and lactobacilli) at the expense of non-cariogenic bacteria. The situation is worsened by a dietary increase in fermentable carbohydrates consequent to the xerostomia, again selecting for acidogenic bacteria.

High dose irradiation of the jaws predisposes to osteoradionecrosis (ORN). This is related to a decrease in osteocytes and vascularity of the bone rendering it susceptible to trauma and infection, especially if postradiation extractions are needed. The risk of development of ORN is maximal after cumulative doses to the bone that exceed 65 Gy; this is particularly true of the molar region of the mandible.

In the past, removal of all teeth was undertaken prior to radical RT. No there is a trend not remove any teeth even in the high dose area, providing the teeth are in good order. This requires careful restoration of salvageable teeth and strict adherence to dental hygiene measures during and after RT. Recent research has shown that two very effective measures are the use of fluoride (which strengthens tooth enamel) and chlorhexidine (which favourably influences the balance of oral flora away from cariogenic organisms).

Jansma et al developed a protocol divided into three phases of patient care, namely before radiation exposure, during and after radiation exposure.

All teeth with a questionable prognosis should be extracted before radiation therapy. One important factor includes the patient’s motivation and ability to comply with the preventive regimen. A lack of motivation on the part of the patient should lead to a decision to extract teeth before radiation therapy.

There are almost no recovery of salivary flow when the major salivary glands are situated in the treatment portals and receive a cumulative radiation dose in excess of 40 Gy. In many patients with head and neck cancer, cumulative radiation dosages of 60-70 Gy are administered to one or more of the salivary glands, so hyposalivation is irreversible in most instances. This has a tremendous effect on caries challenge and quality of life for the patient.
References
Cervical root resorption of the mandibular right canine

Patient
54-year old North European woman referred to Post Graduate Clinic, 15th of November 2007, for treatment of the mandibular right canine.

Chief complaint
For the last year she had some sensitivity to cold in the area and for the last months some swelling and discomfort in the gingival on the buccal side of the lower right canine.

History
- **Medical**
  Non-contributory

- **Dental**
The patient has had orthodontic treatment two times. The first time was when she was 11-12 years and the second time was 12 years ago. She complained to her dentist after almost a year after the first symptoms, because of signs and symptoms of an acute periodontal infection and this revealed the extensive resorptive process that had developed in her lower right canine.

Clinical Examination 15th of November 2007
- **Extra-orally**
  No pathology was found

- **Soft tissue**
The mucosa around the canine showed signs of infection with redness, swelling and pus drainage from the pocket.
• **Tooth**
  41: D composite
  42: M composite
  43: Normal
  44: Porcelain crown, bridge abutment
  The patient had a lingual retainer from 33-43.

Clinical Tests 15\textsuperscript{th} of November 2007

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_Tabel 1 Clinical tests_

Radiographic Examination 15\textsuperscript{th} of November 2007

• **Dental:**
  43: Radiopaque M filling, irregular mottled radiolucent zone starting in the cervical part of the root and extending to the middle part
  44: Radiopaque crown, abutment
  46: Radiopaque crown, abutment
  45: Missing

• **Marginal bone**
  Localised bone loss around 33

• **Apical bone**
  The lamina dura can be followed around the roots of 44 and 46. Diffuse sign of apical periodontitis at the apex of 43.
Diagnosis

- **Pulpal diagnosis tooth 33**
  Pulpal Necrosis (K04.1)
- **Periapical diagnosis**
  Asymptomatic Apical periodontitis (K04.5)
- **Marginal bone**
  Localised marginal bone loss
- **Tooth 33**
  Pathological tooth resorption (K03.3)

Treatment plan

1. Non-Surgical Endodontics with root canal disinfection and obturation.
2. Locate and repair the perforation surgically with composite.

Problem list

- Extent of the root resorption
- Remaining tooth structure
- Difficult to keep the root canal dry during obturation

Progress notes 15th of November 2007

Access preparation was made. It was difficult to keep the root canal dry because of extensive bleeding from the granulation tissue in the resorption defect. It was decided to perform an explorative surgery to confirm the extend of the resorption and to perform the restorative build up of the root before further root canal instrumentation.

Root canal disinfection and instrumentation

1. **Mechanical:**
   - NiTi Hand instrumentation
     #30/20 mm

2. **Chemical:**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconat 2%

3. **Intracanal dressing**
   - Ca(OH)₂

4. **Temporary filling:**
   - IRM

Progress notes 29 November 2007

**Surgical procedure**

1. Anaesthesia
2. Incision 44D-42M, with a releasing incision 42M
3. Reflection of the flap
4. Locating the resorption
Treatment of the resorption

1. Mechanical
   - Cleaning and shaping of the cavity with bur

2. Filling
   - Composite Z250

There was extensive destruction of tooth structure and a GP point was inserted in the canal during placement of the composite filling to prevent occlusion of the canal. Haemostasis was achieved with Ferric Sulphate and Epinephrine thread.

Endodontic procedure
The tooth was then instrumented and disinfected under rubberdam and a new intracanal medicament with Ca(OH)$_2$ was placed. Guidelines of treatment of a tooth with necrotic was followed

- **Tooth 43**
  - #55/20 mm

Progress notes 16$^{th}$ December 2007
The patient returned after one week for suture removal. There had been minimal pain and discomfort.
Progress notes 15th January 2008
Root canal disinfection and obturation

1. **Mechanical:**
   - NiTi Hand instrumentation
     #55/20 mm

2. **Chemical:**
   - NaOCl
   - EDTA

3. **Obturation**
   - GP and AH+

4. **Top filling**
   - IRM and Composite

Normal mucosa was observed and no clinical pockets when probing.(Fig 14)

Prognosis
- **Endodontic:** Good
- **Tooth:** Uncertain - danger of root-crown fracture due to extensive resorptive lesion.

Follow-up 7th of January 2009 - one year
- No clinical probing dept or bleeding on probing
- The tooth is in function there is good gingival conditions
- Marginal bone loss around tooth 43
- The tooth is further observed
Evaluation
- The patient was informed about the uncertain long term prognosis before treatment started, but wanted to try and preserve the tooth and postpone extensive new prostodontic treatment.
- The cervical resorption should have been diagnosed at an earlier stage.
- The lesion was classified as a Class 3 resorption without visible signs of tunnelling.
- The subgingival filling will result in a deep periodontal pocket prone to infection if the patient is not thorough with dental hygiene.
- There is a possibility of leakage at the margins of the composite filling and a reinfection of the canal, resulting in apical disease.
- The tooth was not treated with trichloracetic acid. This could have removed resorptive tissue in non accessible areas to the curette/bur.

The objective of the treatment:
- In short term: To eliminate infection and postpone new prosthodontic treatment.
- In long term: To preserve the tooth as long as possible.

Discussion
Invasive cervical resorption is relatively uncommon and often an aggressive form of external root resorption. It occurs immediately below the epithelial attachment of the tooth, and is characterized by its cervical location and invasive nature, usually but not always in the cervical area of the tooth. The exact pathogenesis of cervical root resorption is not fully understood.

The aetiology of invasive cervical resorption is unknown, one theory is that the inflammatory process is activated by sulcular microorganisms. The other theory is a type of benign proliferative fibrovascular or fibro-osseous disorder, that invade the tooth and that microorganisms may become secondary invaders. Histological study shows the resorption cavity filled with a mass of fibrous tissue, numerous blood vessels and elastic resorbing cells adjacent to the dentine surface.

For invasion to occur there has to be a defect or an injury that alters the protective predentine or precementum layers. Predisposing factors are orthodontics, trauma, surgery (particularly involving the cemento-enamel junction) intracoronal bleaching, periodontal therapy and bruxism.

The pulp plays no role in cervical root resorption and is mostly free of inflammation because a layer of predentin is present around the pulp separating the pulp from the resorbing tissue.

The teeth that are most commonly affected are the maxillary central incisors first, followed by maxillary canines, maxillary lateral incisors, mandibular first molars, maxillary first molars, mandibular second molars and mandibular incisors.

Heitersay has developed a clinical classification of cervical resorption. It is divided into four classes according to severity:
Class 1 – is a small invasive resorptive lesion near the cervical area with shallow penetration into dentine.

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

Class 3 – is 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 – is a large invasive resorptive process that has extended beyond the coronal third of the root.

The condition is usually painless and if there is no clinical sign, the resorptive process is often discovered by chance or during radiologic examination. Because of the protective role of the predentine layer symptoms rarely occur unless there has been superimposed infection in the pulp or periodontium.

Generalized cervical resorption has been reported in a few cases in the literature. It has also been associated with systemic and endocrine disorders.

The radiographic appearance generally shows an irregular mottled, or ‘moth-eaten’ image in the main lesion area and the outline of the root canal can be seen as a radiopaque line demarcating the root canal.

A follow-up study of minimum 3 years of the different types of cervical root resorption showed complete success in class 1 and 2. Class 3 showed an overall survival rate of 77.8% while class 4 only had a survival rate of 12.5%. These 101 teeth in 94 had been treated nonsurgically using topical application of trichloracetic acid, curettage, and restoration.
References
Endodontic treatment in conjunction with apicoectomy of a maxillary left lateral incisor with a palatal invagination

Patient
26 year old Vest Asian female, referred to the Post Graduate Endodontic Clinic, 17\textsuperscript{th} of December 2008, for treatment of the maxillary left lateral incisor.

Chief-complaint
She experienced no pain from the tooth, but had a swelling on the palatal side, for the last two years, that varied in size. There was no puss drainage. The lesion was discovered during routine radiographs and she was referred from the student clinic.

History
- Medical
  Non contributory
- Dental
  Fissure sealant had been applied on the palatal side of 22. No other dental work had been done. The palatal swelling had come and gone for the last two years

Clinical Findings 17\textsuperscript{th} of December 2008
- Soft tissue
  Darker pigmentation of the gingival
  Tumour on the palatal side of the teeth.(fig 3)
  Gingival regression on the buccal aspect of tooth 22.
Good oral hygiene, some calculus in the lower front.

- **Dental**
  12: No fillings, palatal foramen
  11: No fillings
  21: No fillings
  22: Palatal flowable resin
  23: No fillings

Clinical Tests 17\textsuperscript{th} of December 2008

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Tabel 1
Radiographic findings 17th of December 2008

- Dental
  11: Normal tooth
  21: Normal tooth
  22: Palatal invagination
  23: Normal tooth

- Periodontal
  Within normal limits

- Apical
  11: Continuous lamina dura around the root
  21: Continuous lamina dura around the root
  22: Continuous lamina dura around the coronal third of the root. Large circumscribed apical lucency 12 mm in diameter.
  23: Continuous lamina dura around the root

Diagnosis
- Pulpal Diagnosis tooth 22
  Necrotic pulp (K04.1)

- Periapical Diagnosis
  Chronic apical periodontitis
  Tentative: Radiculare cyst (K04.8)

- Periodontal Diagnosis
  Within normal limits

- Tooth Diagnosis
  Dens invaginatus (K00.2)
Treatment Plan

- Non surgical endodontic of a necrotic tooth with disinfection and obturation. Consider long-term treatment with Ca(OH)\(_2\) if the palatal swelling is reduced in size.
- Obturation with GP and AH+ if the swelling is still present
- Surgical endodontic treatment: Apicoectomy and a retrograde filling.

Problem list

- Large bone destruction
- Extra-radicular infection

Progress notes 17\(^{th}\) of December 2008
Access preparation was made and an empty canal was found. The invagination was centrally placed and was removed during access preparation.

Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur
   - One canal #60/20 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Intracanal dressing**
   - Ca(OH)\(_2\)

4. **Temporary filling**
   - IRM

Progress notes 14\(^{th}\) of January 2009
The patient returned. She had not experienced any pain, but she felt that the swelling on the palatal side had increased in size. (Fig 8) It was decided to obturate the tooth and do a apicoectomy with a retrograde filling.

Root canal disinfection and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur and Irrisafe®
   - One canal #60/20 mm

2. **Chemical**
   - NaOCl
   - EDTAC

3. **Obturation**
   - GP, AH+ and IRM

4. **Permanent filling**
   - Composite
Progress notes 25th of February 2009

1. Anaesthesia
2. Intrasulcular flap from 11D-23D, with a buccal releasing incision 11D
3. Osteotomy
4. Microbiological test/Biopsy
5. Apical root resection
6. Retro-preparation
7. Haemostasis
8. Retrograde filling with MTA
9. Sutures
Progress notes 3\textsuperscript{rd} of March 2009

The patient returned after one week for suture removal. She had taken the prescribed analgesics and had only experienced some minor pain. There was a zone of desquamating epithelial cells in the attached gingival. This was removed with a gentle stroke of a cotton roll. (Fig 20)
The lesion was send for Histopathological examination and reviled granulation tissue with inflammation and epithelial cells.

Microbiological test was positive for
Prevotella intermedia (G-, anaerob blackpigmented rod)
Fusobacterium nucleatum (G-, anaerob rod)
Aggregatibacter actiomyctemcomitans (G-, facultative rod)

Prognosis
- Endodontic assumed good
- Tooth assumed good

Evaluation
- The clinical conditions at suture removal were satisfactory.
- Complete healing and good plaque control.
- Probably heal with scar tissue, because the lesion perforated the palatal bone.
- It was decided to perform surgery because of persisting tumour in the palate.
- Three months follow-up shows signs of healing.

Follow-up 26\textsuperscript{th} of April 2009 - three months

Fig 21 Sutures removed

Fig 22 17.13.08
Fig 23 25.02.09
Fig 24 26.04.2009
Discussion
Dens invaginatus is not an uncommon clinical finding in permanent teeth and probably occurs more often than other developmental anomalies. The reported prevalence of adult teeth affected with dens invaginatus is between 0.3% and 10%. Although dens invaginatus is common it may easily be overlooked because of absence of any significant clinical signs. This is unfortunate as the presence of an invagination is considered to increase the risk of caries, pulpal pathosis and periodontal inflammation.

Invagination results from a proliferation and in growth of cells of the enamel organ into the dental papilla during development. The exact aetiology of dens invaginatus is unknown although a genetic cause is probably the most likely factor.

Oehlers classification from 1957 (Fig 25) is the most widely used, and categorizes invaginations into three classes determined by the extend of the invagination radiographically. Shultze and Brand introduced a more detailed classification also including invaginations starting at the incisal edge and dysmorphic root forms (Fig 26)

Type I: The invagination is minimal and enamel-lined, it is confined within the crown of the tooth and does not extend beyond the level of the external amelo-cemental junction.

Type II: The invagination is enamel-lined and extends into the pulp chamber but remains within the root canal with no communication with the periodontal ligament.

Type IIIA: The invagination extends through the root and communicates laterally with the periodontal ligament space through a pseudo-foramen. There is usually no communication with the pulp, which lies compressed within the root.

Type IIIB: The invagination extends through the root and communicates with the periodontal ligament at the apical foramen. In Type III lesions, any infection within the invagination can lead to an inflammatory response within the periodontal tissues giving rise to a 'peri-invagination periodontitis'

Type I invagination is the most common (79%), whilst Type II 15% and Type III only 5% in the reported cases. The maxillary arch seems to be involved more frequently than the mandibular arch and the permanent maxillary lateral incisor is the most affected tooth with posterior teeth less likely to be affected. Isolated cases have been reported in the mandibular region and in the deciduous dentition. Unilateral expression is common, but bilateral cases are also seen, Grahnen et al reported 43%

Teeth affected with dens invaginatus are associated with an increased risk of developing pulpal problems. This can occur without evidence of any obvious caries or history of trauma. Several studies have reported changes within the invagination, which could increase the risk of bacterial contamination, and provide an explanation as to why these teeth are at more risk.

The entrance to the invagination is often barely noticeable with the only indication being a slightly exaggerated cingulum or a pit. In contrast, the lesion may be substantial with a deep
infolding reaching the apical foramen. There may also be associated grooving of the palatal enamel, coincident with the entrance of the invagination.

A preventive procedure to seal minimal invaginations, with fissure sealing is recommended. Pulp vitality can be clinically important, since root canal treatment can imply endodontic treatment of the invagination alone, the main canal, or both. Irrigation supported by ultrasonics has been recommended as another method to enhance disinfection.

Endodontic treatment in conjunction with surgery is necessary when it is difficult to thoroughly clean and shape the canal or invagination especially if there is a palato-radicular groove, which increases the probability of periodontal breakdown.

Extraradicular infections can be dependent on, or independent of the intraradicular infection and the most common form of extraradicular infection is the acute apical abscess. But there is also another form which is characterized by absence of overt symptoms. Some bacteria may establish themselves and live in the periapical area and hence be cause of persisting apical periodontitis. Sunde et al. identified bacteria in periapical lesions of root filled teeth with apical periodontitis using fluorescence in situ hybridization (FISH). Some species of Actinomyces and P. propionicum can participate in extraradicular infections, but also other putative oral pathogens, such as Treponema species, P. endodontalis, P. gignivalis, T. forsythia, Prevotella species and F. nucleatum, have been detected in periapical lesions. These bacteria possess different virulence traits that may allow them to avoid or overcome the host defence in the periradicular tissues.

References
Apicoectomy of a maxillary left lateral incisor

Patient 37-year old North European male referred to the Post Graduate Clinic, 7th of February 2008, from the general practitioner.

Chief-complaint
The patient has no symptoms from the tooth. He was referred from his GP fore an evaluation of tooth 22 because persistent apical periodontitis.

History
- **Medical**
  Non-contributory

- **Dental**
The patient had a dental trauma in 2001. He was treated at the Endodontic Department in 2002 both 21 and 22 received endodontic treatment.

Fig. 1 Frontal view

Fig 2 Completion of endodontic treatment 21 and 22, 24.05.2002
Clinical Findings 7th of February 2008

- **Soft tissue**
  Normal findings

- **Dental**
  11: Normal tooth, no fillings
  21: Palatinal composite filling
  22: Palatinal composite filling
  23: Normal tooth, no fillings

Clinical Tests 7th of February 2008

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Table 1 Clinical tests
Radiographic Findings 7th of February 2008

- **Dental**
  21: Root filled, radiopaque filling
  22: Root filled, radiopaque filling
  23: Normal tooth, no fillings

- **Periodontal**
  Within normal limits

- **Apical**
  21: Continuous PDL space
  22: Expanded PDL space and a circumscribed radio lucent area 6 mm in diameter 2 mm from the apex of tooth 22.
  23: Continuous PDL space

Diagnosis

- **Pulpal Diagnosis tooth 22**
  Root-filled tooth (K04.19)

- **Periapical Diagnosis**
  Asymptomatic apical periodontitis (K04.5)

- **Periodontal Diagnosis**
  Within normal limits

- **Tentative Diagnosis**
  Residual cyst (K04.81)

Treatment Plan

1. Removal of the lesion
2. Apical surgery with a retrograde filling
3. Biopsy of the lesion

Problem list

- Scar tissue
- Root fracture

Progress notes 26th of February 2008

1. Anaesthesia
2. Sulcular flap from 11M-23D, with a buccal releasing incision 23D
3. Osteotomy
4. Biopsy
5. Apical root resection
6. Retro-preparation
7. Haemostasis
8. Retrograde filling with MTA
9. Sutures
Fig 7  Large defect in the buccal bone. The root resection has been done.

Fig 8  Closer view of the defect and the retrograde MTA.

Fig 9  The lesion was removed in toto

Fig 10  Control of retrograde filling after surgery

Fig 11  Sutures in place
Progress notes 5\textsuperscript{th} of Mars 2008

The patient returned after one week for suture removal. He had not experienced any post-op problems. There was some irritation to the papilla and in the gingival margin at the releasing incision (fig. 9).

Histopathological examination of the surgical specimen confirmed epithelium-lined cystic wall with moderate chronic inflammation, foreign body reaction and a large amount of foreign material that appeared to be endodontic material (AH pluss and Kalsiumwolframat).

Prognosis

- Endodontic assumed good
- Tooth assumed good

Follow-up 23\textsuperscript{rd} of October 2008 – 8 months

- Asymptomatic tooth
- Satisfactory clinical conditions
- Radiographic signs of healing with a continuous PDL surrounding the apex.
Follow-up 16th of April 2009 – 14 months
The patient was back for a one year control. Radiograph shows satisfactory healing (Fig 17)

Evaluation
- The initial root canal treatment had been done at the student clinic and there were clear signs of healing when comparing radiograph.
- Radiograph taken 07.02.08 showed that there was an extended PDL space around the apex of tooth 22, and in addition a large radiolucent asymptomatic lesion located away from the apex that we suspected to be a cyst. It was therefore decided to perform apical surgery instead of retreatment.
- Radiograph taken 8 months later, the periapical area shows distinct bony healing and continuous PDL space.

Discussion
Endodontic failure is thought to involve a continuing infection of the root canal system that results in a chronic periapical lesion after treatment. Persisting periapical lesions can be successfully managed by conservative endodontic retreatment in 75% of the cases. The lesions that do not heal after retreatment can be because of a persisting infection that might be inaccessible to instrumentation, extraradicular infections, cysts, and extruded filling materials that cause foreign-body reactions1.

The importance of conservative re-treatment of canals before surgery has showed a success rate of 24% higher in cases of failed endodontic treatment compared to cases were surgery was the only procedure performed. It is possible to obtain a very high success rates when both the intraradicular and the extraradicular causes of failure of endodontic treatment are well managed6.

Periapical cysts are a sequel to chronic apical periodontitis. But every chronic apical periodontitis does not develop into a cyst. The reported prevalence of cysts in the literature varies a great deal but that the “true” number is below 20%2.
The prognosis of root canal treatment with apical periodontitis is 85-90% so most of the cystic lesions heal after endodontic treatment. There are two categories of radicular cysts, true cysts are those containing cavities completely enclosed in epithelial lining and those containing epithelium-lined cavities that are open to the root canals, called pocket cysts. It is the true cysts that are believed to be self sustaining and will not heal after endodontic therapy.

There are two theories regarding the formation of the cyst cavity. One is the “nutritional deficiency theory” and the other is the “abscess theory.”

Nair et al found in a histopathological study of 256 periapical lesions 35% periapical abscesses, 50% periapical granulomas, and 15% were periapical cysts. Irrespective of the histologic status of the specimens, 52% of the lesions were epithelialized and the remaining 48% were nonepithelialized. Carillo et al found 65.7% of lesions were granulomas, 25.7% scar tissue, and 8.6% cysts in a histopathological study of 70 biopsies.

References
Apicoectomy of a maxillary right premolar

Patient

67-year old North European male referred to the Post Graduate Clinic, 5th of May 2007, because of asymptomatic apical periodontitis of the maxillary right first premolar.

Chief-complaint

The patient has no symptoms. He was referred from the undergraduate clinic for treatment. The need for treatment was discovered during routine radiographs.

History

- **Medical history**
  Coronary heart disease in 1986

- **Medication**
  Cozar comp
  Ratiopham amlodipin 5 mg/day
  Selo-Zok 100 mg/day
  Albyl-E 160 mg/day

- **Dental**
  14 had received endodontic and prosthetic treatment many years ago.
Clinical Findings 5th of May 2007

- **Soft tissue**
  BOP, sinus tract in the buccal pocket and 2 mm from the gingival margin

- **Dental**
  11-13: Gold-acrylic bridge
  14: Crown, mobility grade 1
  15: MOD Amalgam
  16: MOD Amalgam
  17: MOD Amalgam

Clinical Tests 5th of May 2007

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Table 1 Clinical tests

Radiographic findings 5th of May 2007

- **Dental**
  13: Metal crown
  14: Metal crown and post, root filled
  15: MOD Radiopaque filling

- **Apical**
  Circumscribed periapical radiolucency around the root of tooth 14.

- **Marginal**
  Marginal bone loss
Diagnosis

- **Pulpal Diagnosis**
  Root filled tooth K04.19

- **Periapical Diagnosis**
  Apical periodontitis with a sinus tract to the oral cavity K04.62

- **Periodontal Diagnosis**
  Marginal periodontitis K05.3

- **Tentative diagnosis**
  Root fracture S02.53

Treatment Plan

1. Explorative surgery
   Extraction if there is a root fracture
2. Apical surgery with retrograde filling if there is no sign of root fracture.

Problem list

- Root fracture
- Destruction of marginal bone

Progress notes 29th of May 2007

The patient stopped taking Albyl-E four days before the surgery

1. **Anaesthesia**
2. **Sulcular flap from 13M-15D, with a buccal releasing incision 13M**
3. **Osteotomy**
4. **Biopsy**
5. **Apical root resection**
6. **Retro-preparation**
7. **Haemostasis**
8. **Retrograde filling with MTA**
9. **Sutures**
Progress notes 5th of June 2007.

The patient returned for suture removal one week later. He did not complain of any heavy pain or swelling in the post operative period. Satisfactory gingival conditions and good oral hygiene. (No clinical picture)
Prognosis

- **Endodontic** uncertain because of total buccal bone loss
- **Tooth** uncertain

Follow-up 18\textsuperscript{th} of September 2007 – four months

The patient had no problems with the tooth. The radiograph revealed signs of healing, good gingival conditions, with 3 mm clinical probing depths, and no bleeding on probing.

![Fig 11 Lateral view of 14](image)

![Fig 12 Close-up view of 14. Healthy gingival. Scar from the sinus tract is still visible.](image)

![Fig 12 05.05.07](image)

![Fig 13 18.09.2007.](image)
Follow-up 22\textsuperscript{nd} of January 2009 – 20 months

Satisfying gingival conditions. Probing depths 4 mm. The tooth is function, but the radiograph reveals uncertain healing. (Fig 14)

Evaluation

- The patient was informed of the uncertain long-term prognosis of the tooth because of total loss of supporting buccal bone.
- The importance of oral hygiene was explained to the patient. A periodontal infection must be avoided.
- There was not discovered any fracture.
- There was little mobility despite the extensive loss of bone.
- The tooth needs to be followed up further to see if there is healing by scar tissue.

Discussion

Bone resorption adjacent to teeth is mainly caused by periodontal and/or pulpal diseases. Sometimes this may lead to an apicomarginal communication. It is not always possible to determine whether such a communication is entirely of endodontic, periodontic or if it is a combined lesion. It has been found that marginal bone loss impairs the prognosis of periapical surgery\textsuperscript{3} and a persisting endodontic infection may be a potential contributing risk factor for progressing of marginal attachment loss\textsuperscript{4}.

Tooth extraction is recommended by many when an apicomarginal communication is detected, because a deep marginal bone defect is a contraindication for apical surgery\textsuperscript{6}.

In a study by Skoglund et al\textsuperscript{6} with 27 cases of total buccal bone loss a 37\% could be regarded as successful, 33\% as uncertain, and 30\% as unsuccessful. The success rate in this study is lower than the overall rate after periapical surgery which in the literature varies from 46\% to 90\%.

With a large buccal bone defect little or no bone regeneration can be expected. Healing probably occurs by means of a capsule-like connective tissue attachment or the formation of a long, thin junctional epithelium\textsuperscript{6}. Experimental studies by Nyman et al, suggests that the periodontal ligament cells possess the ability to re-establish connective tissue attachment \textsuperscript{1}.

In another study by Nyman et al\textsuperscript{2} they examined whether new attachment forms on root surfaces previously exposed to plaque, by preventing the oral epithelium and the gingival connective tissue from participating in the process of healing following treatment. They found that the test surfaces exhibited considerably more new attachment than the control surfaces,
indicating that the placement of the membrane favoured repopulation of the wound area adjacent to the roots by cells originating from the periodontal ligament.

In this case where there was no buccal bone to cover the root, and the periodontal ligament and cementum probably lost because of long standing sinus tract and plaque accumulation, the gingival connective tissue will come in contact with the root surface and migrate in an apical direction. This will result in a deep pocket that will be sensitive to infection if the patients’ dental hygiene deteriorates. It thus seems reasonable to avoid probing vigorously in the gingival pocket at postoperative follow-up examinations.

Platelet inhibitors and anticoagulant drugs are relatively commonly used in the population, causing an increased risk for complications with bleeding when performing oral surgical procedures in these patients. Approximately 10 % of the Norwegian population uses some kind of platelet inhibitors or anticoagulant drugs. In 2007 it was recommended to interrupt the patients’ treatment with Albyl-E four days before surgery at UiO. New guidelines have been developed in 2008 and they recommend INR values less than 3 when performing minor oral surgery and that treatment with platelet inhibitors is not interrupted at al7.

Evidence is substantial that thromboembolic complications, including death, are associated with discontinuation 8.

References
Endodontic treatment of maxillary right first molar in conjunction with apical surgery

Patient
60-year old North European male referred to the Post Graduate Endodontic clinic, 31st of January 2007, for treatment of maxillary right first molar.

Chief-complaint
The patient complained about tenderness to buccal palpation from tooth 16.

History
- **Medical**
  Non contributory
- **Dental**
  Endodontic treatment was started some times earlier because of severe pain. He was then referred to an endodontic specialist, but because of continued tenderness over the buccal roots, his general practitioner referred him to the Post Graduate Endodontic clinic.

Clinical Findings 31st of January 2007
- **Soft Tissue:**
  Oedematous gingival on the palatal side.
  The buccal mucosa is normal.
- **Dental**
  16: O IRM
  Porcelain bridge from 16-26.
  Abutments: 16, 14, 13, 23, 24, 26
Clinical Findings 31st of January 2007

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Table 1 Clinical tests

Radiographic findings 31st of January 2007

- **Dental**
  - 16: PFM crown, abutment
  - 15: PFM crown, abutment, root filled
  - 13: PFM crown, abutment
- **Apical**
  - Circumscribed apical lucency mesio-buccal root. Fractured spiral paste carrier in the apical part of the mesio-buccal root.
- **Periodontal**
  - Marginal bone loss.

Diagnosis

- **Pulpal Diagnosis tooth 16**
  - Pulpal Necrosis (K04.1)
- **Periapical Diagnosis**
  - Chronic apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  - Marginal periodontitis (K05.3)

Treatment Plan

1. Non-Surgical Endodontics treatment with root canal disinfection and instrumentation
2. Surgical Endodontics:
   - Removal of fractured instrument
   - Apicoectomy with a retrograde filling
Problem List
Locate the MB2 canal
Preserve the crown

Progress notes 31st of January 2007
Access preparation was done there was Ca(OH)$_2$ the canals. MB2 was searched for but not found.(Fig 4 and 5)

Root canal disinfection and instrumentation
1. Mechanical
   - NiTi Hand instrumentation
   - Bur
     MB #45/19 mm
     DB #45/21, 5 mm
     P #60/21 mm
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Intracanal dressing
   - Ca(OH)$_2$
4. Temporary filling
   - IRM

Progress Notes 27th of Mars 2007
The patient returned and the symptoms was the same symptoms, and the tooth was obturated.

Root canal disinfection and obturation
1. Mechanical
   - Bur
   - NiTi Hand instrumentation
     MB #45/19 mm
     DB #45/21,5 mm
     P #60/21 mm
2. Chemical
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate
3. Obturation
   - GP and AH+
4. Temporary filling
   - IRM top-filling
Progress Notes 24th of May 2007

1. Anaesthesia
2. Sulcular flap from 14M-16d, with a buccal releasing incision 14M
3. Osteotomy
4. Apical root resection
5. Retro-preparation
6. Haemostasis
7. Retrograde filling with MTA
8. Sutures

Fig 8

Fig 9 Elevation of the flap reveals a buccal fenestration over the MB root. Fractured instrument penetrating the flap.

Fig 10 Retrograde preparation and G-MTA in place

Fig 11 Fractured part of the spiral paste filler removed.

Fig 12 Retrograde filling
Progress Notes 1st of June 2007
The patient returned for suture removal after one week. He had not experienced any pain. The wound had closed nicely and oral hygiene was under control.

Prognosis
5. Endodontic assumed good
6. Tooth assumed good

Follow-up 14th of April 2009 – two years
- Asymptomatic tooth
- Satisfactory clinical conditions
- Radiographic signs of healing
Evaluation

- Endodontic and apicoectomy was performed without any complication
- Care was taken not to weaken the crown and MB root during treatment because of the large prosthetic restoration.
- Endodontic treatment for tooth 16 has a good prognosis.

Discussion

There is always a potential risk that some of the instruments we use in endodontic therapy can fracture within the root canals. This is a major concern, since it can jeopardize the success of treatment. In most situations, fracture occurs in the apical third of the canal and the remaining portion is often difficult to remove, especially if the canal is narrow.\(^6\)

The prevalence of retained fractured instruments in one study\(^1\) was found to be about 3.3%. Hand instruments accounted for 78.1% of the total amount of fractures, (stainless steel 15.9%, paste fillers 4.0% and lateral spreader 2.0%), while the fracture of the Rotary NiTi files was between 0.4-5%.\(^1\)

Treatment of vital teeth, have a 96% success outcome, while teeth with apical radiolucency have an 86% success outcome. In retreatment cases the success outcome drops to 62% in cases with apical periodontitis, while those without apical periodontitis the outcome is almost the same as for vital treatment.\(^5\) Hülsmann\(^3\) et al found that less than 1% of endodontic failures are due to instrument fractures and in a study by Spili\(^1\) et al healing rates were 91.8% for cases with a fractured instrument compared to the controls that was 94.8%. An important finding from many of the studies was that the presence of a preoperative periapical lesion served as the main prognostic factor for the successful treatment.\(^1\) Other studies also concluded that the presence of a periapical radiolucency rather than the fractured instruments was the cause of failure.\(^2,7\) The reported healing rate for fractured instrument cases was considerably lower in the presence of a periapical lesion (47% versus 89%).\(^1\)

Removal of fractured instruments, are difficult and time consuming. There are different instruments that can be helpful, but they have all shown limitations. The problems associated with these include excessive removal of root canal dentin, ledging and extrusion of the fractured portion through the apex. Successful removal relies on the location of the instrument, the more apical, greater the potential for root perforation. Excessive removal of
dentin results in reduced fracture resistance of the root. In some instances it may be best to forgo instrument removal to prevent subsequent complications, particularly when the fragment is at or around the curve in the canal. An attempt to bypass a fractured instrument should always be considered first because it can often be successful, particularly in those situations where the root has more than one canal and if they join before the apical foramen.

The first choice of treatment is conventional root canal therapy because of better outcome than in surgery, particularly with improved techniques and instruments. Accepted indications for endodontic surgery today are; foreign material periapically if it is toxic or associated with an infection, perforations only accessible through surgery, apically located instruments, inaccessible root canals because of posts or high risk of split during post removal, obliterated root canals, lesion that needs to be biopsied, persisting radiolucency and investigating surgery.

Treatment outcome of apical surgery differs in the literature. An average treatment outcome of apical surgery with simultaneous orthograde retreatment is about 81%. The success outcome drops to an average of 59% if no orthograde retreatment has been done, since the combined treatment addresses both the intraradicular and the extraradicular sites of infection.

References
Endodontic retreatment of maxillary right first molar, apicoectomy and later extraction.

Patient
79-year old North European woman referred to the Post Graduate Clinic, 2\textsuperscript{nd} of May 2007, for endodontic treatment of the maxillary right first molar.

Chief-complaint
The patient has had for some years problems with recurrent pain from the maxillary right first molar. Three weeks prior she had acute pain and abscess in the area, and was then referred for treatment from the student clinic.

History
- **Dental**
  Endodontic and crown therapies have been done many years ago.
- **Medical**
  Cancer mamma 1996 and 2006 that was treated with operation and radiation.
  Treatment: operation and radiation therapy
  Cancer colon 1991
  **Medication**
  Lipitor
  Atacard, Zyrtec
Clinical findings 2\textsuperscript{nd} of May 2007

- **Soft tissue**
  - normal color, sinus tract on the vestibular side of 16
- **Dental**
  - 13: Gold-acryl crown
  - 14: Gold-acryl crown
  - 15: Missing
  - 16: Gold crown

Clinical Tests

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Table 1 Clinical tests

Radiographic findings

- **Dental**
  - 13: Metal crown and post, root filled
  - 14: Metall crown
  - 15: Missing
  - 16: Metall crown, root filled
- **Apical**
  - Radiolucent area around the apex mb root of 16.
- **Marginal**
  - Within normal limits

Diagnosis

- **Pulpal Diagnosis tooth 16**
  - Root filled tooth (K04.19)
**Apical Diagnosis**
Chronical apical periodontitis with a sinus tract (K04.62)

**Marginal**
Within normal limits

**Treatment Plan**
- Non surgical endodontic retreatment with instrumentation and disinfection

**Problem list**
- Instrumentation
- Locating the root canals.
- Preserve the crown
- Retrieve working length

**Progress notes 2\textsuperscript{nd} of May 2007**
Access preparation was done through the crown and tree canals were found. Retreatment was performed with Gates-glidden bur, Chloroform and hand files. MB2 was sourced for but not found.

Root canal disinfection and instrumentation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur
     - BM #45/15 mm
     - DB #45/16 mm
     - P #60/16 mm

2. **Chemical**
   - Chloroform
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Intracanal dressing**
   - Ca(OH)\textsubscript{2}

4. **Temporary filling**
   - IRM
Progress notes 20\textsuperscript{th} of June 2007
The sinus tract had closed and the tooth was no longer tender to palpation or percussion. The tooth was obturated with GP and AH+.

Root canal disinfection and obturation

1. **Mechanical**
   - NiTi Hand instrumentation
   - Bur
     - MB #45/15 mm
     - DB #45/16 mm
     - P #60/16 mm

2. **Chemical**
   - NaOCl
   - EDTAC
   - Chlorhexidine Digluconate

3. **Obturation**
   - GP and AH+

4. **Permanent filling**
   - Composite

**Prognosis**
- **Endodontic**: assumed good
- **Tooth**: assumed good

Follow-up 3\textsuperscript{rd} of June 2008 – one year
Endodontic examination 1st of September 2009

The patient returned to the clinic because the sinus tract had returned and the tooth was tender to palpation and percussion. No deep pockets were found. The patient wanted to try to preserve the tooth, and agreed to an apicoectomy of the buccal roots, because of suspicion of MB2.

Progress notes 24th of September
1. Anaesthesia
2. Sulcular flap from 16D-13M, with a buccal releasing incision 13M and 16DB
3. Osteotomy
4. Apical root resection
5. Retro-preparation
6. Haemostasis
7. Retrograde filling with MTA
8. Suturing
9. Postop instructions and analgesics

No root fracture was found.
Progress notes 30th of September 2008
The patient returned for suture removal after one week. The sinus tract was still present. The situation was discussed with the patient.

Progress notes 7th of October 2008
She returned after one week and puss drained from the sinus tract when palpating. Extraction was recommended.
- Anaesthesia was placed
- Uncomplicated extraction using forceps.
- Negative blow test
- Postop information

When the tooth was extracted and granulation tissue removed fracture was found between the buccal and palatal roots, merging in the mesial-distal direction dividing the tooth in two.
Evaluation

- The operation should probably been avoided, but the patient was very determined to try and preserve the tooth, and there was a chance of an un-instrumented MB2 canal.
- With a more angulated probing on the mesial and distal aspect of the tooth I probably would have found a deep pocket and diagnosed a fracture.
- The tooth probably fractured because of loss of tooth structure, and excessive use. The patient had antagonist only on this side.
Discussion

Endodontic surgery is preformed to salvage endodontically involved teeth that can not be satisfactory treated by conventional endodontic procedures.

Healing is graded in four categories: complete healing, incomplete healing (scar), uncertain healing, and failure. Complete healing after surgical endodontics is 60–78% after one year\(^1\),\(^3\). A study showed improved healing at two years compared to that of a year. But it is only after long-term follow-up that incomplete healing (scar) can be regarded as a stable outcome\(^1\),\(^3\). The length of the follow-up period is important, less than a year is too short, so therefore four years are recommended since some of the lesions in the uncertain group will then heal\(^2\). Even dough teeth that are initially considered healed completely 5% to over 40% will later fail; this is because resistance to infection is a dynamic biological process\(^4\).

Outcome of surgical endodontics depends on the quality of the root canal filling. Persistent disease after surgical endodontics usually occurs when the attempt to seal bacteria within the root canal system is ineffective\(^5\). This can be due to accessory canals or isthmuses, exposed dentinal tubules that harboured bacteria, and that the root-end filling fails to seal the canal either because of poor placement and adaptation, or poor sealing ability\(^5\).

Most authors agree that cracked teeth were significantly associated with intracoronal restorations and were prevalent in mandibular molars. The most commonly identified etiologic factor was the design of cavity preparations, large restorations, improper and overzealous preparations, inappropriate use of pins, and marginal ridge restorations were some mentioned factors responsible for cracks of teeth, although other factors, such as sudden biting of hard substances, the excessive contact of a posterior tooth, bruxism, malocclusion, steep cusp inclines and/or deep grooves in the occlusal morphology, and thermal cycling were also mentioned as the causes of the cracks of teeth\(^8\).

Camron\(^5\) found that cracked teeth were more prevalent in females (66.7%), over 50 years of age (58%). The mandibular second molar cracked (37.2%) more followed by the mandibular first molar (29.4%). There was a direct relationship between the size of the restoration and the occurrence of a crack. Teeth with a class II restoration cracked approximately three times more than the teeth with a class I restoration. The loss of a marginal ridge in a class II restoration was considered to be one of the major causes of tooth weakening.

The most common direction of the crack was in the mesiodistal direction in both jaws (108 teeth, 70.1%). The buccolingual direction was found in 29 teeth (18.8%) and 17 teeth (11%) cracked in both directions\(^8\).

Simon\(^6\) categorized a tooth fracture into five major classes; craze line, cuspal fracture, cracked tooth, split tooth and vertical root fracture. The craze line is a fracture line confined to the coronal enamel without signs and symptoms. Split tooth means a complete tooth fracture, which was already movable equally, and it usually involves the infrabony structures. A vertical root fracture is defined as a longitudinal fracture confined to the root. It usually begins on the internal wall of root canal and extends outward to the root surface. A crack is defined as an incomplete fracture of a vital tooth involving the dentin and possibly the dental pulp, while a cusp fracture is a tooth fracture caused by the lack of cusp support as a result of a weakened marginal ridge. The main characteristics of a cusp fracture are that it generally
involved one cusp and usually terminated parallel to the gingival margin or slightly subgingivally.

References

7. Simon DE. Cracking the cracked tooth code. AAE newsletter fall/winter 1997.
Apicoectomy of the buccal and palatal roots of right maxillary right first molar

Patient 55 year old Norwegian woman referred to the Post Graduate Clinic, 17 of September 2008, because of asymptomatic apical periodontitis of the maxillary right first molar.

Chief complaint
The patient has no pain, maybe something is different when chewing, but it is not a problem.

History
- Medical
  Non-contributory
- Dental
  Dental treatment has been done several years ago. She attends treatment regularly.

Clinical Findings 17th of September 2008
- Soft tissue
  Normal gingival and a good dental hygiene
- Dental
  14: Compozite build-up, arrested buccal caries lesion
  15: PFM crown
  16: PFM crown
  17: PFM crown
Clinical Findings 17th of September 2008

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(Tabel 1 Clinical findings)

Radiographic findings 17th of September 2008

- **Dental**
  14: OD radiopaque filling
  15: PFM crown, root-filled and prior apical surgery with a retrograde filling
  16: PFM crown, metal post in the palatal root, root-filled, inadequate root-filling in the MB canal
  17: PFM crown, metal post and root-filled

- **Periodontal**
  Within normal limits
- **Apical**
  14: Continuous PDL space around the root
  15: Complete healing after
      apical surgery and continuous PDL space around the root
  16: Show signs of apical
      pathosis on the MB and P root.
  17: Continuous PDL space around the root

**Diagnosis**
- **Pulpal Diagnosis Toth 16**
  Root-filled tooth (K04.19)
- **Periapical Diagnosis**
  Asymptomatical apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  Within normal limits

**Treatment Plan**
- Apical surgery with a retrograde filling of the buccal and palatal roots

**Problem list**
- Access to the palatal root
- Root fracture

**Progress notes 26th of November 2008**

**Surgery on the MB and DB roots.**
1. Anaesthesia
2. Intrasulcular flap from 14M-17D, with a buccal releasing incision 14M
3. Osteotomy
4. Apical root resection
5. Retro-preparation
6. Haemostasis
7. Retrograde filling with MTA

![Fig 6](6)

**Fig 6** Elevated flap. Buccal fenestration of the distal root. Complete healing after apicoectomy of tooth 15, with a fibrous tissue in the apical region

![Fig 7](7)

**Fig 7** Elevated flap. Buccal fenestration of the distal root. Complete healing after apicoectomy of tooth 15, with a fibrous tissue in the apical region
Progress notes 26th of November 2008

Surgery of the palatal root
1. Anaesthesia
2. Sulcular flap from 14M-17D, with a palatal releasing incision 14M
3. Osteotomy
4. Apical root resection
5. Retro-preparation
6. Haemostasis
7. Retrograde filling with IRM
8. Sutures
9. Compression
10. Prescription of analgesics and penicillin

Fig 8 Rot resection isthmus between MB and MB2 canal
Fig 9 Retrograde preparation
Fig 10 G-MTA in place

Fig 11 Elevated mucoperiosteal flap. A suture was placed through the flap an fixated to 24. This kept the flap out of the way.

Fig 12 Osteotomy of the palatal bone
Fig 13 Located the palatal root.
Progress notes 3\textsuperscript{rd} of December 2008

The patient returned after one week for removal of sutures. There was still some swelling on the palatal side, but there had been little pain.
Prognosis

- **Endodontic** Uncertain long-term prognosis due to the palatal filling and the possibility of reinfection of the periapical tissue.
- **Tooth**: Uncertain in the long run because of reduced bone height and root length.

Follow-up 16\textsuperscript{th} of April 2008 – five months

Fig 20  Sutures removed, some swelling on the palatal side

Fig 21  Sutures removed secondary healing in the buccal releasing incision

Fig 22  Radiograph 26.11.08

Fig 23  Radiograph 16.04.09 shows sign of healing.
Evaluation

- The patient was informed about the uncertain prognosis of the tooth before operation
- Different treatment strategies was given to the patient
- No root fracture was located
- IRM was used as a retrograde filling in the palatal root because of better handling ability
- The palatal retrograde filling was short and possibly a void between the post and the filling.
- Retrograde filling of poor quality reduces the prognosis of the treatment.

Discussion

Endodontic surgery is preformed to salvage endodontically involved teeth that can not be satisfactorily treated by conventional endodontic procedures. Maxillary molar teeth offer substantial technical obstacles partly because of their position in the dental arch and because of the presence of a palatal root. In the mesiobuccal root two canals can be present as much as 93% of the time, in the maxillary first molars, and 59% in the maxillary second molars. Following the apicoectomy and visualization of the resected surface, two canals with a uniting isthmus are usually visible. It is therefore important to routinely prepare the isthmus to prevent coronal leakage especially when the non-surgical root canal treatment fails to clean the canal system thoroughly.

The goal of a retrograde filling is to seal of an infected root canal causing periapical pathosis. Therefore, retrograde root canal fillings should be performed routinely during apical surgery regardless of the technical quality of the root canal obturation, unless orthograde endodontic treatment is performed in conjunction with surgery. When orthograde treatment is not performed, retrograde root canal filling enhances the prognosis of apical surgery.

Different materials have been used as retrograde filling materials. The most important requirements for this kind of material is; easy manipulation and placement, dimensional stability, sealant ability, biocompatible and promote cementogenesis, insoluble, unaffected by moisture, bacteriostatic, radiopaque and not discolour.

Amalgam was widely used but research indicated that amalgam exhibits the greatest amount of leakage when compared with newer materials such as S-EBA and MTA. Zinc oxide-eugenol cements have been used extensively as retrograde materials. The two most widely accepted are IRM and Super EBA. These two materials are superior to amalgam. The success rates over a 10-year period were reported to be 95% for S-EBA, 91% for IRM, and 75% for amalgam. Both IRM and S-EBA exhibit similar and favourable properties and are clinically and histopathologically better than amalgam.

It has been shown that MTA is better biocompatible than IRM and one of the most important advantages of MTA is that histological responses show evidence of tissue regeneration opposed to tissue repair. Some studies show that MTA has superior sealing qualities when compared with S-EBA and amalgam, while other studies show no statistically significant differences in rate of micro leakage comparing MTA, Super-EBA, composite and amalgam. But a better cellular response to MTA has been shown.
When operating in the maxillary molar region the root apices of the teeth are close to the sinus. Prior to surgery the distance between the sinus and the root apices, as well as tooth length, should be determined. If the sinus is in close proximity care should be taken not to penetrating the sinus. If perforation occurs it is essential to avoid debris or the resected apex being forced into the sinus. Replacement of the mucoperiosteal flap provides an effective seal so complications are rare.

With palatal flap surgery it is important to place the vertical relieving incision in the premolar/canine region since the greater palatine neurovascular bundle emerges from the greater palatine foramen palatal to the second/third molar. It runs forward approximately midway between the midline and the gingival margin. The flap should be raised with care not to damage the bundle.

References
2. Degerness R and Bowles W. Anatomic Determination of the Mesiobuccal Root Resection Level in Maxillary Molars. JOE 2008;34:10
Apicoectomy of mandibular left lateral incisor

Patient

60 year old North European female referred to the Post Graduate Clinic, 2nd of December 2008 because of chronic apical periodontitis in mandibular left lateral incisor.

Chief-complaint

The patient has no problems or symptoms from the tooth. She was referred from the student clinic because of chronic apical periodontitis of her lower left lateral incisor that was found during routine radiographs.

History

- **Medical**
  Non contributory
- **Dental**
  The patient lost all of her teeth in the upper jaw at the age of 17 because of periodontitis and has a full-denture. In her lower jaw there is an old gold-acrylic bridge/merged crowns. The root of tooth 44 has been removed. Partial gold crowns on her lower centrals. The root-filling in 32 was done around 1975.

Clinical Findings 2nd of December 2008

- **Soft tissue**
  Normal findings
- **Dental**
  33: Gold-acrylic crown
  32: Gold-acrylic crown
31: ¾ Gold crown, B tooth coloured filling
41: ¾ Gold crown, B tooth coloured filling
42: Gold-acrylic crown
43: Gold-acrylic crown, with an extension

Clinical Tests 2\textsuperscript{nd} of December 2008

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Table 1

Radiographic findings 2\textsuperscript{nd} of December 2008

- **Dental**
  - 43: Metal crown and post, distal extension, root-filled
  - 42: Metal crown and post, root-filled, fused with the metal crown of 43
  - 41: Metal ¾ crown
  - 31: Metal ¾ crown
  - 32: Metal crown and post, root-filled
  - 33: Metal crown and post, root-filled, fused with the metal crown of 32
  - Caries lesion on the mesial surface of 41 and distal surface of 33 was under treatment at the student clinic.

- **Periodontal**
  - Marginal bone loss

- **Apical**
  - 32: Circumscribed apical lucency around the apex
  - Continuous PDL space around 43, 42, 41, 31 and 33
Diagnosis

- **Pulpal Diagnosis Toth 32**
  Root-filled Toth (K04.19)
- **Periapical**
  Asymptomatical apical periodontitis (K04.5)
- **Periodontal**
  Marginal periodontitis (K05.3)

Treatment Plan

- Surgical endodontic treatment with a retrograde filling

Problem list

- Root fracture
- Difficult area for soft tissue management

Progress notes 7\textsuperscript{th} of January 2009

1. Anaesthesia
2. Intrasulcular flap from 42D-33D, with a buccal releasing incision 33D
3. Osteotomy
4. Apical root resection
5. Retro-preparation
6. Haemostasis
7. Retrograde filling with MTA
8. Sutures
9. Postop information and analgesics

Fig 6

![Image](fig6.png)

Fig 7

![Image](fig7.png)

Fig 8 Apical root resection

Fig 9 Probably a VRF on the lingual side (arrow)
Progress notes 13th of January 2008
The patient returned a day sooner because of increasing pain and swelling the last two day. She had to take Paralgin Forte® to be able to sleep. Clinical examination revealed a hard
swelling in the surgical area that could also be seen extra-orally. A prescription of antibiotics and painkillers were given. She was going to be away for one week and a control was scheduled when she returned. (No clinical photos)

Progress notes 28th of January 2008
The patient returned and there was satisfying gingival conditions and a good oral hygiene. (Fig 13 and 14)

Prognosis
- **Endodontic** uncertain because of possible VRF
- **Tooth** uncertain because of possible VRF

Follow-up 15th of April 2009 - three months

Fig 15 Satisfactory gingival conditions and oral hygiene

Fig 16 07.01.2009  
Fig 17 15.04.2009
Evaluation

- The three month follow-up revealed good oral hygiene and gingival conditions.
- It is too early to say if the operation is a success, but there are signs of healing on the radiograph.
- Long term prognosis for this tooth is uncertain because of a VRF that probably will develop further over time.
- The mandibular front area poses some difficulties concerning soft tissue management
- Microsurgical scalpel was used
- There was no buccal bone loss
- The patient is informed about the uncertain prognosis

Discussion

The expected outcome of apical surgery is good and therefore, before considering tooth extraction and replacement, apical surgery should be attempted when it is feasible. In a review of the literature by Friedman\(^1\) the outcome of surgical endodontics differed between 37\%-91\% healed cases several years after surgery. The great variation in outcome reflects differences in the inclusion criteria.

Several pre-operative may influence the outcome of treatment; access and root anatomy, the outcome may be better in teeth with small lesions, excessively short or long root canal fillings, and it may be poorer in teeth treated surgically for the second time. With regard to intra-operative factors that may influence outcome of treatment are the choice of the root-end filling material and the quality of the root-end filling, while the retrograde retreatment procedure clearly offers a better outcome than the standard root-end filling\(^1\).

Vertical root fractures (VRF) are responsible for 4.3\% of endodontic failures\(^2\), especially in teeth that are more susceptible to VRF, such as the mandibular incisors and the lower molars.

Root canal treatment is a factor that increases the incidence of vertical root fractures\(^3\). Studies have shown that vertical root fracture occurs most commonly in the buccolingual plane\(^4\), but may also start anywhere between the apex and the crown. Excessive force during lateral compaction caused 84\% of vertical root fractures\(^5\).

Vertical root fractures extend from the root canal to the periodontium, and a large and rapid destruction of the bone and periodontium can follow the fracture line\(^6\). The destruction is a manifestation of debris, necrotic tissue and bacteria harboured in the fracture which prevent repair, and require extraction of the fractured root or the entire tooth\(^7\).

Instrumentation and obturation during root canal treatment can result in small, incomplete fractures, which may eventually become complete vertical root fractures. With additional stress applied through occlusal force or further restoration like post placement, the latent fractures can develop into complete fractures at a later time\(^8\).
References

Apicoectomy of mandibular left first molar

Patient

34-year old North European male referred to the Post Graduate Endodontic Clinic, for treatment of the lower left first molar because of asymptomatic apical periodontitis.

Chief-complaint

The patient has no pain from the tooth, but experiences some tenderness to percussion.

History

- **Medical**
  Non-contributory

- **Dental**
  Endodontic treatment was performed in a private practice because of deep caries and pain. The patient then started treatment at the Dental Faculty and crown and post treatment was initiated. The temporary filling fell out between treatment sessions. During some months apical periodontitis developed. The post was cemented without discovering the apical pathosis.
Clinical Findings 12\textsuperscript{th} of December 2008

- **Soft tissue**
  Normal findings
  Leukoplackia under the upper lip, because of tobacco use.

- **Dental**
  34: Normal tooth, no fillings
  35: Normal tooth, no fillings
  36: Temporary tooth coloured crown
  37: MO Amalgam

Clinical Tests 12\textsuperscript{th} of December 2008

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<th>34</th>
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Table 1 Clinical tests

Radiographic findings 12\textsuperscript{th} of December 2008

- **Dental**
  35: Normal tooth, no fillings
  36: Root-filled tooth overextended in the mesial root, metal post, temporary crown and surplus of cement in the approximal space.

- **Apical**
  35: without fillings, lamina dura can be followed around the entire root.
  36: Disrupted lamina dura around the apex of the mesial root.
  37: MO radioopaque filling, lamina dura
can be followed around the entire root.

- **Periodontal**
  Within normal limits

The mandibular canal can be followed below the roots of tooth 37 and 36. The mental foramen are located apically to tooth 35.

**Diagnosis**

- **Pulpal Diagnosis tooth 36**
  Root-filled tooth (K04.19)
- **Periapical Diagnosis**
  Chronic apical periodontitis (K04.5)
- **Periodontal Diagnosis**
  Within normal limits

**Treatment Plan**

- Surgical endodontic treatment: Apicoectomy with a retrograde filling

**Problem list**

- Locating the ML canal and the placement of a retrograde filling
- The location of the mental foramen and the danger of paresthesia

**Progress notes 11th of February 2009**

1. Anaesthesia
2. Intrasulcular flap from 33m-37d, with a bucal releasing incision 33m
3. Location of the mental foramen
4. Osteotomy
5. Apical root resection
6. Retro-preparation
7. Haemostasis
8. Retrograde filling with MTA
9. Sutures
10. Post operative information and prescriptions

![Fig 8 Osteotomy and apical perforation of GP. Location of the mental foramen (arrow)](image)

![Fig 9 Apicoectomy Isthmus between the MB and ML canal](image)

![Fig 10 Retrograde preparation](image)

![Fig 11 Retrograd MTA](image)
Progress notes 18th of February 2009

Removal of sutures after one week, the patient had only felt some minor discomfort and swelling the first two days post operative. During these days he had taken recommended analgesics. He was informed before the operation that there was a chance of temporarily numbness or reduced sensation in the lower left lip some time after surgery. He had reduces sensation in the area, but it did not bother the patient.
Prognosis

- Endodontic assumed good. No problems during surgery.
- Tooth assumed good, even though there are always some danger of root fracture when a post is placed.

Evaluation

- Important to inform the patient about possible reduced sensation before surgery.
- No problems during surgery
- Surgery was chosen as treatment because of possible over-instrumentation in the mesial canals.

Follow-up 16th of April 2009 – 2 months
Discussion
The outcome of endodontic treatment in teeth without periapical lesion, are 96 %\(^1\). This patient did not receive endodontic treatment at the UiO, but started at the student clinic after endodontic treatment was completed. He had lost the temporary filling a short time, but it is difficult to say if the bacterial leakage happened during endodontic treatment or post treatment through defect filling.

Several studies demonstrate that coronal leakage is a factor in treatment failure. Ray and Trope\(^2\) evaluated the relationship between the quality of the coronal restoration and the root canal filling on radiographs of endodontically treated teeth. They found that the technical quality of the coronal restoration was significantly more important than the technical quality of the endodontic treatment on apical periodontal health.

Swanson and Madison\(^3\) found that it only took the bacteria 3 days to contaminate the root canals in teeth exposed to artificial saliva. Torabinejad\(^4\) et al. also showed that in 80-90 % of the exposed canals showed bacterial penetration between day one and four.

Operating in the mandibular region may present technical and anatomical problems. The position of the mental foramen should always be identified on preoperative radiographs. The neurovascular bundle is at risk during the vertical incision, with bone removal, root-end resection, from crushing with the retractor and stretching of the flap\(^5\).

The patient was informed about a possible persistent anaesthesia after the operation. One week post-operative he had a reduced feeling in his lower left lip. At the 3 month control he had normal feeling. He had regained full sensation in the area 3-4 weeks post-operative. Even though we were careful with the retractor, and flap during surgery, the nerve was reversibly injured. It is important to inform the patient before treatment of the possibility of nerve damage.

References