UNIVERSITY OF OSLO
DENTAL FACULTY

Department of Endodontics

Postgraduate program in **Endodontics**

Case book
by

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Spring Semester 2007

Non-surgical cases:

Surgical cases:

Case 1. Pulpitis, Tooth 16

Pulpectomy of a tooth with unusual root morphology.

Fig. 1 Frontal view

Referral
A 27-year old white male (Fig. 1) was referred October 2006 to the private clinic limited to endodontics from his General Practitioner for treatment of the maxillary right first molar.

Medical history:
Non-contributory, the patient did not take any medication.

Chief complaint & Dental History:
The General Practitioner initiated endodontic treatment tooth 16, but encountered problems with the estimation of the working length. He filled the access cavity with IRM and referred the patient to complete the treatment.

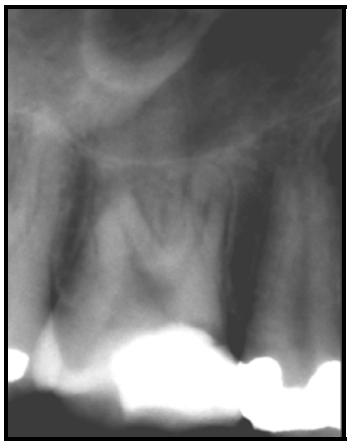
Clinical examination
Preoperative photo showed the region from maxillary right canine to maxillary right first molar (Fig. 2)

No pathology was found extra-orally. Normal oral mucosa was observed. Probing depths were within normal limits.
No pain to percussion or to palpation was found.

Fig. 2 Buccal view tooth 16.

Maxillary right first molar: had an occlusal IRM filling and on the mesio-buccal cusp a composite filling. The tooth was positive to EndoIce®.
Maxillary right second premolar: had a MOD amalgam filling.
Maxillary right first premolar: had an OD composite filling.
Maxillary right canine: intact.

Radiographic examination
Preoperative radiograph showed the region from maxillary right second premolar to maxillary right first molar (Fig. 3).



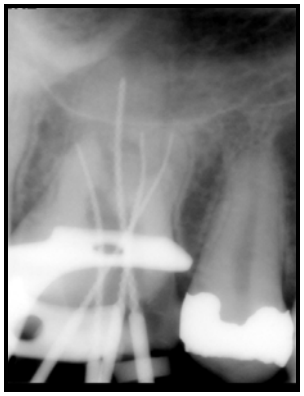
Maxillary right second premolar: had a MOD amalgam filling. The lamina dura could be followed without disruption.
Maxillary right first molar: had a radioopaque MO filling. The lamina dura could be followed without disruption. The mb and db roots appeared to be short. The tooth was positive to Endo-Ice®.

Fig. 3 Preoperative radiograph tooth 16

Diagnosis
Maxillary right first molar with pulpitis

Treatment
Pulpectomy

Treatment:
1st appointment: 16.10.2006
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. The IRM filling was removed and the canals were localized with the help of a microscope. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
Four canals were localized and files were inserted. The canals were wide and with the help of an apex locator (Root ZX®) it was possible to determine the working length. A working radiograph was taken (Fig. 4)

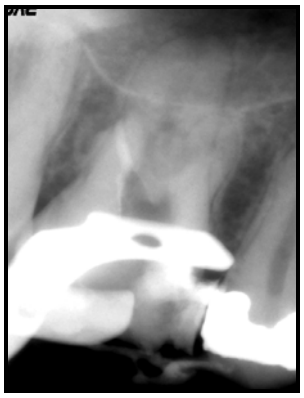


The canals were instrumented as followed:
MB nr 40 / 18.5 mm
MP nr 45 / 18 mm
DB nr 50 / 15.5 mm
P nr 70 / 21.5 mm

Fig. 4 Working length radiograph.

During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

2nd appointment: 6.11.2006
The patient was symptom free.
Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The IRM was removed and the calcium hydroxide washed out with NaOCl. The canals were rinsed with 2 % chlorhexidine digluconate.



The disto-buccal canal was filled with MTA (Fig. 5). The other canals were filled with calcium hydroxide with the help of Lentulo spiral and paper points. The canal openings were sealed with cavit. A humid cotton pellet was placed above the MTA and the access cavity was sealed with IRM.

Fig. 5 MTA in the disto-buccal canal

3rd appointment: 4.12.2006

The patient was asymptomatic. Rubber dam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the cotton pellet from the access cavity and the calcium hydroxide from the canals with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 6).

Fig. 6 Master cone radiograph, tooth 16.

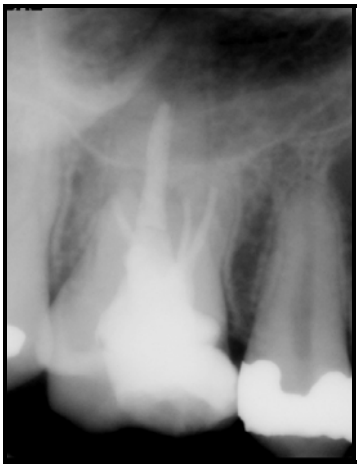


Fig. 7 Final radiograph, tooth 16.

The gutta-percha in the palatinal canal was too short and the length was corrected (Fig. 6). The canals were dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 7).

Prognosis

The prognosis of the endodontic treatment was assumed to be good.

Discussion

The tooth was presented with pulpitis and the success of the root canal treatment in this case is dependant on the prevention of apical periodontitis. The outcome of a pulpectomy is successful in 83 – 100% (Ørstavik 1996; Friedman *et al.* 1995; Sjögren *et al.* 1990). However, the combination of short roots and marginal bone loss could pose a threat to the prognosis of the tooth.

Maxillary molars generally have three roots and can have as many as three mesial canals, two distal canals and two palatal canals. Vertucci (1984) reported 2 mesio-buccal canals in 55 % of the maxillary first molars; however, 2 canals at the apex presented only 18 % of the teeth. Negotiation of the MB-2 canal is often difficult due to a ledge of dentine that covers its orifices, the mesiobuccal inclination of its orifices on the pulpal floor and its pathway which often takes one or two abrupt curves in the coronal part of the root (Vertucci 1984).

Görduysus *et al.* (2001) studied the location and pathway of the MB-2 canal in maxillary first and second molars using the operating microscope and found that the location of this canal varies greatly. It was consistently located mesial to or directly on a line between the MB-1 and the palatal orifices, within 3.5 mm palatinally and 2 mm mesially from the MB-1 orifices. Not all MB-2 orifices lead to a true canal. An 'apparent' MB-2 canal could not be traced far beyond the orifices in 16% of the teeth.

MTA is a powder consisting of fine hydrophilic particles of tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. It also contains small amounts of other mineral oxides, which modify its chemical and physical properties. Hydration of the powder results in a colloidal gel that solidifies in approximately three hours. Bismuth oxide powder has been added to make the aggregate radioopaque. MTA has a pH of 12.5 after setting, similar to calcium hydroxide (Torabinejad *et al.* 1995b). The material has low solubility (Torabinejad *et al* 1995b) and a radiopacity slightly greater than that of dentin (Shah *et al.* 1996).

MTA has been used in both surgical and nonsurgical applications, including root-end fillings (Torabinejad *et al.* 1995a; Torabinejad *et al.* 1997), direct pulp capping (Farsi *et al.* 2006; Iwamoto *et al.* 2006), perforation repairs in roots (Lee *et al.* 1993) or furcations (Pitt Ford *et al.* 1995; Arens & Torabinejad 1996) and apexification (Schwartz *et al.* 1999; Abedi & Ingle 1995).

MTA may be the ideal material to use against bone, because it is the only material that consistently allows for the overgrowth of cementum and formation of bone, and it may facilitate the regeneration of the periodontal ligament (Torabinejad *et al* 1995a; Torabinejad *et al* 1997; Pitt Ford *et al* 1995; Abedi & Ingle 1995). Kettering & Torabinejad (1995) found it to be nonmutagenic, and Torabinejad *et al.* (1995d) found it to be less cytotoxic than SuperEBA and IRM. In animal studies, MTA was the only material studied which allowed cementum overgrowth (Torabinejad *et al* 1995a; Torabinejad *et al* 1997).

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Case 2. Pulpitis and marginal periodontitis, Tooth 46.

Pulpectomy and hemisection.

Fig. 1 Frontal view

Referral
A 64- year old white male was referred January 2007 to the post-graduate endodontic clinic at the University of Oslo from the Surgical Department of the same faculty for treatment of mandibular right first molar.

Medical history:
Non contributory.
The patient smokes.

Dental History & Chief complaint
Patient had no symptoms. He consulted his General Practitioner due to increased mobility of the teeth in upper right maxilla.
The GP referred the patient to the Radiological Department, University of Oslo where an OPG was taken (Fig. 2).

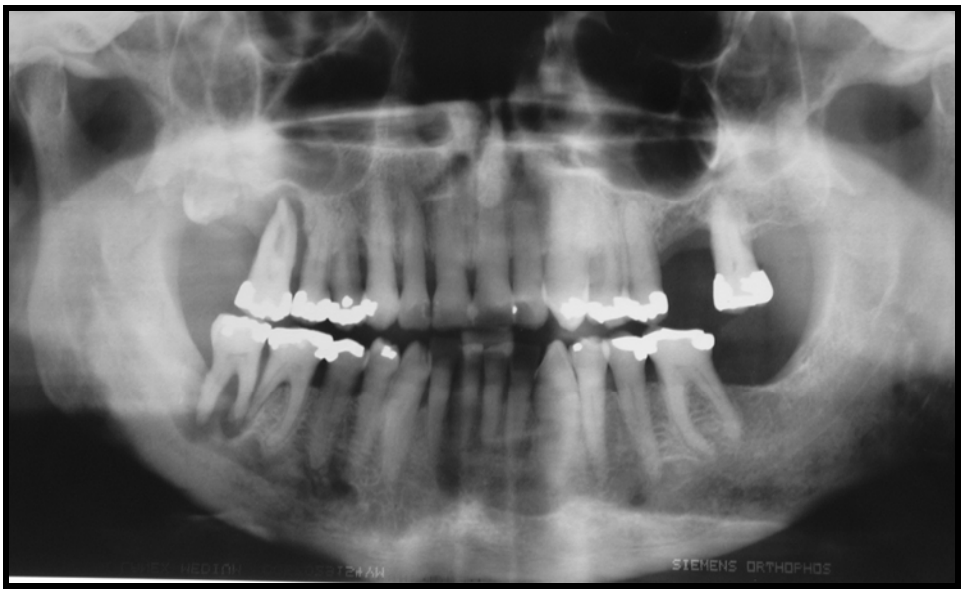


Fig 2 OPG

Because of radiographic changes in bone morphology in the region of the mandibular right canine to the mandibular right first molar, a CT was taken (Fig. 3 & 4).

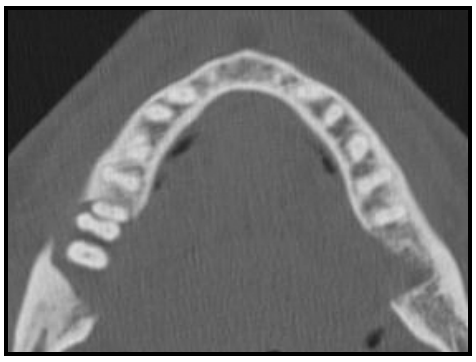


Fig. 3 CT scan

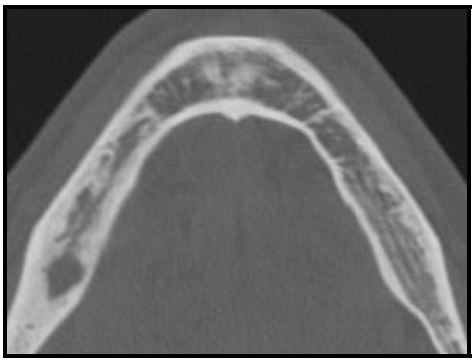


Fig. 4 CT scan

Based on the radiographs and CT, the diagnosis chronic osteomyelitis was set (K.10.2) by the Radiological Department.
Maxillary right first and third molar were extracted at the Surgical Department and a biopsy was taken from the tooth 18.
Mandibular right second molar was extracted by his GP.

Pathological Department

The histopathological evaluation of the biopsy from the maxillary right third molar revealed granulations tissue partially epithelized with moderate chronic inflammation which could originate from a deep periodontal pocket.

Clinical examination
Preoperative photos showed the region from mandibular right first molar to mandibular right first premolar (Fig. 5 & 6).

No pathology was found extra-orally.
Normal oral mucosa was observed.
No pain to percussion or to palpation was found.

The healing (2 months postoperatively) of the extraction site of the mandibular right second molar was not satisfactory (Fig. 5 & 6).
The probing depths of the neighbouring teeth were within normal limits.

Fig. 5 Buccal view tooth 46

Fig. 6 Occlusal view tooth 46

Mandibular right first molar: had a MODL amalgam filling. Distally of the tooth a pocket of 12 mm could be probed. The tooth was positive to Endo-Ice®.
Mandibular right second premolar: had a MOD amalgam filling. The tooth was positive to Endo-Ice®.
Mandibular right first premolar: Had an occlusal amalgam filling. The tooth was positive to Endo-Ice®.

Radiographic examination
Preoperative radiographs showed the region from mandibular right first molar to mandibular right second premolar (Fig. 5 & 6).

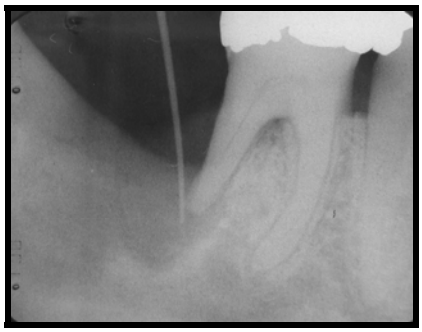


Fig. 5 Preoperative radiograph

Fig. 6 Fistulograph

Mandibular right first molar: had a MOD amalgam filling. The lamina dura could be followed without disruption around the mesial roots. A pocket of 12 mm length was probed distally of mandibular right first molar (Fig. 6). A radiolucency of approx. 2 cm in size extended from the extraction site to the distal root of the mandibular right first molar.
Mandibular right second premolar: had a MOD amalgam filling. The lamina dura could be followed without disruption.

Diagnosis
Mandibular right first molar with pulpitis.
Marginal periodontitis.

Treatment
Pulpectomy of the mesial canals.
Hemi-section and removal of the distal root.

Treatment
1st appointment: 31.01.2007
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access cavity was prepared and the distal canal localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
A K-flex file nr 15 was introduced 17 mm and a working length radiograph was taken (Fig. 7). The canal was instrumented to a size 45. During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA. The canal was dried with paper point and filled with IRM (Fig. 8)

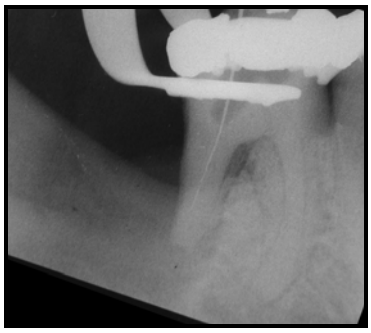


Fig. 7 Working length radiograph

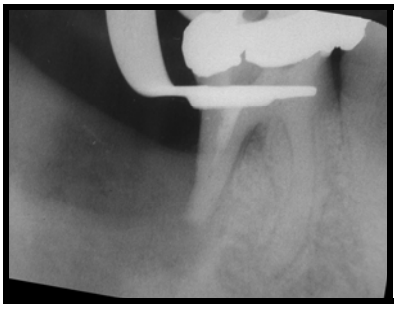
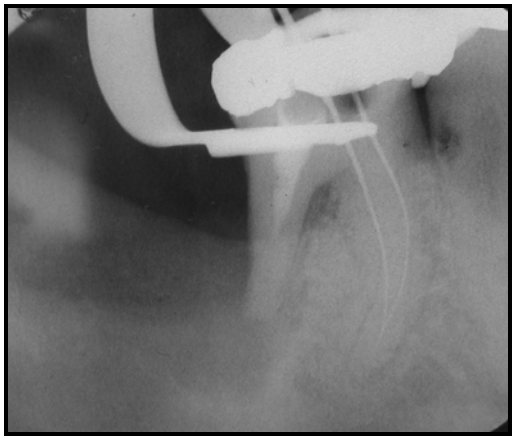


Fig. 8 Control radiograph

The mesial canals were covered with cavit. The coronal 3 mm of the distal canal were filled with composite. The access cavity was sealed with IRM.

2nd appointment: 08.02.2007

One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The IRM was removed and the mesial canals localized.



Two files were inserted, mesio-buccal canal K-flex nr 15 / 22 mm, mesio-lingual canal K-flex nr 15 / 22 mm and a working length radiograph was taken (Fig. 9).
The working length of both canals was confirmed with an apex locator (Root ZX®).

Fig. 9 Working length radiograph tooth 46

The mesio-buccal canal was instrumented to size 45 / 22mm and the mesio-lingual canal to size 45 / 22.5 mm. During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. After the instrumentation, a master cone radiograph was taken (Fig. 10).

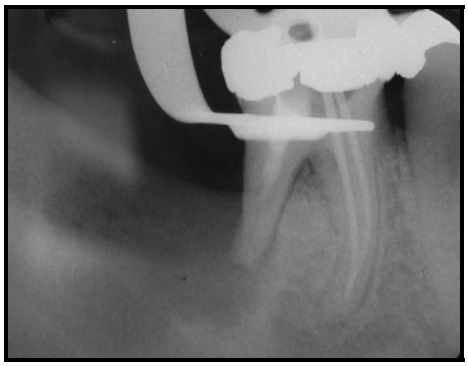


Fig. 10 Master cone radiograph tooth 46

Fig. 11 Final radiograph tooth 46

The canals were dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique.
After removing the excess of gutta-percha, the canal openings were sealed with IRM (Fig. 11). The access cavity was filled with composite.

3rd appointment: 10.04.2007
One carpule Xylocaine/adrenaline was used to establish anesthesia. An incision was made around the tooth and the gingiva was reflected.

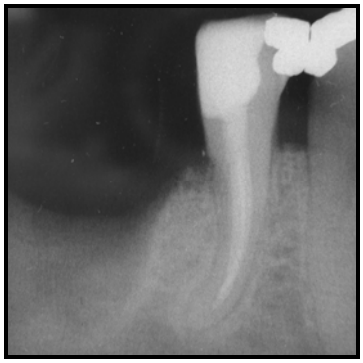


Fig. 12 Control radiograph tooth 46

The tooth was separated into two pieces in a bucco-lingual direction and the distal root was extracted. One suture was placed and a control radiograph was taken (Fig. 12)

4th appointment: 17.04.2007 (1 week later)
The patient had no symptoms and the healing was satisfactory (Fig. 13).

Fig. 13 One week control tooth 46

Discussion:
The patient was referred to the Radiological Department for a panoramic radiograph because of the mobility of the teeth in the upper right maxilla. During the examination of the radiograph, suspicions were raised at the area of the mandibular right canine to first molar and the patient was send for a CT scan. From the OPG and CT scan, the diagnosis of chronic osteomyelitis was set.
The patient had never experienced pain or had any production of pus; clinical examination revealed nothing unusual. He did not receive any specific treatment for this diagnosis.

Osteomyelitis is defined as an inflammatory process involving cortical and cancellous bone. In the maxillofacial region the mandible is by far the most frequently affected bone. In the vast majority of cases an odontogenic infectious aetiology is apparent. However, in some cases, no clear causal factor can be found (Marx & Stern 2003).
Suppurative osteomyelitis can be defined as an infection of the medullary portion of bone that includes the production of pus. The two most common causes are an extension of a dentoalveolar infection or a complication of a fracture (Marx & Stern 2003).
Chronic sclerosing osteomyelitis is a sclerosing intramedullary bone infection caused by one of the *Actinomyces* species. The hallmark of chronic sclerosing osteomyelitis is persistent intense pain. No suppuration or drainage is noted. The Actinomyces species are normal inhabitants of the oral flora. They become pathogenic upon gaining a portal of entry into bone, where they establish and maintain an anaerobic environment via sclerosing and fibrosis. A panoramic radiograph will show a poorly demarcated, increased trabecular bone density, which will diffusely involve alveolar bone, basilar bone and / or the ramus. The mandibular canal will appear to be widened. Occlusal radiographs and axial CT will show a prominent endosteal sclerosis without prominent cortical bone loss and with minimal or no periosteal bone formation (Marx & Stern 2003).
The diffuse sclerotic nature of a panoramic radiograph will mimic fibro-osseous diseases and abnormalities of bone remodelling. A well-differentiated osteosarcoma that produces dens tumour bone may also initially present a similar picture.

For a diagnostic work-up, panoramic radiograph, occlusal radiograph and a CT scan are recommended. The mandible requires medullary bone exploration for biopsy and cultures.

Smoking has local and systemic effects on the microcirculation (Lehr 2000), wound healing (Silverstein 1992) and the immune system (Kinane & Chestnutt 2000; Sørensen *et al.* 2004). As well as impairing hard tissue healing (Dahl & Toksvig-Larsen 2004; Castillo *et al.* 2005; Gullihorn *et al.* 2005) and soft tissue healing (Webster *et al.* 1986; Chang *et al.* 1996), smoking is associated with wound infection after soft tissue incision procedures (Sørensen *et al.* 2003). Smoking is likely to affect healing in surgical endodontic cases that involve bony and soft tissue healing. Unfortunately, in most recent studies evaluating the outcome of surgical endodontics, none includes any reference to smoking as a risk factor (Velvart 2002; Velvart *et al.* 2004; Chong *et al.* 2003; Gagliani *et al.* 2005).

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Case 3. Pulpitis, Tooth 16.

Pulpectomy of a tooth with dentinal dysplasia.

Fig. 1 Frontal view

A 29-year old asian woman (Fig. 1) was referred March 2007 to the postgraduate endodontic clinic at the University of Oslo from her General Practitioner for treatment of maxillary left first molar.

Medical History:
The patient had systemic lupus erythematosus (diagnosed in 2000). She experienced moments of fatigue due to her systemic illness and were not able to work on regular base.

She was taking the following medicaments:
Prednisolon
Cozaar
Myfortic

Chief complaint & Dental History
The patient experienced pain in the maxillary left first molar especially when drinking cold beverages.
Several months before the examination, treatment was started on tooth 36 which was not finished because of problems to negotiate the canals. The radiograph showed short roots and the patient was referred to the TAKO-centre (national resource-unit for oral health in rare medical conditions), Oslo for evaluation of tooth 36. She was diagnosed with dentinal dysplasia. The General Practitioner referred the patient further to the postgraduate endodontic clinic at the University of Oslo for fulfil the treatment.

Clinical examination
Preoperative photos showed the region from maxillary left second premolar to maxillary left second molar (Fig. 2 & 3).

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig. 2 Buccal view tooth 26

Fig. 3 Palatinal view tooth 26

Maxillary left second premolar: intact.
Maxillary left first molar: had a MO composite filling. The tooth was hypersensitive to cold and air blow.
Maxillary left second molar: intact.

	25	26	27
EndoIce®	+	+	+
percussion	-	+	-
palpation	-	-	-

Radiographic examination:
Preoperative radiograph showed the region from maxillary left second premolar to maxillary left second molar (Fig. 4).

Fig. 4 Preoperative radiograph tooth 26

Maxillary left second premolar: had an OD composite filling. The lamina dura could be followed around the root without disruption.
Maxillary left first molar: had a MO composite filling. The roots were short and it was not possible to distinguish the lamina dura or the circumference of the roots.
Maxillary left second molar: intact. The roots were short and it was not possible to distinguish the lamina dura or the circumference of the roots.

Diagnosis
Maxillary left first molar with pulpitis.

List of problems
Dentinal dysplasia
Obliterated canals

Treatment
Pulpectomy.

Treatment
1st appointment: 12.04.2007
Anaesthesia was established with 3 carpules Xylocaine/adrenaline. The access cavity was prepared and the canal openings could be localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. Pulp remnants were removed and the canal openings exposed (Fig. 5); however, only the palatinal canal could be negotiated 12 mm (Fig. 6).

Fig. 5 Mb and db canal openings, tooth 26

Fig. 6 Palatinal canal

The length of the palatinal canal was controlled with an apex locator (Root ZX®) which indicated that the file had not reached the apex. Carefully, with the help of the microscope, calcification was removed, but no canal could be negotiated further.
Calcium hydroxide was applied and access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

2nd appointment: 27.04.2007 (2 weeks later)
The patient was symptom free postoperatively from tooth 26. However, 4 days postoperatively, the patient experienced pain from tooth 27. Clinical examination revealed that tooth 27 was tender to percussion. It was decided to finish the treatment of tooth 26 and then treat tooth 27 at the same appointment.

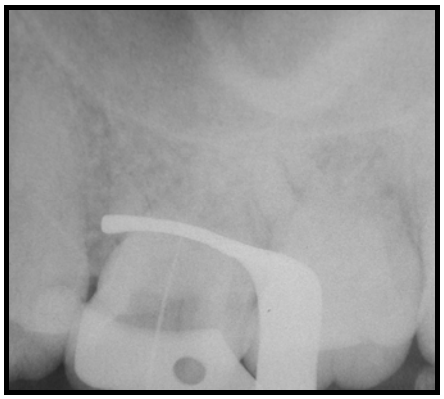

Fig. 7 Working length radiograph tooth 26

One carpule of Xylocaine/adrenaline was applied to establish anaesthesia.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. A new attempt was made to negotiate the canals.
It was possible to insert a file # 15 to a length of 12 mm in the palatinal canal.
A working length radiograph for the palatinal canal was taken (Fig. 7).

The palatinal canal was cleaned with a LN bur to the working length (Fig. 8). Care was taken to remove all pulp remnants from the access cavity. The cavity was rinsed with an abundant amount of 1% NaOCl and 17% EDTA. The palatinal canal as well as the access cavity was filled with IRM. A final radiograph was taken (Fig. 9).

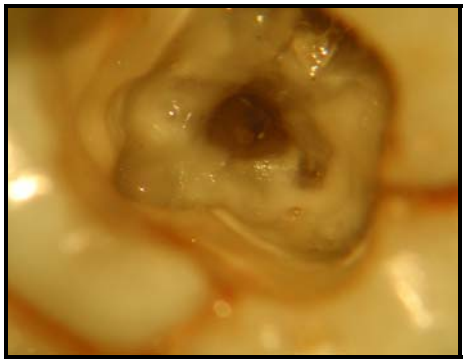

Fig. 8 Palatinal canal tooth 26

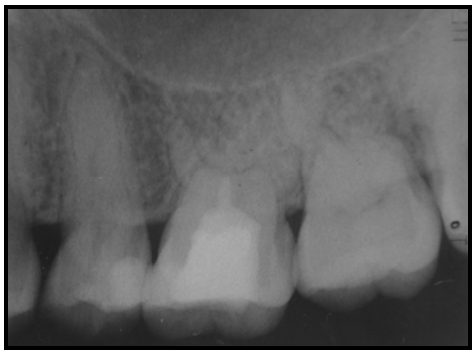

Fig. 9 Final radiograph

The patient felt tired after the treatment of tooth 26 and a new appointment was scheduled one week later to treat tooth 27.

Prognosis:
The prognosis was assumed to uncertain.

Discussion
Dentinal dysplasia (DD-I) also known as rootless teeth, is a rare autosomal dominant genetic disease causing incomplete tooth formation that results in premature exfoliation of both the primary and permanent dentitions. The enamel and coronal dentin are well formed, but the radicular dentin lacks histological organization and subsequently is shortened dramatically. The patients present with normal appearing crowns in both deciduous and permanent dentitions, short, conical, or absent roots, and partial or full obliteration of the crown pulp chamber except for a thin, crescent-shaped pulp remnant. Histologically, the mantle dentin and the majority of the coronal dentin are unaffected (O'Carroll 1994; Shields *et al.* 1973; Witkop, Jr. 1975). However, associated with the pulpal remnant, abnormal dentin is seen within large pulp stones with calcified tubular dentin and atypical osteodentin (Melnick *et al.* 1980).
Radiography shows short, pointed or blunted roots and periapical radiolucencies despite the absence of dental caries (Sauk, Jr. *et al.* 1972; Shankly *et al.* 1999; Ansari & Reid 1997).
In dentinal dysplasia, calcified pulp chambers, unfavourable crown-root ratio, periapical radiolucent areas and the nature of the periapical lesion are the characteristic findings that present the dentist with problems in the management of this condition. The exact mechanism responsible for the abnormal tooth development and obliteration of the pulp

space in DD is unknown. Rushton (1939) and Logan *et al.* (1962), proposed that multiple degenerative foci in the dental papillae became calcified, leading to reduced growth and final obliteration of the pulp space. Sauk, Jr. *et al.* (1972) suggested that it was not the dental papillae, but the epithelial root sheath that was responsible for the root development and that this invaginated too early, which then induced ectopic dentine formation in the pulp space. Wesley *et al.* (1976) disagreed with these theories and proposed that the condition is caused by an abnormal interaction of odontoblasts with ameloblasts leading to abnormal differentiation and/or function of these odontoblasts. In dentinal dysplasia Type I, pulp necrosis and periapical pathosis are common findings present in the affected teeth. Ravanshad & Khayat (2006) suggested that the pulp necrosis found in this condition occurs because of impairment in pulpal circulation and nourishment deficiency of the dental pulp, which renders the pulp susceptible to bacteraemia. Other authors attribute this finding to pulp contamination through the tunnels present in the defective dentine (Steidler *et al.* 1984).

Systemic lupus erythematosus (SLE) is a chronic inflammatory rheumatic disease of immunologic origin, which is characterized by autoantibody production and variable clinical manifestations. The aetiology of SLE is unknown; similar to many autoimmune diseases, it is thought that environmental factors trigger the disease in genetically predisposed individuals.
It is characterized by fever, weakness, joint pain, erythematous lesions, pleurisy and kidney dysfunction. Affected individuals may produce autoantibodies and the interaction of those with the specific antigens produces various symptoms (Bhattacharyya *et al.* 2003).
The oral lesions of systemic lupus are most prevalent on the buccal mucosa, followed by the gingival tissues, lip and palate. The lesions are frequently symptomatic and often consist of one or more of the following components: erythema, surface ulceration, keratic plaques and white striae or papules. This may mimic a marginal gingivitis. They typically respond well to topical or systemic steroids (Marx & Stern 2003).

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Case 4. Necrotic pulp, Tooth 25

Treatment of a nonvital tooth with obliterated canals.

Fig. 1 Frontal view

Referral
A 50-year old white female (Fig. 1) was referred November 2006 to the postgraduate endodontic clinic at the University of Oslo from the student clinic for treatment of the maxillary left second premolar.

Medical history:
Non contributory.
The patient was a smoker

Chief complaint & Dental History:
The patient was under treatment at the student clinic. Crown therapy was planed for tooth 25 and sensibility test revealed a necrotic pulp.

Clinical examination
Preoperative photo showed the region from maxillary left lateral incisor to maxillary left first molar (Fig. 2)

No pathology was found extra-orally. Normal oral mucosa was observed. Probing depths were within normal limits.
No pain to percussion or to palpation was found.

Fig. 2 Buccal view tooth 25

Maxillary left lateral incisor: was intact
Maxillary left canine: was intact
Maxillary left first premolar: had a crown.
Maxillary left second premolar: had a MOD amalgam filling. The tooth was negative to EndoIce®.

Radiographic examination:
Preoperative radiograph showed the region from maxillary left first premolar to maxillary left first molar (Fig. 3).

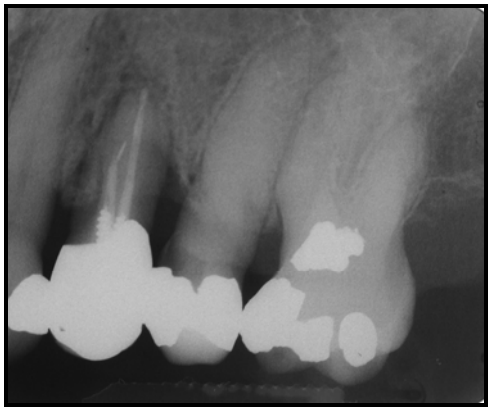

Fig. 3 Preoperative radiograph tooth 25

Maxillary left first premolar: had a crown. Radiographic root filling material could be seen in the palatinal and buccal canals. A post was present in one of the canals. The lamina dura could be followed around the root tip without disruption. Marginal bone loss was approx. 5 mm.

Maxillary left second premolar: had a mod amalgam filling. The lamina dura could be followed around the root without disruption.
Maxillary left first molar: had a MO, occlusal and buccal amalgam filling. The lamina dura could be followed around the root without disruption.

Diagnosis
Maxillary left second premolar with necrotic pulp.

List of problems
Obliterated canals

Treatment
Treatment of a nonvital tooth.

Treatment
1st appointment: 14.11.2006
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. The amalgam was removed and the access cavity prepared. The canals could not be localized and the cavity was covered with a cotton pellet soaked in eugenol and sealed with an IRM filling.

2nd appointment: 29.11.2006 (2 weeks later)
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. The IRM filling was removed and two canals were localized with the help of a microscope and a control radiograph (Fig. 4).

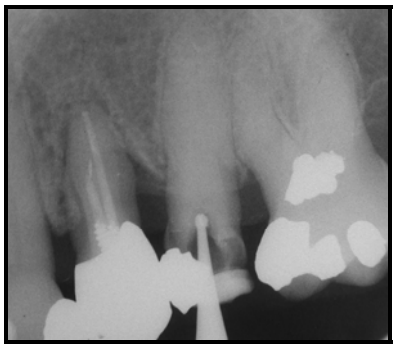

Fig. 4 Control radiograph.

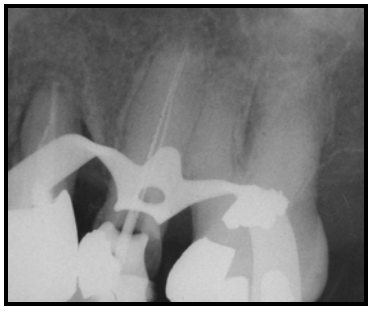

Fig. 5 Working length radiograph

One K-flex file nr 15 was inserted into the buccal canal and H-file nr 15 into the palatinal canal. The working length (palatinal 20 mm and buccal 21. 5 mm) was established with the help of an apex locator (Root ZX®) and a working length radiograph (Fig. 5). Both canals were instrumented to size 45. During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA.

The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.

3rd appointment: 6.12.2006 (1 week later)

The patient was asymptomatic. Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 6). The two canals joined 3 mm from the apex.

Fig. 6 Master cone radiograph tooth 25

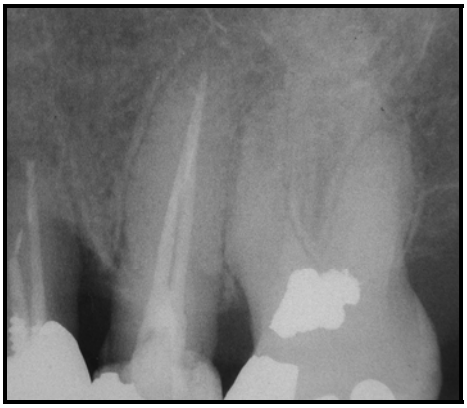

Fig. 7 Final radiograph tooth 25

The canals were dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 8).

Prognosis

The prognosis was assumed to be good.

4 months follow-up: 20.04.2007

The patient was asymptomatic and restored with a temporary crown.

Fig. 8 Buccal view tooth 25

Fig. 9 Control radiograph tooth 25

Discussion

It was possible to localize the canals with a minimal removal of tooth structure. No pathological lesion was discernable radiographically and the tooth was filled after one week with calcium hydroxide. The crown restoration is of importance regarding coronal leakage and the stability of the tooth.

The application of calcium hydroxide has been shown to eliminate bacteria from the root canal when used as an intracanal dressing for one months (Cvek 1972; Byström *et al.* 1985). However, in a study by Sjögren *et al.* (1991) it was shown that calcium hydroxide was effective in killing the root canal flora when applied for one week.

The radiographic level of the endodontic obturation related to the success rate is an aspect which has been investigated since many years. It was found that teeth with necrotic pulp and periapical lesions had the best prognosis if the filling reached within 1-2 mm of the radiographic apex (Sjögren *et al.* 1990; Smith *et al.* 1993; Swartz *et al.* 1983). The importance of staying inside the root canal with the obturation and avoiding extruding material into the periapical tissue in order to obtain a higher success rate has been stressed (Smith *et al* 1993; Sjögren *et al* 1990; Friedman *et al.* 1995)

Endodontically treated teeth have lost substantial tooth structure as a result of previous restorations, dental caries, and the access preparation for the endodontic therapy. Maintenance of tooth integrity and strength is critical to the longevity of any restoration. Proper coronal restoration is strongly recommended after root canal therapy (Saunders & Saunders 1994; Torabinejad *et al.* 1990) This is usually done to prevent tooth fracture or microbial leakage, which will lead to therapy failure. Bacteria and bacterial products could penetrate the marginal gap of a leaky restoration and the interface between the root filling and the canal wall to reach the periapical region. Endodontically treated teeth often lack sufficient support for a permanent restoration, where additional retention through the root canal is necessary. Traditionally, core and post were recommended (Bergman *et al.* 1989; Roberts 1970). In order to create space for a post part of the root canal filling material must be removed. It is recommended to leave 5 mm of gutta-percha at the apical third of the root canal in order to avoid coronal leakage (Zmener 1980; Portell *et al.*

1982; Camp & Todd 1983). A reduction to 3 mm can result in an unpredictable seal (Abramovitz *et al.* 2001).
Different studies have shown that a core and post had little effect in reinforcing the tooth (Yang *et al.* 2001; Trope *et al.* 1986). These studies further suggest that a post should be used only when there is insufficient tooth substance remaining to support the final restoration. In other words, the main function of a post is the retention of a core to support the coronal restoration.

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Case 5. Chronic apical periodontitis, Tooth 32.

Treatment of a nonvital tooth with obliterated canals

Fig. 1 Front view

A 20-year old white female (Fig. 1) was referred February 2002 to the postgraduate endodontic clinic at the University of Oslo from the student clinic for treatment of mandibular left lateral incisor.

Medical history:
Non contributory.

Dental History & Chief complaint
The patient did not have any pain or other complaints. During routine control, an apical lesion (tooth 32) was discovered and the patient was referred for endodontic treatment.

Clinical examination
Preoperative photo showed the region from mandibular right lateral incisor to mandibular left canine (Fig. 2).

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.
No pain to percussion or to palpation was found.

Fig. 2 Buccal view tooth 32

	32	**32**	**33**
EndoIce®	+	-	+
Percussion	-	-	-
Palpation	-	-	-

Radiographic examination:
Preoperative radiograph showed the region from mandibular left central incisor to mandibular left canine (Fig. 3).

The height of the marginal bone was within normal limits.

Mandibular left central incisor: was intact and the lamina dura could be followed without disruption.
Mandibular left lateral incisor: was intact. At the apex a radiolucent lesion of 3 mm in diameter could be observed. No canal space was observed.
Mandibular left canine: was intact and the lamina dura could be followed without disruption.

Fig. 3 Preoperative radiograph tooth 32

Diagnosis:
Mandibular left lateral incisor with chronic apical periodontitis.

Treatment:
Treatment of a nonvital tooth.

Treatment
1st appointment: 27.02.2002
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia and the access cavity was prepared. No canal could be localized. A round bur was used in order to remove calcification with the help of a microscope.

At the end of the appointment the rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The access cavity was rinsed with 1 % sodium hypochlorite and 17 % EDTA. and dried with paper points and calcium hydroxide was applied. The access cavity was further cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Fig. 4 Round burs, tooth 32

2nd appointment: 20.03.2002 (3 weeks later)
The patient was symptom free. The IRM was removed and the calcium hydroxide washed out with sodium hypochlorite.

No rubber dam was applied. The canal could not be localized and Torpan bur was used in order to drill into the canal. The position of the instrument was verified by radiographs (Fig. 5 & 6). A length of 14 mm was reached.

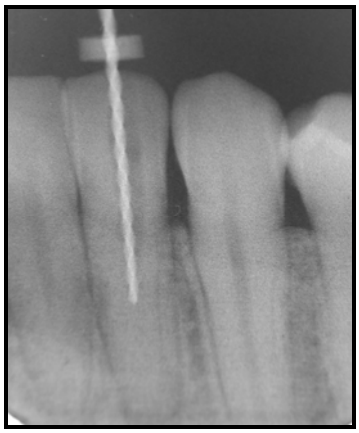

Fig. 5 Mesio eccentric

Fig. 6 Disto eccentric

Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The canal space was rinsed with 1 % sodium hypochlorite and 17 % EDTA. The canal was dried with paper points and was packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.

3rd appointment: 17.04.2002 (1 month later)

The patient was asymptomatic. One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. The IRM was removed and the calcium hydroxide washed out with 1 % sodium hypochlorite. No canal could be probed and it was decided to continue to drill with Torpan burs and to verify the position of the drill by means of radiographs in order to prevent lateral perforation (Fig. 7 & 8).

A length of 17.5 mm was reached. It was decided to stop further drilling with Torpan burs.

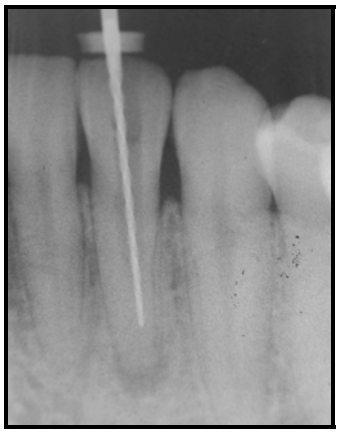

Fig 7 Mesio eccentric

Fig. 8 Disto eccentric

Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The canal space was rinsed with 1 % sodium hypochlorite.

The canal space was further rinsed with 17 % EDTA and cleaned with the help of a piezoelectric Satalec ultrasound device using a K-file tip. An attempt was made to find the canal with a K-flex file nr 08.
The canal was dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM

Fig. 9 Radiograph with $Ca(OH)_2$

4th appointment: 12.11.2002 (7 months later)
The patient was asymptomatic. A radiograph was taken and a reduced periapical lesion was observed (Fig. 10). It was decided to complete the root canal treatment and to fill the canal with gutta-percha.

Fig. 10 Seven months control

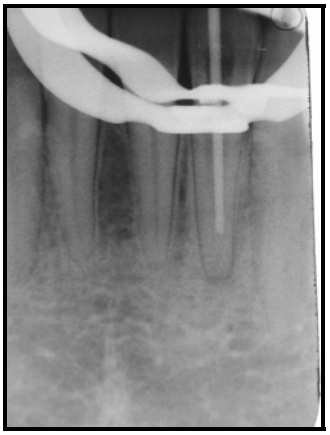

Fig. 11 Master cone radiograph

Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The IRM was removed. The calcium hydroxide was removed with NiTi instruments and 1 % sodium hypochlorite and 17 % EDTA solutions. A master cone radiograph was taken (Fig. 11).

The canal was dried with sterile paper points. The canal filled with AH plus and gutta-percha with a cold lateral condensation technique. The gutta-percha was removed until 2 mm under the marginal bone level and sealed with an IRM plug. The access cavity was sealed with a composite filling (Fig. 12 & 13).

Fig. 12 Final radiograph

Fig. 13 Composite filling

Prognosis

The prognosis of the endodontic treatment was considered to be uncertain.

1 year follow-up: 15.12.2003

Fig. 14 One year follow-up

The patient was asymptomatic.

Clinical and radiological examination revealed no periapical pathology (Fig. 13)

4 years follow-up: 15.11.2006 (4 years later)
The patient was asymptomatic. Radiographically complete bone healing was observed. (Fig. 15-17)

Fig. 15 Close-up tooth 32

Fig. 16 Four years follow-up

Discussion
The patient could not recall any trauma or symptoms of the maxillary left lateral incisor. The apical periodontitis was found during a routine caries control. It was not possible to find the canal. However, with the help of radiographs taken from different angles it was possible to drill into the canal space without lateral perforation. Calcium hydroxide was applied as a long-term medication because the working length was not optimal. Complete healing and bone regeneration was observed after 1 year.

Tooth luxation is relatively common and in case of concussion or subluxation the tooth is not displaced. Most frequent complications are pulp necrosis and obliteration of pulpal tissues. Pulp necrosis only occurs in 3 % of teeth subjected to concussion. Subluxation seems to affect the pulp to a higher degree; about 6 % of the affected pulps do not survive this trauma (Andreasen & Pedersen 1985).
Obliterations of the endodontic system after a concussion occur in 3 % of teeth with unformed roots, and in 7 % of teeth with completely formed roots (Andreasen *et al.* 1986). The incidence of obliteration after subluxation is slightly higher, 11 % and 8 % respectively (Andreasen *et al* 1986). Generally, obliteration of the pulp canal space advances in a corono-apical direction. Two types of pulp canal space obliteration can be differentiated; the partial obliteration limited to the coronal part of the tooth and the total obliteration which extends to the coronal and radicular pulp canal space.
A late complication after obliteration of the pulp canal space is necrosis of the pulp. It is not yet clear how pulpal necrosis arises in these cases; it can be assumed that the limited

neurovascular supply through the narrowed apical foramen and the pulp canal cause the pulp to be more vulnerable to such damage. In recent clinical studies, the occurrence of pulpal necrosis as a result of pulp canal obliteration was found to be up to 1 % after up to 10 years (Andreasen *et al.* 1987) and 8.5 % in a period up to 22 years (Robertson *et al.* 1996).
Without a doubt, root canal treatment can help to prevent the development of apical periodontitis in teeth with progressive obliteration of the root canal system. The low incidence of this late complication, however, implies that endodontic treatment should never be performed as a prophylactic measure but rather should be used only in those cases where signs or symptoms of apical periodontitis appear.
The mineralization can be so extensive that the entire root canal system is obliterated. As a result, root canal treatment can become a difficult if not impossible task. The treatment poses the risk of perforating the root, a complication that affects long-term prognosis.

Periradicular healing has been shown to be dependent of the elimination of bacteria from the root-canal system (Byström *et al.* 1987; Sjögren *et al.* 1997). Clinical and experimental studies have shown that calcium hydroxide will induce periradicular healing (Kerekes *et al.* 1980; Cvek 1972; Cvek 1992) and eliminate the root-canal microbial flora (Byström *et al.* 1985; Byström *et al* 1987; Sjögren *et al.* 1991).
Additionally, calcium hydroxide assists in the debridement of the root canal system as it breaks and thus aids in the dissolution of necrotic tissue remnants (Hasselgren *et al.* 1988; Andersen *et al.* 1992; Wadachi *et al.* 1998).

It can be discussed if surgical removal of the infected root tip without orthograde treatment would be an alternative treatment. In a study by Danin *et al.* (1999), it was shown that half of the teeth with apical periodontitis and treated by surgery and root-end filling showed radiographic evidence of satisfactory healing 1 year postoperatively. However, viable bacteria may persist in the canals, constituting a potential risk factor for recurrence of periradicular pathosis.

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Case 6. Chronic apical periodontitis, Tooth 46

Treatment of a nonvital tooth with overinstrumentation

Fig. 1 Frontal view

Referral
A 38-year old white female (Fig. 1) was referred to the private clinic limited to endodontics from her General Practitioner for treatment of mandibular right first molar.

Medical history:
Non-contributory.

Dental history & Chief complaint
The patient had received treatment for 1 ½ years of the mandibular right first molar (chronic apical periodontitis). The tooth was still tender to percussion and radiographically a radiolucent lesion at the apexes was observed.

Clinical examination
Preoperative photos showed the region from mandibular right first molar to mandibular right lateral incisor (Fig. 2), and from mandibular right second molar to mandibular right second premolar (Fig. 3).

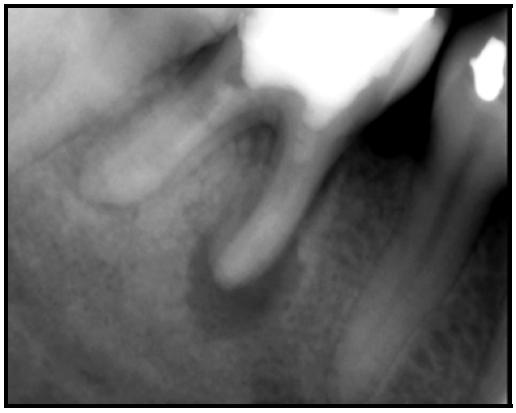
No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig. 2 Buccal view

Fig. 3 Occlusal view

Mandibular right second molar: had an occlusal composite.
Mandibular right first molar: had an occlusal IRM top filling. The buccal and distal wall of the tooth was missing. The tooth was tender to percussion and palpation.

Radiographic examination:
Preoperative radiograph showed the region from maxillary right second premolar to maxillary right first molar (Fig. 4).



Mandibular right second premolar: had an O amalgam filling.
Mandibular right first molar: The tooth was heavily decayed and an IRM filling was observed. A periapical lesion of approx. 7 mm in size was observed around the mesial roots and 3 mm around the distal roots.

Fig. 4 Preoperative radiograph tooth 46

Diagnosis:
Mandibular right first molar with chronic apical periodontitis.

Treatment:
Treatment of a nonvital tooth.

Treatment:
1st appointment: 13.11.2006
The IRM filling was removed and the canals were localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
Four files were inserted, mesio-buccal canal NiTi nr 25 / 18.5 mm, mesio-lingual H-file nr 45 / 18.0 mm, disto-buccal K-flex nr 15 / 15 mm and disto-lingual K-flex nr 20 / 18 mm and a working length radiograph was taken (Fig. 5).

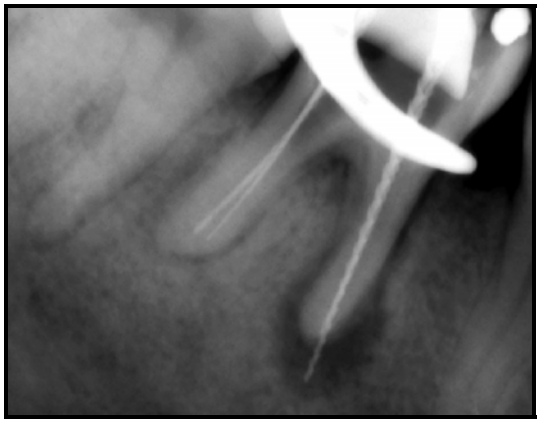
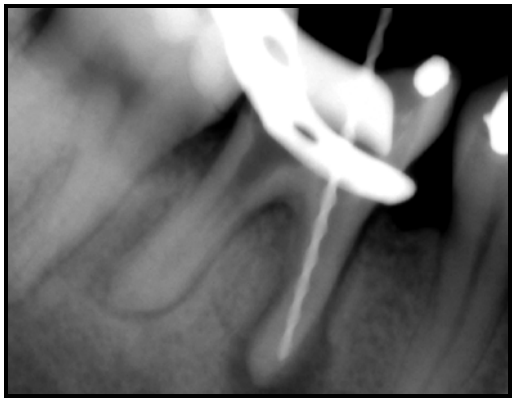


Fig. 5 Working length radiograph.

However, despite precaution, the file in the mesio-lingual canal extended 3 mm into the lesion (Fig. 5). The patient felt some discomfort which she described to be the same feeling every time the dentist re-instrumented the canals and filled them with $Ca(OH)_2$.



The working length was corrected and new working length radiograph was taken (Fig. 6 & 7).
The working length was confirmed with an apex locator (Root ZX®).

Fig. 6 Working length radiograph of the ml canal

The canals were instrumented as followed:
MB 18 mm / nr 55
ML 15.5 mm /nr 80
DB 15 mm / nr50
DL 18 mm / nr 45

Fig. 7 Working length radiograph of the mesio-buccal canal

During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. Special care was taken not to get irrigation solution into the lesion. The canals were dried with paper point and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

2nd appointment: 4.12.2006 (3 weeks later)
The patient had weak symptoms.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, the mesial canals were filled with MTA. A humid cotton pellet was applied and the opening of the mesial canals was sealed with IRM.
A master cone radiograph was taken in order to control the length of the gutta-percha in the distal canals (Fig. 8).

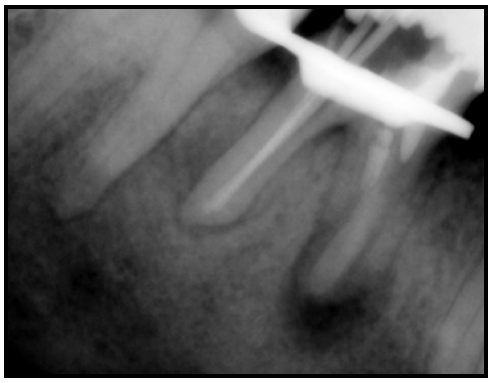


Fig. 8 Master cone radiograph

The canals were dried with sterile paper points. The distal canals were filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM.

3rd appointment: 11.12.2006
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. The cotton pellets were removed and the canal opening sealed with IRM (Fig. 9).

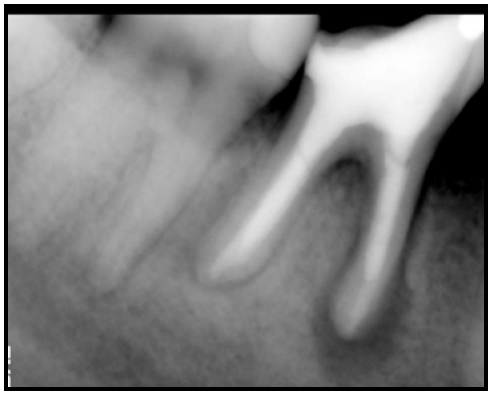


Fig. 9 Final radiograph

Prognosis
The prognosis was assumed to be uncertain.

3 months follow-up: 05.03.2007
The patient had no symptoms. No pathological pocket could be probed.

The patient decided not to get the recommended restoration after the root canal treatment was finished, but to wait for the 3 months control.

Fig. 10 3 months follow-up

Discussion

Proper instrumentation and disinfection of the canals resulted in the disappearance of the symptoms. Because of an apical box at the correct working length, MTA could be applied without overfilling. However, the long-term prognosis remains uncertain because of the reduced tooth substance thereby the increased risk for fracture.

Different studies have shown that specific bacteria are associated with pain and tenderness to percussion of infected teeth with apical periodontitis (Hashioka *et al.* 1992; Jacinto *et al.* 2003; Gomes *et al.* 2004). A proper disinfection of the root canal system through mechanical and chemical procedures will therefore not only eliminate the infection but also give pain relief.

Prognosis for endodontic treatment is dependant on the successful removal of the microorganisms from the root canal system (Byström *et al.* 1987; Sjögren *et al.* 1990; Sjögren *et al.* 1997). Different factors affect the outcome and compromise the prognosis of the tooth. The level of obturation is one of these factors. If the endodontic treatment is too long and the canals are overfilled, about 57 to 75% of the teeth show periapical lesions (Eriksen *et al.* 1988; Eriksen & Bjertness 1991; De Cleen *et al.* 1993; Saunders *et al.* 1997).

Restorations for endodontically treated teeth are designed to protect the remaining tooth from fracture, prevent reinfection of the root canals system and replace the missing tooth structure. Lynch *et al.* (2004) reported that loss of endodontically treated teeth occurred more often with those restored with temporary restorations (34.5%) than other restoration types). Endodontically treated teeth that were not crowned after obturation were lost at a 6.0 times greater rate than teeth crowned after obturation. They found a strong association between crown placement and the survival of endodontically treated teeth. These results corroborates with those of the study by Aquilino & Caplan (2002). The coronal coverage presumably reduced the risk of tooth fracture, one of the most often cited reasons for root-canal-treated tooth loss (Sjögren *et al* 1990; Vire 1991; Caplan & Weintraub 1997; Eckerbom *et al.* 1992).

In a recent prospective clinic study by Creugers *et al.* (2005) the survival rate of cast post-and-core restorations was compared to the survival of direct post-and-core restorations and post-free all-composite cores. The type of post and core was not relevant with respect to survival. The amount of remaining dentin height after preparation influenced the longevity of a post-and-core restoration. These findings corroborated with those by Salvi *et al.* (2007). They concluded that the adjusted 5-year tooth survival rate amounted to 92.5% for teeth restored with titanium posts, to 97.1% for teeth restored with cast post-and-cores and to 94.3% for teeth without post restorations, respectively. The most frequent complications included root fracture (6.2%), recurrent caries (1.9%), post-treatment periradicular disease (1.6%) and loss of retention (1.3%).

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Case 7. Chronic apical periodontitis, Tooth 14

Treatment of a nonvital tooth with a fractured instrument

Fig. 1 Frontal view

Referral
A 59-year old white female (Fig. 1) was referred November 2005 to the private clinic limited to endodontics from her General Practitioner for treatment of the maxillary right first premolar.

Medical history:
Non contributory.

Dental History & Chief complaint:
The patient experienced pain from the maxillary right first premolar. The General Practitioner started the treatment (chronic apical periodontitis); however, an instrument was fractured and remained in the root canal.

Clinical examination
Preoperative photos showed the region from maxillary right first premolar to maxillary right lateral incisor (Fig. 2 & 3).

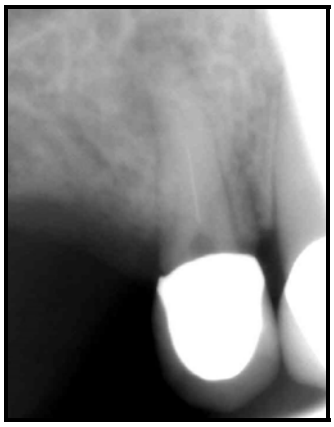
No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig. 2 Buccal view

Fig. 3 Occlusal view

Maxillary right first premolar: had a crown and was tender to percussion.
Maxillary right canine: pillar of the bridge.
Maxillary right lateral incisor: part of the bridge (pontic).

Radiographic examination:
Preoperative radiograph showed the region from maxillary right first premolar (Fig. 4).



Maxillary right first premolar: had a crown. At the apex the lamina dura was widened to give a lesion of 4 mm in diameter. A broken file was observed in one of the canals.

Fig. 4 Preoperative radiograph tooth 14

Diagnosis
Maxillary right first premolar with chronic apical periodontitis.

List of problems:
Broken instrument.

Treatment
Treatment of a nonvital tooth.

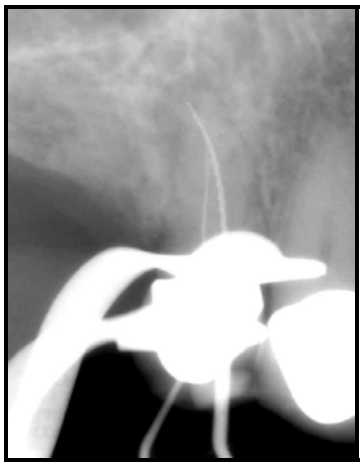
1st appointment: 7.11.2005
The IRM filling was removed and the 2 canals were localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. It was possible to expose the broken instrument which was located in the buccal canal (Fig. 5)

Fig. 5 Broken instrument

Fig. 6 Working length radiograph

A K-file nr 15 could be inserted 18 mm in the palatinal canal and a working length radiograph was taken (Fig. 6). The palatinal canal was instrumented to a size 45 / 17 mm. During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. It was not possible to remove the instrument from the buccal canal.
The palatinal canal was dried with paper point and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

2nd appointment: 11.11.2005 (4 days later)
The patient was asymptomatic.



With the help of an ultrasound instrument it was possible to remove dentine around the broken file.
The broken file was bypassed and removed with the help of an H-file nr 15. Two files were inserted, buccal canal K-flex 15 / 16 mm and palatinal canal H-file 25 / 17 mm and a new working length radiograph was taken (Fig. 7).
During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA.

Fig. 7 Working length radiograph tooth 14

The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

3rd appointment: 28.11.2005 (17 days later)
The patient was asymptomatic.
Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The IRM was removed and the calcium hydroxide washed out with NaOCl. A master cone radiograph was taken (Fig. 8).

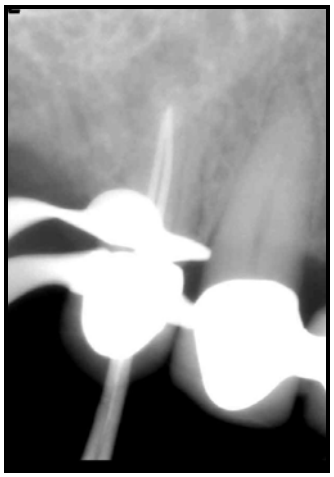


Fig. 8 Master cone radiograph

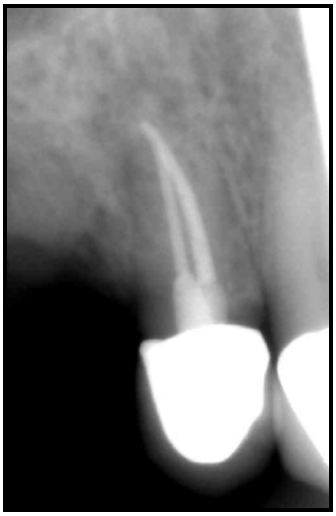


Fig. 9 Final radiograph

The canals were dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 8).

Prognosis
The prognosis of the endodontic treatment was considered to be good.

1 year follow-up: 13.11.2006
The patient was asymptomatic. The radiograph showed complete bone healing at the periapex (Fig. 10).

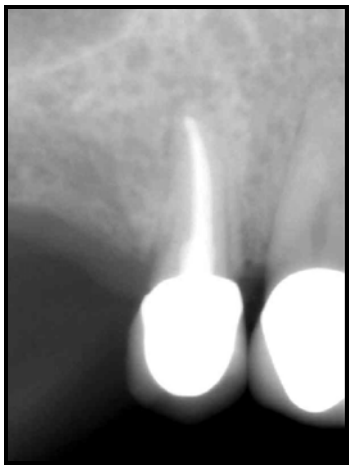


Fig. 10 One year follow-up

Discussion
Apical periodontitis is an inflammatory disorder of periradicular tissues caused by persistent microbial infection within the root canal system of the affected tooth (Fabricius *et al.* 1982; Kakehashi *et al.* 1966; Sundqvist 1976). Initial endodontic treatment consists of eradicating the root canal microbes or substantially reducing the microbial load and preventing re-infection by root canal filling. Subsequently the bone will regenerate and the apical lesion will disappear (Byström *et al.* 1987; Sjögren *et al.* 1990). In the Toronto Study (Marquis *et al.* 2006), the outcome of initial endodontic treatment was assessed and the overall healed rate in the pooled sample was 85%.

If a fractured instrument remains in the canal, the root canal cannot be cleaned properly, leaving behind remnants of pulp tissue and bacteria. Therefore the outcome of root canal treatment is compromised (Marquis *et al* 2006; Rocke & Guldner 1993; Sjögren *et al* 1990). It is clear that the prognostic impact of a retained instrument fragment is influenced by the presence of a preoperative periapical lesion which subsequently is the

main prognostic factor for the successful treatment of such cases (Engström *et al.* 1964; Bergenholtz *et al.* 1979; Spili *et al.* 2005).
However, attempts to remove fractured instruments may lead to ledge formation, overenlargement and transportation of the prepared root canal or perforation. Thus, the clinician has to evaluate the options of attempting to remove the instrument, bypassing it or leaving the fractured portion in the root canal. This decision should be made with consideration for the pulp status, canal infection, the canal anatomy, the position of the fractured instrument and the type of fractured instrument.
Different studies have evaluated the removal of instruments from root canals and factors such as tooth type, location (before or after the curvature), fragments size and type of instrument were identified and shown to affect the successful removal (Hülsmann & Schinkel 1999; Shen *et al.* 2004). Contrary, Suter *et al.* (2005) found no statistically significant difference in the success rate with respect to the location of the fractured instrument, the type of fractured instrument or the different methods of instrument removal.

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Case 8. Chronic apical periodontitis, Tooth 11

Treatment of a nonvital tooth with unusual canal morphology

Fig. 1 Frontal view

A 15-year-old white male (Fig. 1) was referred January 2007 to the postgraduate endodontic clinic at the University of Oslo from his General Practitioner for treatment of maxillary right central incisor.

Medical history:
Non contributory.

Dental History & Chief complaint
The patient had a trauma of the upper front teeth at 7 years of age, but did not experienced any symptoms. Endodontic treatment was started in March 2003 (unknown diagnosis); however, this treatment was never completed. The patient had a new trauma in the same area in 2005. He consulted his GP who diagnosed apical periodontitis in the upper central incisors and found the root canal treatments uncompleted. The GP referred the patient to the Department of Paediatric Dentistry, University of Oslo. The Department of Paediatric Dentistry referred the patient further to the Department of Endodontics for treatment of the maxillary left and right central incisor.

Clinical examination
Preoperative photo showed the region from maxillary right lateral incisor to maxillary left lateral incisor (Fig. 2)

No pathology was found extra-orally. Normal oral mucosa was observed. Probing depths were within normal limits.

Fig. 2 Buccal view

	12	11	21	22
EndoIce®	-	-	-	+
percussion	-	+	+	-
palpation	-	-	-	-

Radiographic examination:
The preoperative radiograph showed the region from maxillary right lateral incisor to maxillary right central incisor (Fig. 3).

Fig. 3 Preoperative radiograph tooth 11.

Maxillary right lateral incisor: Had a mesial radioopaque restoration. The lamina dura could be followed without any widening until 1 mm from the apex. From that point the lamina dura was widened to give a lesion of 4 mm in size
Maxillary right central incisor: Had an occlusal radioopaque restoration. The lamina dura could be followed without any widening until 2 mm from the apex. From there the lamina dura was widened to give a lesion of 5 mm in size. A widening of the canal space in the middle part of the root was observed.

Diagnosis:
Maxillary right central incisor with chronic apical periodontitis.

Treatment:
Treatment of nonvital tooth.

Treatment
1st appointment: 18.01.2007
The IRM filling was removed and the canal localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
A K-flex file nr 15 / 19 mm was inserted and a working length radiograph was taken (Fig. 4). The canal was instrumented to nr 60 / 18.5 mm after the working length was controlled with an apex locator (Root ZX®).

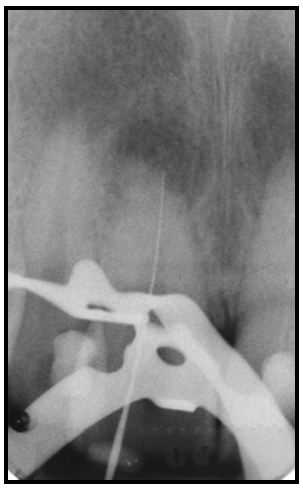

Fig 4. Working length tooth 11.

During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA and dried with paper points. Through the microscope a second canal was observed (Fig. 6) and a working length radiograph was taken with a K-flex file nr 15 in the palatinal canal and a NiTi nr 40 in the buccal (already instrumented) (Fig. 5).

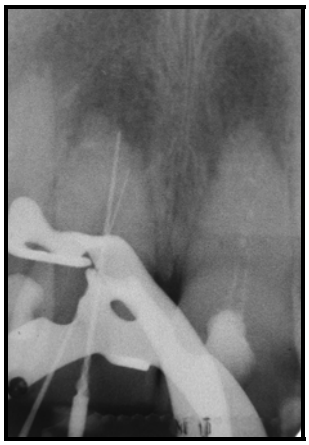

Fig 5. Working length.

Fig 6. Close-up tooth 11.

The palatinal canal was instrumented to nr 45 / 18 mm. During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA. The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with cavit and IRM.

2nd appointment: 28.03.2007

The patient was asymptomatic. Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 7).

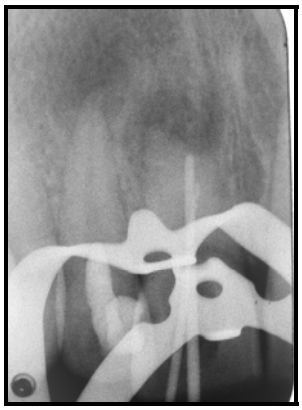

Fig. 7 Master cone radiograph

Fig. 8 Final radiograph tooth 11

The canals were dried with sterile paper points. The two canals were filled with GuttaFlow®. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 8).

Prognosis
The endodontic treatment was considered to be good.

Discussion
The trauma occurred 7 years of age when upper front incisors have open apices. The radiograph of the maxillary right central incisor showed an aberrant pulp chamber and root tip. It can be speculated that the tooth with a vital pulp sustained trauma which resulted in the coronal pulp to become necrotic whilst apically there was a normal vital pulp present which resulted in closure of the apex of the tooth.

Epidemiological studies show that 11.6 - 33 % of all boys and 3.6 – 19 % of all girls suffer dental trauma of varying severity (Baghdady *et al.* 1981; Clarkson *et al.* 1973; Järvinen 1979). Obliteration of the pulp space can be seen as a response to a more or less marked restriction of the pulps' neurovascular supply, which after healing leads to an increased deposition of dentin. Although considered normal of the aging process, the obliteration can be considerably accelerated as a result of the dental trauma (Andreasen 1970; Jacobsen & Kerekes 1977).

Vertucci (1984) stated that maxillary central incisor have one root and one canal in 100 % of cases. Because of the simple canal morphology, these teeth are considered to be least difficult subjects for endodontic treatment.
However, in rare instances, these teeth is associated with morphological irregularities, which makes the treatment complicated. Such irregularities are the presence of two canals, germination, fusion, dens invaginatus and accessory canals (Heling 1977; Duckmanton 1995; Kim & Jou 2000; Genovese & Marsico 2003; Mancuso 2003; Sponchiado, Jr. *et al.* 2006).
Accessory canals are minutes canals that extend in a horizontal, vertical or lateral direction from the pulp to the periodontium. In 73.5 % of the case they are found in the apical third of the root, in 11.4 % in the middle third and in 15.1 % in the cervical third (Vertucci 1984). These canals contain connective tissue and vessels and do not supply the pulp with collateral circulation. They are formed by the entrapment of periodontal vessels in Hertwig's epithelial root sheath during calcification (Cutright & Bhaskar 1969). Kasahara *et al.* (1990) reported the incidence of accessory canals in the maxillary central incisors to exceed 60 percent. They found that most of these accessory canals had a diameter equivalent to that of the tip of a no. 10 file. However, in 3 percent of their cases, they found the diameter to be large as that of a tip of a no. 40 file.

Apical periodontitis is an inflammatory response in the host tissue caused by persistent microbial infection of the affected tooth. The main goal of endodontic treatment is therefore the removal of the bacteria from the whole root canal system by cleaning and disinfecting the root canal. The presence of an untreated canal may be the reason for failure. The inability to clean the smaller canals may not have any clinical significance, but failure to clean and fill canals of larger diameter, especially in cases involving necrosis and infection, may lead to root canal failure.

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Case 9. Chronic apical periodontitis, Tooth 36

Treatment of a nonvital tooth.

Fig. 1 Frontal view

Referral
A 45-year old white male (Fig. 1) was referred May 2005 to the postgraduate endodontic clinic at the University of Oslo from the Department for Periodontics for treatment of mandibular left first molar.

Medical history:
Non-contributory, the patient does not take any medication.
The patient was a heavy smoker.

Dental History & Chief complaint
The patient had no symptoms or complains. He was under treatment at the Department for Periodontics at the same faculty. During a routine examination, a periapical radiolucency was observed radiographically on tooth 36.

Clinical examination
Preoperative photos showed the region from mandibular left lateral incisor to mandibular left first molar (Fig. 2 & 3)

No pathology was found extra-orally.
Normal oral mucosa was observed.
No pain to percussion or to palpation was found.

Fig. 2 Buccal view tooth 36

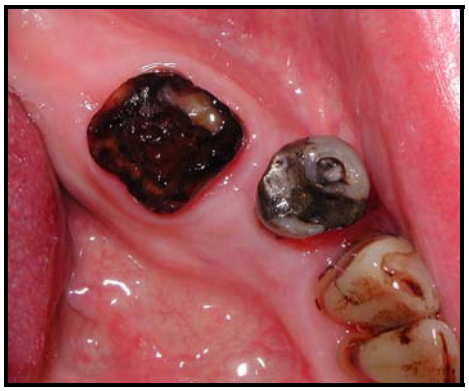


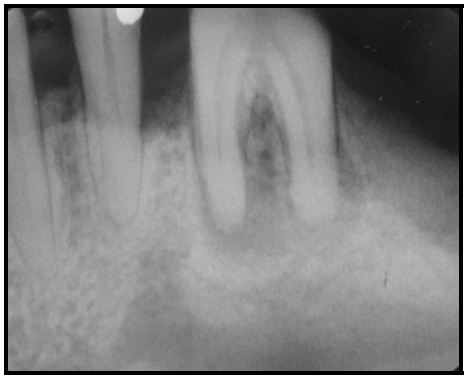
Fig. 3 Occlusal view tooth 36

Mandibular left lateral incisor: had a buccal composite filling.
Mandibular left canine: had a buccal amalgam filling.
Mandibular left first premolar: had a MODB amalgam filling.
Mandibular left second premolar: missing
Mandibular left first molar: was heavily decayed and no crown was present.

	34	**35**	**36**
EndoIce®	+	+	-
Percussion	-	-	-
Palpation	-	-	-
Probing	6 mm	6 mm	5 mm

Radiographic examination:
Preoperative radiograph showed the region from maxillary left first premolar to maxillary left first molar (Fig. 4).

A loss of the marginal bone of around 5 mm could be seen.



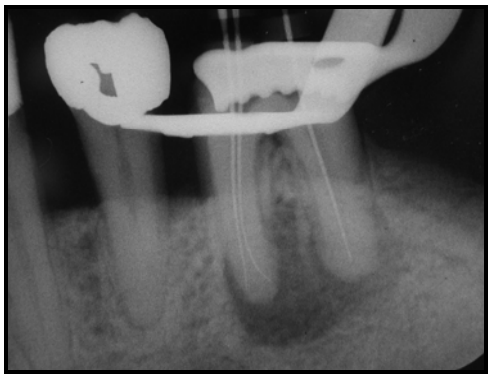
Mandibular left first premolar: had a MODB amalgam filling. The lamina dura could be followed around the root without disruption.
Mandibular left first molar: A lesion of approx. 7 mm in size could be observed around the mesial and distal roots.

Fig. 4 Preoperative radiograph tooth 36

Diagnosis:
Mandibular left first molar with chronic apical periodontitis.

Treatment:
Treatment of a nonvital tooth.

Treatment:
1st appointment: 18.05.2005
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. Access cavity was prepared and caries removed. Three canals could be localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
Three files were inserted, mesio-buccal canal K-flex nr 15 / 16 mm, mesio-lingual canal K-flex nr 15 / 14.5 mm and distal canal K-Flex nr 15 / 14 mm and a working length radiograph was taken (Fig. 5).



The canals were instrumented as followed:
Mesio-lingual: nr 45 / 14 mm
Mesio-buccal nr 45 / 16 mm
Distal nr 55 / 14 mm
The working length was confirmed with an apex locator (Root ZX®). During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA.

Fig. 5 Working length radiograph tooth 36.

The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

2nd appointment: 08.06.2005 (3 weeks later)
The patient was asymptomatic; however, a swelling buccally of tooth 36 was observed. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The IRM filling was removed and no interappointment medicament was found in the canals.
The canals were again thoroughly irrigated with 1% NaOCl and 17% EDTA. The canals were dried with paper point and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

3rd appointment: 30.08.2005 (2 ½ months later)
The patient was symptom free. No swelling was observed.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 6).

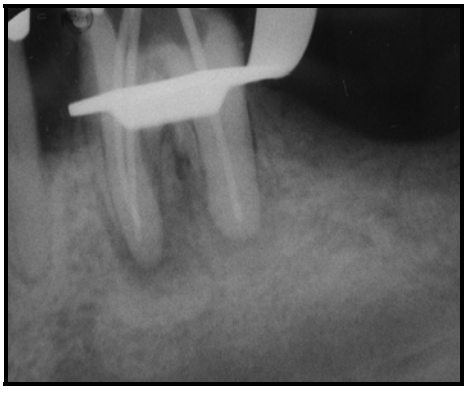


Fig. 6 Master cone radiograph

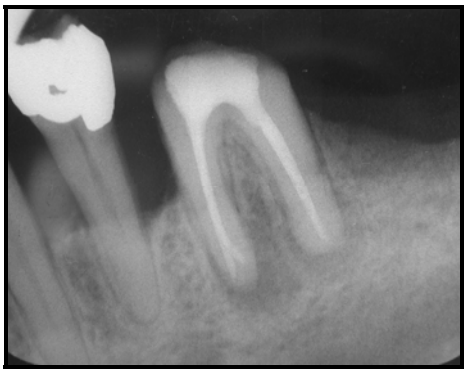


Fig. 7 Final radiograph tooth 36

The canals were dried with sterile paper points. All the canals were filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 7).

The patient was send back to the Department of Periodontics for further treatment. The patient was also set on a waiting list for restorative work.

Prognosis
The endodontic prognosis was considered to be good.

1 year follow-up: 30.10.2006
The patient was asymptomatic**.** No restoration had been placed. Partial healing with bone regeneration could be observed radiographically (Fig. 8).

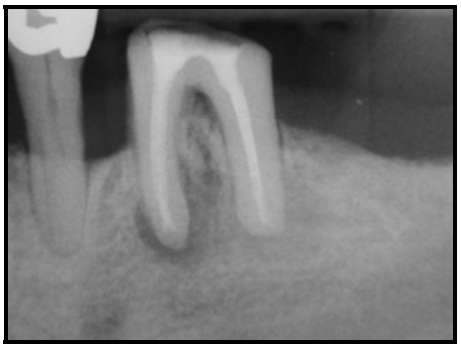


Fig. 8 Control radiograph tooth 36

17.04.2007 (1 ½ years later)
The patient was referred from the student clinic for evaluation of the same tooth. December 2006, the tooth was restored with a temporary crown. In April 2007, the patient returned to the clinic for cementation of the permanent crown; however, a fistula was observed (Fig. 9). The patient was asymptomatic and was not aware of the fistula.

Fig. 9 Tooth 36 with fistula

Fig. 10 Lingual aspect

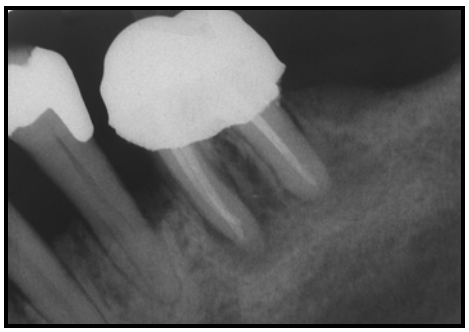


Fig. 11 Control radiograph tooth 36

Fig. 12 Fistulograph tooth 36

24.04.2007 (1 week later)
The temporary crown was removed; rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The composite filling was removed from the access cavity which revealed that the entire IRM filling had been removed.
The gutta-percha in the distal canal was reduced 3 mm to the level of the marginal bone. The gutta-percha in the mesial canals was removed and the working length controlled radiographically. The canals were thoroughly irrigated with 1 % NaOCl and 17 % EDTA. Calcium hydroxide was packed into the canals with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM. The temporary crown was cemented with Nobetec®.

30.04.2007
Examination showed that the fistula had disappeared.

Discussion
Healing with bone regeneration could be seen on the 1 year follow-up radiograph indicating the elimination of bacteria from the root canal system.
After the tooth was build up with composite and restored with a temporary crown, a fistula appeared. The chronological order of events indicates that the fistula is caused by a reinfection rather than a persisting infection. Therefore, it was decided to retreat the mesial canals and not to perform an apical surgery.

The treatment of apical periodontitis consists of eliminating infection from the root canal and preventing re-infection by a tight seal of the root canal space. When the treatment is done properly, healing of the periapical lesion usually occurs with osseous regeneration, which is characterized by gradual reduction and resolution of the radiolucency on subsequent follow-up radiographs (Byström *et al.* 1987; Sjögren *et al.* 1990; Sjögren *et al.* 1997; Sundqvist *et al.* 1998). However, for various reasons, a complete bone healing or reduction of the apical radiolucency may not occur in all root-canal-treated teeth.
In studies by Stassen *et al.* (2006) and Hommez *et al.* (2002) it was shown that the quality of the root filling as well as the coronal filling evaluated radiographically had an impact

on the periapical health. Siqueira, Jr. *et al.* 2005 found that the coronal restoration had a significant impact on the periradicular health, however, the quality of the root canal filling was found to be the most critical factor in this regard. These findings concur with results of Tronstad *et al.* (2000). Contrary, studies have shown that the quality of both the root filling and the restoration were found to impact on the periapical health of root-filled teeth, with the impact of the restoration being most critical when the quality of the root filling was adequate (Dugas *et al.* 2003; Ray & Trope 1995).

Any link between caries and smoking clearly presents a challenge to the restoration and prognosis of endodontically treated teeth, as generally these teeth are heavily restored and may well be crowned. It was suggested that this cariogenic effect was probably not due to the direct effects of smoke itself (Hahn *et al.* 1999), but other oral factors associated with smoking such as reduced flow of saliva and gingival exudates (Macgregor 1989). Perhaps the most likely reason for the increase of root caries in patients who smoke is that they are more prone to marginal periodontitis than non-smokers (Johnson & Hill 2004). Furthermore, the survival of endodontically treated teeth mainly depends on adequate coronal restoration (Meeuwissen & Eschen 1983; Vire 1991; Fuss *et al.* 1999).

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Case 10. Chronic apical periodontitis, Tooth 11

Retreatment and bleaching.

Fig. 1 Frontal view

Referral
A 20-year old african female (Fig. 1) was referred November 2006 to the postgraduate endodontic clinic at the University of Oslo from her General Practitioner for treatment of maxillary right central incisor.

Medical history:
Non-contributory.

Dental History & Chief complaint
The patient could not recall any trauma. The tooth has been root filled two times previously; however, the patient had pain and was unsatisfied with the colour of the tooth.

Clinical examination
Preoperative photos showed the region from maxillary right lateral incisor to maxillary left lateral incisor (Fig. 2) and from the maxillary right lateral incisor to maxillary left central incisor (Fig. 3)

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig. 2 Buccal vi**ew**

Fig.3 Palatinal view

Maxillary right lateral incisor: intact
Maxillary right central incisor: The tooth was discoloured and had a buccal and occlusal composite.
Maxillary left central incisor: intact

	12	**11**	**21**
EndoIce®	+	-	+
Percussion	-	+	-
Palpation	-	+	-

Radiographic examination:
Preoperative radiograph showed the region from maxillary right central incisor to maxillary left central incisor (Fig. 4).

The height of the marginal bone was within normal limits.

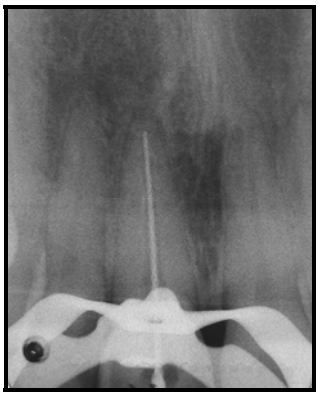
Maxillary right central incisor: Had an occlusal radiolucent restoration. A radioopaque filling material could be seen in the root canal. The lamina dura could be followed without any widening until the apex. At the apex the lamina dura was widened to give a lesion of 2 mm.
Maxillary left central incisor: Had an intact crown and the lamina dura could be followed around the entire root without disruption.

Fig. 4 Preoperative radiograph tooth 11

Diagnosis:
Maxillary right central incisor with chronic apical periodontitis.

Treatment:
Retreatment.
Internal bleaching and occlusal composite filling.

Treatment
1st appointment: 14.11.2006
The composite filling was removed and the gutta-percha exposed. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
The gutta-percha was removed without chloroform. A NiTi file nr 40/ 21.5 mm was inserted and a working length radiograph was taken (Fig. 5). The canal was instrumented to nr 80.



During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA. The canal was dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with cavit and IRM.

Fig. 5 Working length radiograph tooth 11

2nd appointment: 18.01.2007 (2 months later)
The patient was asymptomatic.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph (Fig. 6) was taken.

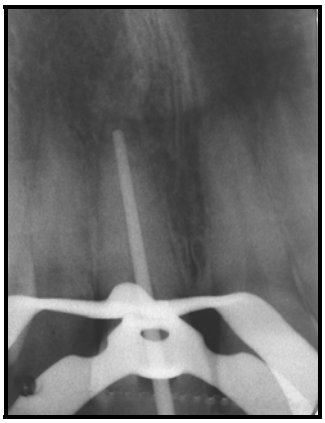


Fig. 6 Master cone radiograph

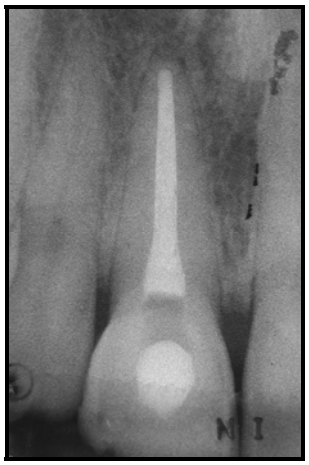


Fig. 7 Control radiograph

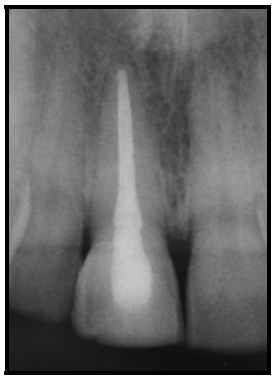
The canal was dried with sterile paper points. The canal was filled with AH plus and gutta-percha with a cold lateral condensation technique.

After removing excess of gutta-percha, the access cavity was treated with Scotchbond Etchant. Natriumperborat + 3 % hydrogen peroxide was applied and the access cavity was sealed with IRM (Fig. 7).

3rd appointment: 22.03.2007 (2 months later)
The patient returned 2 months later with an asymptomatic. She was already satisfied with the changed colour of the tooth. However, it was decided to reapply internal bleach before filling the tooth with composite.

Rubberdam was applied and disinfected with chlorhexidine-ethanol. IRM and bleaching paste were removed. Natriumperborat + 3 % hydrogen peroxide was applied and the access cavity was sealed with IRM.

4th appointment: 10.04.2007 (3 weeks later)



Rubberdam was applied and disinfected with chlorhexidine-ethanol. IRM and bleaching paste were removed. An occlusal composite (Vita Inceram®) was placed after acid-etching and one-step bonding (Syntac Sprint®).

Fig. 8 Final radiograph

Fig. 9 Buccal view

Fig. 10 Occlusal view

Prognosis

The prognosis of the endodontic treatment was considered to be good.

Discussion

The patient presented with symptoms in a previously root-filled tooth which radiographically seemed not to be tight. The retreatment resulted in a symptom free tooth. The access cavity through the pulpal floor creates an open conduit between the oral cavity and the alveolar bone which must be sealed to prevent the ingress of bacteria. The preoperative radiograph (Fig. 4) showed an inadequate filled root canal. The presences of bacteria in a root canal are the source of symptoms and after proper cleaning and disinfection the symptoms usually disappear (Hashioka *et al.* 1992; Jacinto *et al.* 2003; Gomes *et al.* 2004).

In trauma, haemoglobin is released into tissues; iron oxides, formed by oxygen and iron in haemoglobin, cause discoloration and swelling that infringes on pulp space, forcing the pulp to recede with a potential loss of tooth vitality. In endodontic treatment, haemorrhaging components, materials used or incomplete removal of necrotic tissue may

cause staining. Discoloration of non-vital teeth is an aesthetic deficiency frequently requiring bleaching treatment. This is a conservative treatment of tooth tissue and may delay the need for more invasive veneers and crowns. The 'walking bleach' technique introduced in 1961 for bleaching of non-vital teeth involved sealing a mixture of sodium perborate and water into the pulp chamber between patients' visits (Spasser 1961). The method was later modified and water was replaced by 30-35% H_2O_2, to improve the whitening effect (Nutting & Poe 1963).

In vitro studies have concluded that sodium perborate in water, sodium perborate in 3% and 30% hydrogen peroxide, and 10% carbamide peroxide are all efficient for internal bleaching of non-vital teeth (Ari & Ungor 2002; Freccia *et al.* 1982; Rotstein *et al.* 1991; Rotstein *et al.* 1993; Vachon *et al.* 1998). A recent study by Amato *et al.* (2006) showed that the colour of 63 % of the teeth subjected to intracoronal bleaching had remained stable after 16 years.

An adverse effect that has been reported following internal tooth bleaching is cervical root resorption (an inflammatory-mediated external resorption of the root) (Friedman *et al.* 1988). However, a large number of cases had suffered from trauma, and it is difficult to distinguish if the cervical resorption is a consequence of the bleaching or the trauma. The underlying mechanism for this effect is unclear, but it has been suggested that bleaching agents reaches the periodontal tissues through the dentinal tubules and initiates an inflammatory reaction (Cvek & Lindvall 1985). Therefore it is of importance to place a cervical base in order to prevent or to minimize the leakage along the root canal filling and into the dentinal tubules. The root canal filling is shortened to a level 2-3 mm below the cementoenamel junction and then covered with an impermeable material.

This type of cervical resorption, which is occasionally found after bleaching of a non-vital tooth, is often excessive, as it can rapidly progress through the root without being hindered by pulp and predentin.

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Case 12. Chronic apical periodontitis, Tooth 16

Retreatment and crown lengthening

Fig. 1 Frontal view

Referral:
A 59-year old white male (Fig. 1) was referred December 2006 to the postgraduate endodontic clinic at the University of Oslo from the student clinic for treatment of the maxillary right first molar.

Medical history:
Infarct of the heart in 1995
Rectal cancer (diagnosed in 2003) - radiotherapy

The patient took the following medicaments:
Zocor
Tenomin
Albyl E (75 mg)
Movene (625 mg)

Dental History & Chief complaint:
The patient had no complains or symptoms.

Clinical examination
Preoperative photos showed the region from maxillary right canine to maxillary right first molar (Fig. 2 & 3).

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.
No pain to percussion or to palpation was found.

Fig. 2 Buccal view

Fig. 3 Occlusal view

Maxillary right first molar: had a MO IRM filling and an ODP amalgam filling. The mesio-buccal cusp was missing
Maxillary right second premolar: had an OD IRM filling
Maxillary right first premolar: had an ODB IRM filling, the buccal cusp was missing.

Radiographic examination
Preoperative radiograph showed the region from maxillary right first molar to maxillary right first premolar (Fig. 4).

Fig. 4 Preoperative radiograph

Maxillary right first molar: had a restoration of two different materials. A radioopaque filling material could be seen in the palatinal root canal. The lamina dura could be followed around the disto-buccal and palatinal roots without any disruption. The mesio-buccal root was presented with disrupted lamina dura of approx. 1 ½ mm.
Maxillary right second premolar: had an IRM filling. A radioopaque filling material could be seen in the root canal. The lamina dura could be followed around the entire root without disruption.
Maxillary right first premolar: had an occlusal radioopaque filling. Mesially, the marginal bone loss was of approx. 6-7 mm.

Diagnosis
Maxillary right first molar with chronic apical periodontitis.

Problem list:
Previously root filled tooth
Obliterated canals

Treatment plan:
Retreatment.

Treatment:
1st appointment: 31.01.2007
The coronal restoration was removed and the canals were localized with the help of a microscope. It was not possible to apply a tight rubber dam, and the attempt to rebuild the tooth failed because it was not possible to put a matrice around the tooth.
The access cavity was disinfected with chlorhexidine-ethanol solution and a layer of Ca(OH)2 was applied and covered with IRM.

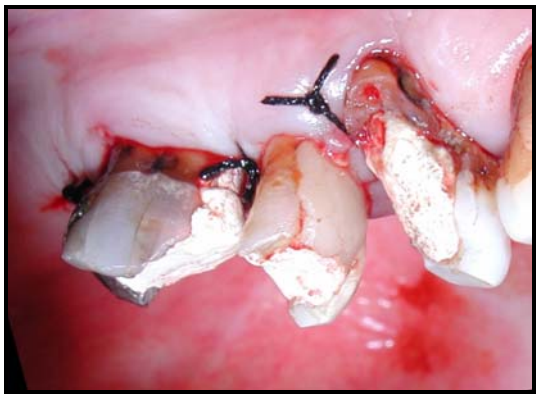
2nd appointment: 21.02.2007 (3 weeks later)

3 carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the distal aspect from the maxillary right first premolar extending posterior to the maxillary right first molar (Fig. 5).

The flap was carefully reflected and an osteotomy of 2 mm in width on the mesial and palatinal aspect of the tooth was accomplished with a round bur (Fig. 5).
The site was then carefully irrigated with sterile saline. The flap was repositioned and 4 sutures were placed.

Fig. 5 Flap and osteotomy

3rd appointment: 28.02.2007 (1 week later)

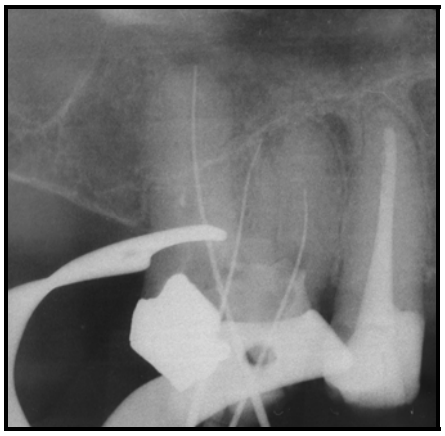


Postoperatively, the patient was presented with mild pain.

Wound healing was satisfactory (Fig. 6) and the sutures were removed.

Fig. 6 One week after surgery

Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The Ca(OH)2 was removed and the three canals exposed. A working length radiograph (Fig. 7) was taken with K-file 15/15.5 mm MB, K-file 15/19.5 mm DB and NiTi file 25/ 21 mm MB. An attempt was made to negotiate further the mesio-buccal canal with irrigation of EDTA and K-files 20,15,10, 08 and 06.



The canals were instrumented to sizes 50/15.5 mm MB, 45/18.5 mm DB and 60/19mm P with copious amounts of 1% NaOCl and 17%EDTA.
An attempt was made to find a 4th canal with the help of a microscope. It was not possible to find a 4th canal.
The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points.

Fig. 7 Working length radiograph

The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM

4th appointment: 14.03.2007 (2 weeks later)
The patient was asymptomatic. Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a new attempt was made to find the 4th canal. During the search, a perforation was made in the area between the mesio-buccal and palatinal canal. This was verified by a radiograph and apex locator (Root ZX®). The perforation was sealed with IRM and a master cone radiograph was taken (Fig. 8).

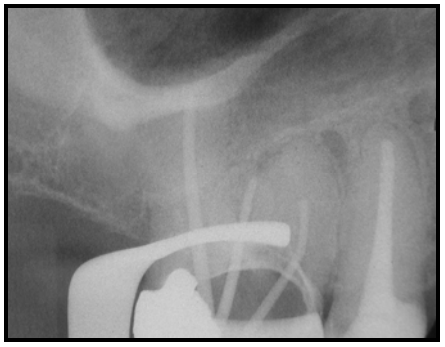


Fig. 8 Master cone radiograph

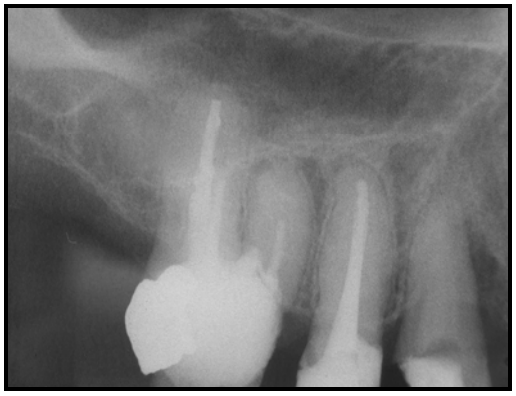


Fig. 9 Final radiograph

The canals were dried with sterile paper points. The canals were filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 9).

Prognosis

The prognosis was assumed to be uncertain due to the short root filling in the mesio-buccal root.

Discussion

Teeth that require retreatment with apical periodontitis have a success rate between 48-78 % (Bergenholtz *et al.* 1979; Farzaneh *et al.* 2004; Sjögren *et al.* 1990; Sundqvist *et al.* 1998). The initial periapical status has an affect on the outcome of the endodontic treatment (Byström *et al.* 1987; Sjögren *et al* 1990; Farzaneh *et al* 2004).
Failures occur most commonly if the endodontic treatment is not performed after accepted standards. Inadequate aseptic control, missed canals, inadequate instrumentation and leaking temporary fillings are some of the encountered problems (Chugal *et al.* 2003; Sjögren *et al* 1990; Sundqvist & Figdor 1998). The radiographic level of the endodontic obturation related to the success rate is an aspect which has been investigated since many years. It was found that teeth with necrotic pulp and periapical lesions had the best prognosis if the filling reached within 1-2 mm of the radiographic apex (Sjögren *et al.* 1990; Smith *et al.* 1993; Swartz *et al.* 1983).

Crown lengthening is a periodontal resective procedure, aimed at removing supporting periodontal structures to gain sound tooth structure above the alveolar crest level. Periodontal health is of paramount importance for all teeth, both sound and restored. Clinical crown of the tooth is the distance from gingival margin to incisal edge or occlusal surface of the tooth. This distance should be increased when margins of caries lesion are subgingivally; margins of tooth crown fractures are subgingivally; or tooth crown is too short for retention of restoration.
Gingival biological width is the area of gingiva attached to the surface of the tooth coronary from the alveolar bone (Vacek *et al.* 1994). Direct or indirect restorations of tooth crown defects with margins located in the gingival biological width area induce gingival inflammation, loss of connective tissue attachment and unpredictable bone loss. Clinically it could be manifested as gingival bleeding, periodontal pocket formation or gingival retraction.
In order to avoid pathological changes or to predict treatment results more precisely, it is necessary to keep gingival biological width unaltered during teeth restoration. If there is less than 2 mm from restoration's margin to marginal bone, clinical crown lengthening possibility should be considered in dental treatment plan. The choice depends on relationship of crown-root-alveolar bone and aesthetical expectations. In order to keep margins of restoration supragingivally, the distance from marginal bone to margins of restoration should not be less than 3 mm (Planciunas *et al.* 2006). Ideally the margins of restoration should be supragingivally or at the same level as marginal gingiva. When

margins of restoration are prepared subgingivally, the distance from marginal gingiva to margins of restoration should not be more than 0.7 mm.

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Case 11. Chronic apical periodontitis, Tooth 14.

Retreatment

Fig. 1 Frontal view

Referral
A 59-year old white male (Fig. 1) was referred May 2002 to the postgraduate endodontic clinic at the University of Oslo from the student clinic for treatment of pain in the region of the maxillary right first and second premolar.

Medical history:
Non-contributory, the patient did not take any medication.
The patient was a heavy smoker.

Dental History & Chief complaint:
The patient complained of pain in the region of the maxillary right first and second premolar, but he could not discriminate the precise location of the pain. The tooth 14 was previously root filled at the student's clinic with persisting pain.

Clinical examination
Preoperative photos showed the region from maxillary right second premolar to maxillary right lateral incisor (Fig. 2 & 3)

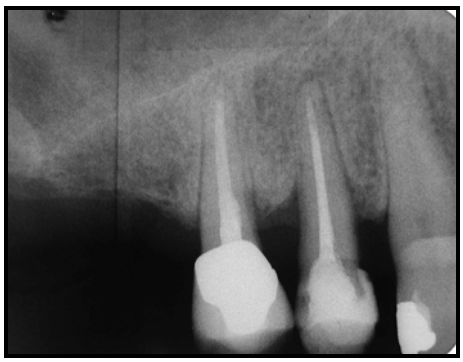
Fig. 2 Buccal view

Fig. 3 Occlusal view

Maxillary right second premolar: had a prosthetic ceramic crown and an occlusal IRM filling. The tooth was tender to percussion.
Maxillary right first premolar: had a composite onlay and an occlusal IRM filling. The tooth was tender to percussion.
Maxillary right canine: had a distal amalgam filling
Maxillary right lateral incisor: had a distal amalgam filling

No pathology was found extra-orally.
Normal mucosa was observed.
The probing depths of teeth 15, 14 and 13 were within normal limits.
No pain to palpation was found.

Radiographic examination:
Preoperative radiograph showed the region from maxillary right second premolar to maxillary right canine (Fig. 4).



Maxillary right second premolar: had a crown. A radioopaque rootfilling material could be seen. The lamina dura could be followed without disruption.

Fig. 4 Preoperative radiograph

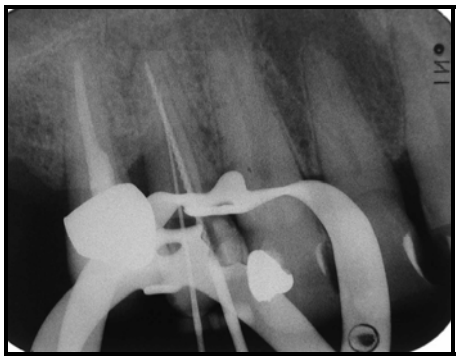
Maxillary right first premolar: A MOD composite filling was observed. A radioopaque rootfilling material could be seen and was approx. 1 mm short from the apex. The lamina dura could be followed without any widening until the apex. At the apex, the lamina dura was widened to give a lesion of 1 mm in diameter. The marginal bone loss around the maxillary right first premolar was approx. 4 mm.

Diagnosis
Root filled maxillary right first premolar with chronic apical periodontitis.

Treatment plan:
Retreatment.

Treatment:
1st appointment: 28.05.2002
The IRM filling was removed and the canal was localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The gutta-percha was removed without chloroform and a working length radiograph was taken.

Two files were inserted, buccal canal NiTi nr 25 / 20 mm and palatinal canal K-Flex 15 / 19 mm and a working length radiograph was taken (Fig. 5). The buccal canal was instrumented to nr 50 and it was thought that the two canals joined to form one canal.

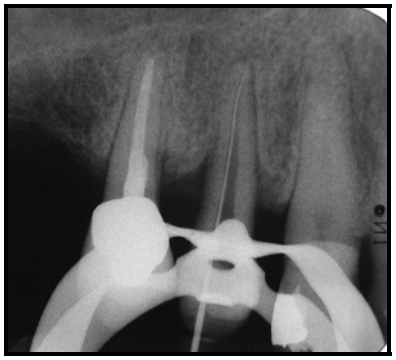


During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Fig. 5 Working length radiograph tooth 14.

2nd appointment: 11.06.2002 (2 weeks later)
Postoperatively, the patient only had one painfree day; then the pain returned.

Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The IRM was removed and the calcium hydroxide was washed out with NaOCl.
A second canal in the apical third of the root was found (Fig. 6) with help of the microscope. The working length of 21 mm was verified with a working length radiograph. This canal was instrumented up to NiTi file nr 45.



During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA, and dried with paper points. The canal was packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.

Fig. 6 Working length radiograph tooth 14

3rd appointment: 03.09.2002 (3 months later)
Postoperatively the patient was symptom free.

Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 7).

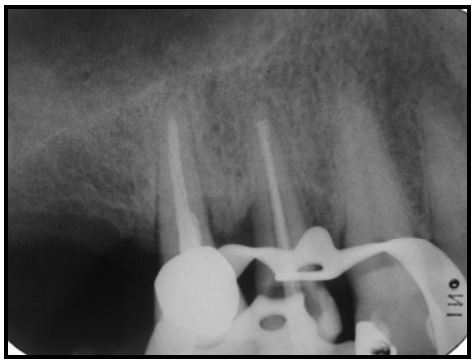


Fig. 7 Master cone radiograph

Fig. 8 Final radiograph tooth 14

The canals were dried with sterile paper points and the two canals were filled with AH plus and gutta-percha with a cold lateral condensation technique.
After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 8).

Prognosis
The prognosis of the endodontic treatment was considered to be good.

4 years follow-up: 09.11.2006

Fig. 9 Control radiograph tooth 14

Fig 9 Buccal view tooth 14

Maxillary right first premolar was asymptomatic and the patient was satisfied with the present crown restoration (Fig. 9). Radiographically, complete bone healing was observed.

Discussion:
The treatment of the maxillary right first premolar consisted of an orthograde retreatment. An extra root canal was localized and properly filled. The patient's chronic pain subsided and the tooth was restored with a crown.

It is established that a root with a tapered canal and a single foramen is the exception rather than the rule (Caliskan *et al.* 1995; Gulabivala *et al.* 2001; Kartal & Yanikoglu 1992; Sert & Bayirli 2004). Investigations have shown multiple foramina, additional canals, fins, deltas, intercanal connections, loops, C-shaped canals, and furcation and lateral canals in most teeth (Pineda & Kuttler 1972; Skidmore & Bjorndal 1971; Vertucci & Williams 1974; Vertucci 1984).
Vertucci & Williams (1974) used cleared teeth in which the root canal system had been stained with hematoxylin dye. They identified eight pulp space configurations which can be described as followed:

One canal at the apex
Type I: A single canal extends from the pulp chamber to the apex (1).
Type II: Two separate canals leave the pulp chamber and join short of the apex to form one canal (2-1).
Type III: One canal leaves the pulp chamber and divides into two in the root; the two then merge to exit as one canal (1-2-1).

Two canals at the apex
Type IV: Two separate canals extend from the pulp chamber to the apex (2).
Type V: One canal leaves the pulp chamber and divides short of the apex into two separate canals with separate apical foramina (1-2).
Type VI: Two separate canals leave the pulp chamber; merge in the body of the root, and redivide short of the apex to exit as two distinct canals (2-1-2).
Type VII: One canal leaves the pulp chamber, divides and then rejoins in the body of the root, and finally redivides into two distinct canals short of the apex (1-2-1-2)

Three canals at the apex
Type VIII: Three separate, distinct canals extend from the pulp chamber to the apex.

In the present case, the tooth had a Type V configuration – one canal leaving the pulp chamber to divide into two distinct canals short of the apex with two distinct apical foramina. This configuration is present in 1.75 % of the maxillary first premolars (Vertucci 1984). Kartal *et al.* (1998) found type V in 2.66 % of the teeth, when the division occurred in the apical third, and 6.33 % when the division occurred in the middle third of the tooth.

The association between the presence of bacteria in the root canal system and pain has been shown in previous studies (Gomes *et al.* 2004; Hashioka *et al.* 1992; Jacinto *et al.* 2003). A proper disinfection of the root canal system through mechanical and chemical procedures will therefore not only eliminate the infection but also give pain relief.

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Case 13. Cervical root resorption and chronic pulpitis, Tooth 46

Pulpectomy and repair of the resorption lesion

Fig. 1 Frontal view

A 64-year old white male (Fig. 1) was referred October 2005 to the postgraduate endodontic clinic at the University of Oslo from his General Practitioner for treatment of the mandibular right first molar.

Medical history:
Non-contributory.

Dental History & Chief complaint
The patient had no symptoms or complaints. During a routine control with radiographs, radiolucencies were observed in the cervical regions of the mandibular right and left first molars.

Clinical examination
Preoperative photos showed the region from mandibular right first premolar to mandibular right second molar (Fig. 2 & 3)

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.
No pain to percussion or to palpation can be found.

Fig. 2 Buccal view

Fig. 3 Occlusal view

Mandibular right first premolar: intact
Mandibular right second premolar: had an OD composite filling
Mandibular right first molar: had a MO and OD composite filling and was positive to Endo-Ice®. Puss from the pocket was observed.
Mandibular right second molar: had a MO composite filling.

The patient was send for CT examination (Fig. 5)

Radiographic examination:
Preoperative radiograph showed the region from maxillary right second premolar to maxillary right second molar (Fig. 4).

Fig. 4 Preoperative radiograph tooth 46

Fig. 5 Resorption opening tooth 46

Mandibular right second molar: had a MO radioopaque filling
Mandibular right first molar: had MOD radioopaque filling. The lamina dura can be followed around the roots without disruption. A radiolucency of about 6 mm in diameter was observed at the coronal part of the mesial roots extending from the crown margin to the furcation.
Mandibular right second premolar: had an OD radioopaque filling.

Diagnosis
Mandibular right first molar with pulpitis
Cervical resorption

Treatment
Pulpectomy
Closure of the resorption site

Treatment
1st appointment: 12.10.2005
One carpule of Xylocaine/adrenaline was applied to establish anaesthesia. The access cavity was prepared and 3 canals localized. Files were inserted in the canals (K-flex nr 15 / 21 mm) and a working length radiograph was taken (Fig. 6).

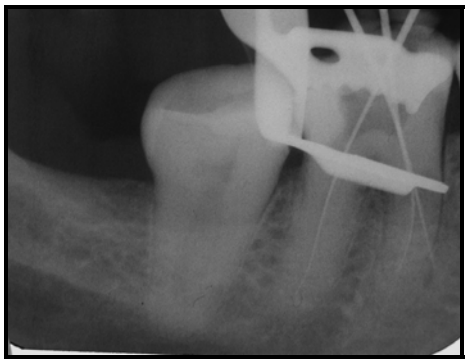
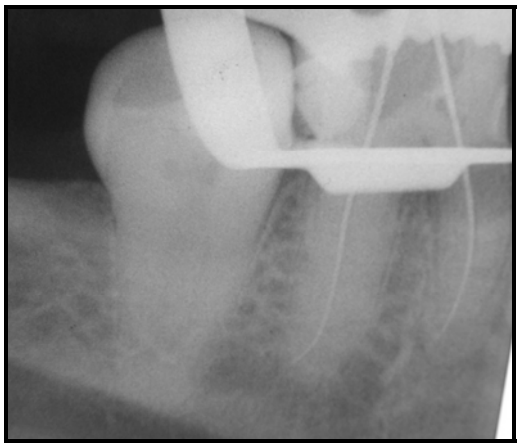


Fig. 6 Working length radiograph

Radiographically, it was observed that the file in the mesio-buccal canal did not follow the canal anatomy and instead perforated in the periodontal area. The apical part of the mesio-buccal canal could therefore not be negotiated.
Mesial canals were covered with calcium hydroxide and Cavit and the distal canal was covered with a cotton pellet soaked in eugenol. The access cavity was sealed with a temporary IRM filling.

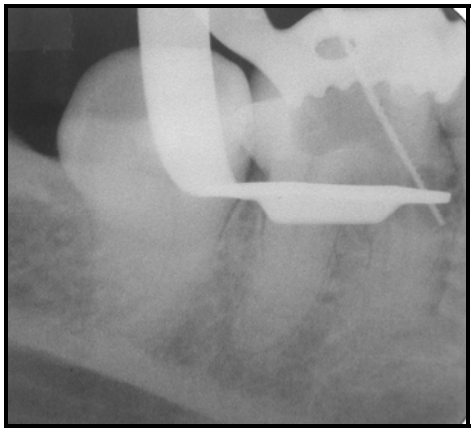
2nd appointment: 25.10.2005 (2 weeks later)
The patient was asymptomatic. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. IRM and the cotton pellet were removed and a new working length radiograph was taken (Fig. 7). The working lengths were confirmed with an apex locator (Root ®ZX).



The distal canal was instrument to a size 55 / 21.5 mm and the mesio-lingual canal to a size 45 / 20.5 mm. During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA.
The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Fig. 7 Working length radiograph tooth 46

3rd appointment: 15.11.2005 (3 weeks later)
The patient returned with a swelling buccally of tooth 46. Puss could be drained from the mesio-buccal pocket.
Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. The IRM filling was removed.



A radiograph (Fig. 8) was taken in order to confirm the length to the lesion (15.5 mm) and the access to the mesio-buccal area was increased with the help of a Gates Glidden bur. The canals were dried with paper point and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Fig. 8 Working length radiograph to the lesion.

4th appointment: 13.12.2005 (1 month later)
Persisting swelling, nevertheless, the patient was asymptomatic.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. The canals were irrigated with 1 % NaOCl and 17% EDTA. The mesio-buccal could not be dried and it was decided repack the canals calcium hydroxide. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Due to extent of the resorption and the inability to perform optimal orthograde and surgical treatment, the prognosis was assumed to be poor. The patient was informed about the poor prognosis of the tooth and he was advised to contact his GP for extraction of 46.

5th appointment: 30.05.2006 (5 months later)
The patient returned for treatment of tooth 36. However, tooth 46 was still in place and asymptomatic. Puss was drained from the mesio-buccal pocket. The patient did not want to extract, but to continue the endodontic treatment of 46.

Rubberdam was applied and disinfected with chlorhexidine-ethanol. The IRM was only removed from the mesio-lingual and distal canals, leaving the mesio-buccal canal covered during the treatment. The mesio-lingual and distal canals were irrigated with 1 % NaOCl and 17% EDTA. A master cone radiograph was taken (Fig. 9).

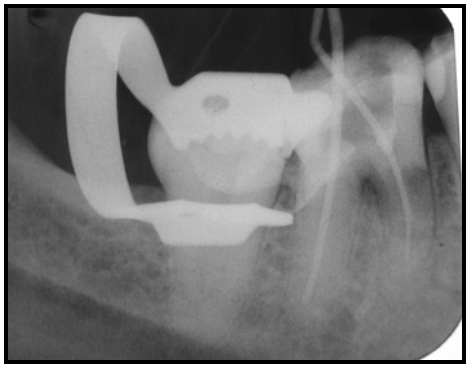


Fig. 9 Master cone radiograph tooth 46

Fig. 10 Final radiograph

The canals were dried with sterile paper points and were filled with AH plus and gutta-percha with a cold lateral condensation technique.
Excess of gutta-percha was removed and the access cavity washed with chlorhexidine.

The IRM filling over the mesio-buccal canal was removed; no calcium hydroxide remained in the lesion. The mesio-buccal canal was carefully cleaned with chlorhexidine in order to avoid bleeding. The canal could not be properly dried and the canal was filled

with IRM. The distal and mesio-lingual canals were covered with IRM and the access cavity was sealed. A final radiograph was taken (Fig. 10)

Prognosis
The prognosis of the endodontic treatment in the mesio-lingual and distal canals was assumed to be good. However, the prognosis of the tooth was poor due to the cervical resorption.

6 months follow-up: 11.2006

Fig. 12 6 months follow-up

The patient was presented with an asymptomatic tooth 46. Radiographically, the resorption had increased in size and progressed apically.

Discussion
The patient presented both mandibular first molars with cervical root resorption. The treatment of the mandibular right first molar consisted of cleaning and disinfecting the canal system. However, the apical part of the mesio-buccal could not be negotiated and properly filled. The resorption lesion could not be dried and the application of the IRM was not optimal. The follow-up radiograph showed that the resorption process had not been arrested.
In the case of the mandibular left first molar, treatment consisted of cleaning and disinfecting including calcium hydroxide application. MTA was applied in the resorption lesion.

Fig. 5 Preoperative radiograph

Fig. 6 months follow-up

However, in this case the mesio-buccal canal could be negotiated and the entire canal was filled with MTA. The 6 months follow-up radiograph showed that the resorption process had been arrested.

External resorption is a process that leads to an irreversible loss of cementum, dentin and bone. It takes place in both vital and pulpless teeth and the identification is mostly made during routine radiographic or clinical examination as the majority of cases are asymptomatic. External resorptions may be physiological or pathological. Andreasen (1985) suggested an advanced classification. Nowadays, theses categories of surface, inflammatory and replacement-ankylosis resorption are commonly used.
Cervical root resorption can have several etiologic factors and many theories have been presented. External root resorption in vital teeth can occur late after orthodontic tooth movement, orthognathic and other dentoalveolar surgery, periodontal root scaling or planing, trauma, bruxism, fracturing, developmental defects or a combination of these predisposing factors (Tronstad 1988; Heithersay 1999). It remains to be seen whether even vital bleaching in some teeth will result in cervical root resorption at a later date (Cvek & Lindvall 1985).

The aetiology of different types of root resorption requires two phases: a) mechanical or chemical injury to the protective tissues and b) stimulation by infection or pressure. Proper treatment selection is related to the stimulating factors. In cervical root resorption, infection originating from the periodontal sulcus stimulates the pathological process. As adequate infection control in the sulcus is unlikely, removal of granulation tissue from the resorption lacuna and sealing are necessary for repair.
New information indicates that this type of resorption also can go on without stimulation from an infection.

In the case of cervical root resorption, bacteria from the periodontal sulcus may penetrate patent dentinal tubules, coronal to the epithelial attachment, and exit apical to the epithelial attachment without penetrating the pulpal space (Tronstad 1988b). Consequently, the damaged area of the root surface is colonized by hard tissue resorbing cells which penetrate into dentin through a small denuded area, causing the resorption inside the root to spread. At first stage, the resorptive process does not penetrate the pulp

space because of the protective layer of predentin, but rather spreads around the root canal in an irregular fashion (Wedenberg 1987). With time, the process may penetrate into the root canal. Additionally, periodontal infection resorption will include the alveolar bone adjacent to the resorption lacuna of the tooth. If the resorptive process reaches a supragingival area of the crown, the vascularized granulation tissue of the resorption lacuna may be visible through the enamel showing a pink discoloration at the crown. Radiographically, periodontal infection resorption can be seen as a single resorption lacuna in the dentin usually at the crestal bone level, expanding to the coronal and apical direction.
Calcium hydroxide is the treatment of choice. Its strong antibacterial effect and low solubility create a long-term effect in the root canal, and remove the stimulating factor. Calcium hydroxide also increases the pH in the dentin (8.0–10.0), and thereby inhibits the activity of osteoclastic acid hydrolases in the periodontal tissues and activates alkaline phosphatises (Tronstad *et al.* 1980). As it is not possible to reach a long-term disinfection of the periodontal sulcus, the most effective therapy is to expose the resorption lacuna orthodontically or surgically and to remove the granulation tissue. Surgical treatment of invasive cervical resorption generally consists of periodontal flap reflection, curettage, restoration of the defect with composite resin (Cvek M 1981; Goodman & Wolffe 1980) and glass-ionomer cement (Cvek M 1981; Heithersay 1985). Endodontic treatment is necessary only when there is perforation to the root canal. When perforation is strongly suspected or ascertained, root canal treatment may be performed prior to the surgical exposure of the resorption lacuna. If the resorption lacuna presents minimal entrance opening, it can be cleaned out and obturated from the root canal instead of adopting a surgical approach (Frank 1981). Follow-up examinations are especially important to determine that the resorptive process has been arrested.

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Case 14. Cervical root resorption and chronic pulpitis, Tooth 36

Pulpectomy and hemisection.

Fig. 1 Frontal view

Referral
A 47-year old white male was referred March 2007 to the post-graduate clinic at the University of Oslo from the student clinic for treatment of mandibular left first molar.

Medical history:
Non contributory.

Dental History & Chief complaint
The patient was under treatment for caries at the student clinic. During a routine radiographic investigation, a radiolucent lesion was observed at the cervical area of tooth 36. The patient was asymptomatic.

Clinical examination
Preoperative photos showed the region from mandibular left first molar to mandibular left lateral incisor (Fig. 3 & 4)

No pathology was found extra-orally.
Normal oral mucosa was observed.

No pain to percussion or to palpation was found.

Fig. 3 Buccal view tooth 36

Fig. 4 Lingual view tooth 36

Mandibular left first molar: had a crown and was positive to Endo-Ice®. Mesio-lingual of the tooth a pocket of 9 mm could be probed.
Mandibular left second premolar: had a MOD amalgam filling and was positive to Endo-Ice®.
Mandibular left first premolar: had an OD and buccal amalgam filling. The tooth was positive to Endo-Ice®.

Radiographic examination
Preoperative radiograph showed the region from mandibular left first molar to mandibular left first premolar (Fig. 5)

Fig. 5 Preoperative radiograph

Mandibular left first molar: had a crown and the lamina dura was followed without disruption. A radiolucency of approx. 4 mm in diameter was observed at the coronal part of the mesial roots, extending from the crown margin to the furcation area.

Mandibular left second premolar: had a MOD amalgam filling. The lamina was followed without disruption.
Mandibular left first premolar: had an OD and buccal amalgam filling. The lamina dura was followed without disruption.

Diagnosis
Mandibular left molar with pulpitis
Cervical root resorption

Treatment
Root filling of the distal canal
Hemi section and removal of the mesial roots

Treatment
1st appointment: 08.03.2007

One carpule Xylocaine/adrenaline was used to establish anaesthesia. The crown was separated into two pieces exposing a bleeding (Fig. 6 & 7).

Fig. 6 Occlusal view

Fig. 7 Removal of the crown

After the removal of the crown, the lesion was localized (Fig. 8). Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. After cleaning the tooth, a round lesion could be observed on the disto-buccal side. However; it seemed not be a resorption lesion. The bleeding in the resorption could be stopped with the application of $Ca(OH)_2$ and was sealed with IRM.

Fig. 8 Resorption lesion tooth 36

Fig. 9 Resorption lesion tooth 36

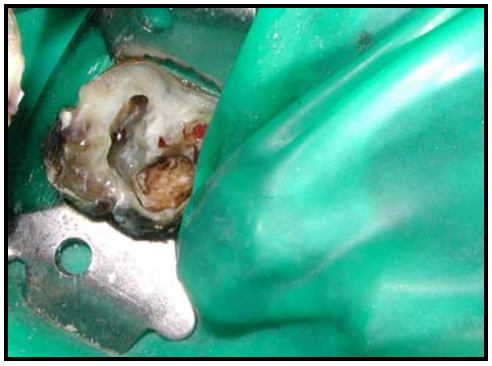


Fig. 10 Access cavity tooth 36

The access cavity was prepared and two distal canals were localized (Fig. 10). A K-flex file nr 15 / 17 mm was inserted in the disto-buccal canal, a H-file nr 15 / 17 mm was inserted into the disto-lingual canal and a working length radiograph was taken (Fig.11).

Fig. 11 Working length radiograph

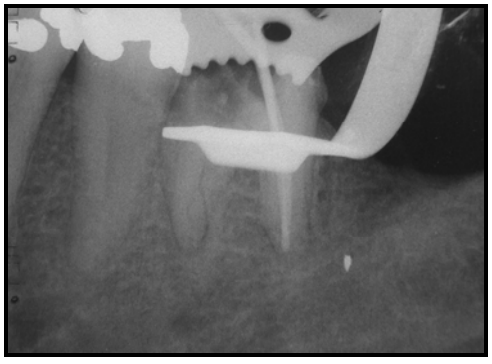
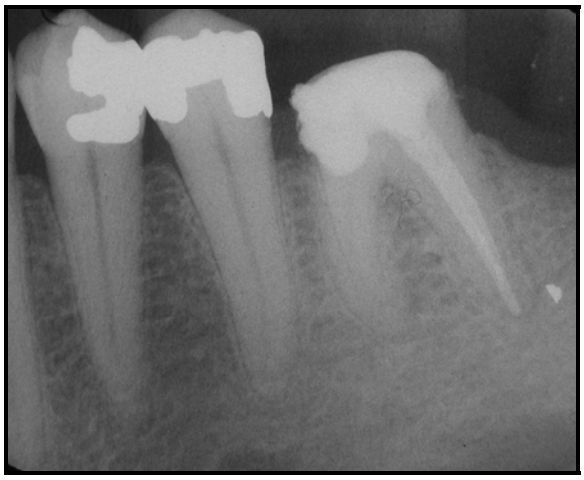


Fig. 12 Master cone radiograph



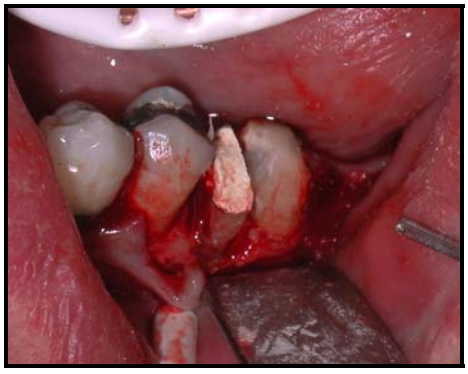
The canals were instrumented to a size 55 / 16 mm after confirmation with an apex locator (Root ZX®). During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA. After instrumentation, a master cone radiograph was taken (Fig. 12). The canals were dried with sterile paper points and were filled with AH plus and gutta-percha with a cold lateral condensation technique.

Fig. 13 Final radiograph tooth 36

After removing excess of gutta-percha, the distal canal openings were sealed with IRM. The remaining access cavity was sealed with glass-ionomer cement and a final radiograph was taken (Fig. 13).

2nd appointment: 20.03.2007

Three carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the mesial aspect from the mandibular right first premolar extending posterior to the mandibular right first molar (Fig. 13).



The flap was carefully reflected and the tooth was split into two pieces (Fig. 14). An osteotomy was performed around the mesial roots followed by an atraumatic extraction.
The site was then carefully irrigated with sterile saline, the flap was repositioned and 3 sutures were placed.

Fig. 14 Reflected gingiva

3rd appointment: 28.03.2007 (1 week later)
The healing was satisfactory (Fig. 14) and the sutures were removed. The patient was asymptomatic. The patient was referred further to the student clinic for a bridge 35-36.

Fig. 14 One week follow-up

Prognosis
The prognosis of the endodontic treatment was considered to be good.

Discussion
The patient had been presented with cervical root resorption of the mandibular right first molar. The radiolucent lesion extended from the mesial canals into the furcation area. It was decided to extract the mesial roots because of the uncertain prognosis of the tooth (fracture risk in the furcation).

Cervical external resorption, frequently called invasive cervical resorption (Heithersay 1999) or peripheral inflammatory root resorption (Gold & Hasselgren 1992), presents a special type of pathological tooth condition that could be classified in the group of inflammatory resorptions. In recent years, several etiologic factors have been advocated and some morphological descriptions were made. Nevertheless, prediction and prevention are still impossible and an exact diagnosis and treatment is often far from easy, depending on the severity and localization of the defect.
Clinically, cervical external resorption is associated with inflammation of the periodontal tissues and does not have any pulpal involvement (Frank & Torabinejad 1998). The pulp remains protected by a thin layer of predentin until late in the process and it has been postulated that bacteria in the sulcus sustain the inflammatory response in the periodontium (Tronstad 1988; Heithersay 1999). Cervical external resorption occurs immediately below the epithelial attachment of the tooth. As a result, it must be noticed that the location is not always cervical but related to the level of the marginal tissues and pocket depth. Unless proper treatment is initiated, this type of resorption continues and a large irreversible loss of tooth structure may appear over time.

As mentioned previously, the pulp plays no role in cervical external resorption and is mostly normal in these situations. In particular, teeth with cementum deficiencies related to previous trauma (Cvek & Lindvall 1985) or a cemento-enamel disjunction (10%) due to histological variation (Schroeder & Scherle 1988) seemed to be at high risk.

As with most external resorptions, the cervical root resorptions are usually painless and go unnoticed by the patient unless pulpal or periodontal infection supervenes. In addition, a deep resorptive cavity can result in sensitivity to changes in temperature because of proximity to the pulp. In most cases, cervical resorptions are detected during routine radiographic or clinical examination. If the lesion is located marginally, there may be no external signs, or a pink coronal discoloration of the tooth crown may be noticed. If the lesion is more apically or proximally situated, it may be detectable by deep probing. When the local 'pocket' is probed, copious bleeding and a spongy feeling are commonly observed as the granulation tissue of the resorptive defect is disturbed.

It has to be emphasized that electric and thermal pulp tests remain positive throughout the continuation of the pathological process. The resorption starts on the root surface, but when the predentin is reached, the resorption proceeds laterally and in an apical and coronal direction, progressively enveloping the root canal. This coronal extension process results ultimately in cavitation of the overlying enamel (Tronstad 1988). Furthermore, a series of channels containing resorptive tissue are present, and they usually have connections further apically with the periodontal ligament (Heithersay 1999). In severe external resorptions, only a thin layer of dentin remains protecting the pulp (Makkes & Thoden 1975). This could be explained by the fact that predentin possesses a resistance to resorption, as was demonstrated by Stenvik & Mjor (1970). It has been suggested that the organic phase of the predentin contains an enzyme inhibitor against resorption (Wedenberg & Lindskog 1985).

The hemisection is used to preserve multirooted teeth and as an alternative to extraction and single tooth implant. The compiled results of studies in hemisection revealed an average reported failure rate of 13.1 % (Buhler 1994). In comparison, the success rate of single tooth implants lies around 94 % (Levin *et al.* 2006). Thus, because hemisection is a relative simple and inexpensive treatment with a good success rate, it should always be considered as an option before molar extraction.

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Case 15. Chronic apical periodontitis with abscess, Tooth 24.

Apicectomy with retrograde filling.

Fig. 1 Frontal view

Referral
A 52-year old white female (Fig. 1) was referred November 2006 to the postgraduate endodontic clinic at the University of Oslo from her General Practitioner for treatment of maxillary left first premolar.

Medical history:
Non-contributory.

Dental History & Chief complaint
The patient had an abscess and was treated with antibiotics prescribed from her General Practitioner. The symptoms subsided after the antibiotic treatment. However, a swelling buccally of tooth 24 remained.

Clinical examination
Preoperative photo showed the region from maxillary left lateral incisor to maxillary left first molar (Fig. 2)

A swelling could be observed between maxillary first and second premolar.
The probing depths were within normal limits.

Fig. 2 Buccal view tooth 24

Maxillary left lateral incisor: had a discoloration
Maxillary left canine: The tooth was intact and positive to EndoIce®.
Maxillary left first premolar: had a crown.
Maxillary left second premolar: had a MOD amalgam filling and the tooth was positive to EndoIce®.

	23	**24**	**25**
EndoIce®	+	-	+
Percussion	-	+	-
Palpation	-	+	-

Radiographic examination:
Preoperative radiograph showed the region from maxillary left first premolar to maxillary left first molar (Fig. 3).

The height of the marginal bone was within normal limits.

Fig. 3 Preoperative radiograph tooth 24

Maxillary left first premolar: had a crown. Radiographically root filling material could be seen in the palatinal and buccal canals. A post was also observed in the palatinal canal. The lamina dura could be followed around the buccal root until it widened at the apex into a radiolucent lesion of approx. 4 mm. The lamina dura of the palatinal root could be followed around the root without disruption.
Maxillary left second premolar: had a MOD amalgam filling. The lamina dura could be followed around the root without disruption.
Maxillary left first molar: had a MOD amalgam filling. The lamina dura could be followed around the root without disruption.

Diagnosis:
Maxillary left first premolar with chronic apical periodontitis with abscess.

List of problems
Previously root filed tooth.
Core and post, crown.

Treatment:
Apicectomy.

Treatment
1st appointment: 13.12.2006
3 carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the mesial aspect of the maxillary left canine extending posterior to the maxillary left first molar (Fig. 4). A vertical releasing incision was made starting from the mesiobuccal line angle of the maxillary left canine.

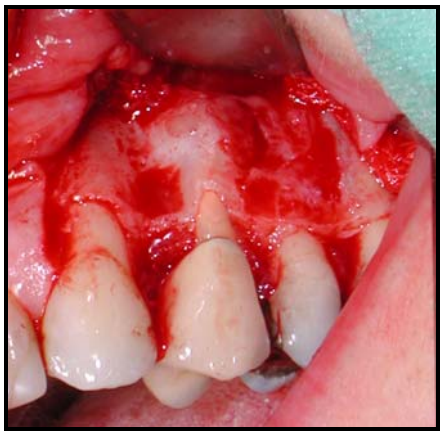

Fig. 4 Reflected gingiva

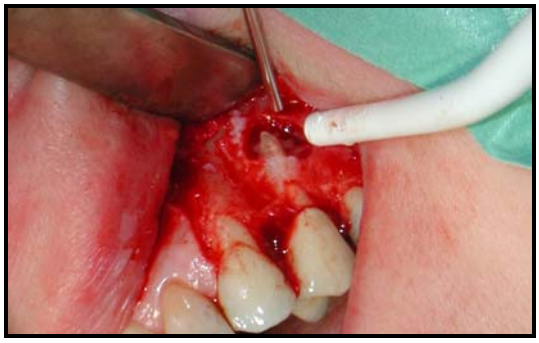

Fig. 5 Buccal root tooth 24

The flap was carefully reflected and osteotomy with a round bur was accomplished 10 mm from the crown margin to expose the root tip (Fig. 5). Granulation tissue was removed and the root tips of both roots were cut using a high speed hard metal bur.

The retrograde preparation on both roots was carried out with the piezoelectric Satalec ultrasound device using the tip CT under constant cooling with sterile saline.
MTA was placed as a retrograde filling using a plastic instrument as a carrier and was condensed with a microplugger.

The site was then carefully irrigated with sterile saline. The flap was repositioned and 5 sutures were placed (Fig. 6)

Fig. 6 Buccal view

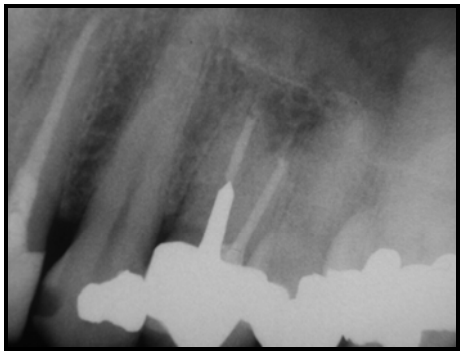

Fig. 7 Control radiograph tooth 24

A control radiograph was taken which shows that the MTA filling in both canals was tight (Fig. 7).

One week follow-up: 21.12.2006

The patient was asymptomatic and the sutures were removed.
The healing of the muco-gingival tissue was satisfactory (Fig. 8 & 9).

Fig. 8 One week after the surgery

Fig. 9 After removal of the sutures

Prognosis
The prognosis was assumed to be good.

4 months follow-up: 25.04.2007
The patient had no complains or symptoms. However, buccally of tooth 24 a fistula could be observed (Fig. 10) and a Fistulograph was taken (Fig. 11).

Fig. 10 Buccal view tooth 24

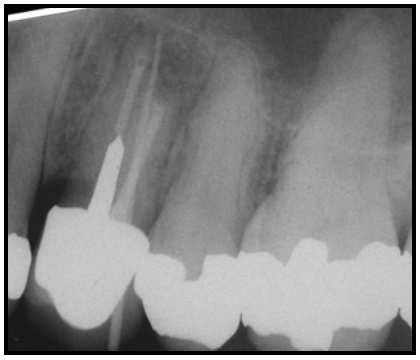

Fig. 11 Fistulograph tooth 24

Discussion
The patient was presented with an acute apical periodontitis on a previously root-filled tooth, restored with a post and core and a crown. Even though radiographically the root filling seemed to be of satisfactory quality, the roots were associated with apical periodontitis. In order to perform orthograde retreatment, it would have been necessary to remove the crown and the post. However, this type of treatment is associated with a

certain risk for root fracture. The functional and aesthetic quality of the crown was satisfactory and the decision was therefore made to perform apical surgery, leaving the restoration in place. Four months postoperatively, the patient was presented with a fistula, indicating the possibility of a root fracture. Further treatment is pending.

The goal of endodontic surgery with retrograde filling is the removal of infected tissue and tight sealing of the root canal system by forming a barrier between the irritants within the confines of the affected root and the tissues surrounding the root. This hermetic seal is usually accomplished by root-end cavity preparation with subsequent root-end obturation. Before the introduction of microsurgical techniques, success rates ranging from 44 to 90% with a weighted average of 59% were reported for periapical surgery (Hepworth & Friedman 1997). Recent studies incorporating microsurgical principles in periapical surgery have described improved success rates ranging from 80 to 95% (Chong *et al.* 2003; Maddalone & Gagliani 2003; Rubinstein & Kim 2002; Rud *et al.* 1991; von Arx & Kurt 1999; Zuolo *et al.* 2000). These increased success rates are credited to a number of factors that have all contributed to the improved outcome of periradicular surgery such as microinstruments, magnification and intraoperative inspection and root-end filling materials.

Root-end cavities have traditionally been prepared by means of small round burs or inverted cone burs in a microhandpiece. Since the early 1990s, sonic or ultrasonic microtips have been propagated for retrograde cavity preparation (Carr 1997; von Arx & Kurt 1999). This technique has simplified the preparation of a more centred and sufficiently deep retrocavity. A recent study by Tsesis *et al.* (2006) comparing the traditional technique (retrograde cavity prepared with bur) versus the microsurgical technique (using ultrasonic retrotips and a dental operating microscope) reported a significantly higher healing rate in teeth that were treated with the microsurgical technique.

In a study by von Arx *et al.* (2007) preoperative, surgical, and postoperative variables as possible predictors for the 1-year healing outcome in periapical surgery were evaluated. Only one parameter, pain at initial examination, reached the usual 0.05 level of significance in the logistic regression analysis, meaning that patients presenting with pain at the initial examination before surgery had a significantly lower rate of healing at the 1-year follow-up compared with patients having no pain at the initial examination. Similarly, Lustmann *et al.* (1991) reported only 38% success in teeth with preoperative signs or symptoms, compared with 67% success in teeth without signs or symptoms. However, because of the low number of teeth in the latter group, they reported no statistical difference. It is not fully understood why preoperative clinical signs and symptoms, such as pain, swelling, sinus tract, or abscess, had negatively affected the healing outcome after periapical surgery. It can be speculated that preoperative clinical signs and symptoms reflect an acute or subacute stage of infection associated with specific bacteria, and subsequently with a reduced healing potential. Host-parasite relations, microbial interactions, and the composition of the flora initially present in the periapical area might compromise the healing after periapical surgery.

A number of studies have assessed the healing rate in relation to the preoperative size of the periapical lesion (Lustmann *et al* 1991; Jensen *et al.* 2002); however, only one study (Wang *et al.* 2004) reported a significantly higher healing rate for lesions ≤5 mm

compared with lesions >5 mm (86% versus 65%, p = 0.02). In another study (Rahbaran *et al.* 2001), teeth with no lesions had a healing rate of 43% compared with 24% in teeth with a lesion (p = 0.029).

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Case 16. Acute apical periodontitis and root fracture, Tooth 21

Treatment of a nonvital tooth and surgical removal of the apical root fragment.

Fig. 1 Frontal view

Referral
A 24-year old white female (Fig. 1) was referred October 2006 to a private clinic limited to endodontics from her General Practitioner for treatment of maxillary left central incisor.

Medical history:
Non-contributory, the patient does not take any medication.

Dental history & Chief complaint
The patient could not recall the exact time of the trauma. The patient was initially asymptomatic, but developed recently pain and intermittent gingival swelling from the left central incisor.

Clinical examination
Preoperative photo showed the region from maxillary right central incisor to left central incisor (Fig. 2)

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Maxillary left central incisor was tender to percussion and palpation. The tooth was negative to Endo-Ice®.
Maxillary right central incisor: The tooth was intact.

All neighbouring teeth were positive to Endo-Ice®.
No discoloration of any tooth was observed

Fig. 2 Close-up tooth 21

Radiographic examination
Preoperative radiograph showed the region from maxillary right central incisor to maxillary right central incisor (Fig. 3).

Fig. 3 Preoperative radiograph tooth 21.

Maxillary right central incisor: The tooth had mesial radioopaque filling. The lamina dura could be followed around the entire root without disruption.
Maxillary left central incisor: The tooth had a mesial and a distal radioopaque filling. At the apical 1/3 of the root a fracture line was observed. The lamina dura could be followed around the coronal part of the root without disruption; at the fracture line, a periapical radiolucency was observed.

Maxillary left lateral incisor: The tooth had mesial radioopaque filling. The lamina dura could be followed around the entire root without disruption.

Diagnosis:
Maxillary left central incisor with chronic apical periodontitis.
Root fracture

Treatment:
Treatment of a nonvital tooth.
Surgical removal of the apical root fragment.

Treatment
1st appointment: 12.10.2006
Access cavity was prepared and one canal could be localized. Rubber dam was applied and disinfected with chlorhexidine-ethanol solution.
A NiTi file nr. 40 was inserted to the fracture area and a working length radiograph taken (Fig. 4). The working length was confirmed with an apex locator (Root ZX□).

The canal was instrumented to size 60. During instrumentation the canal was irrigated with 1% NaOCl and 17% EDTA. The canal was dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and sealed with IRM.

Fig. 4 Working length radiograph tooth 21

2nd appointment: 2.11.2006 (3 weeks later)
The patient was symptom free.
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, the canal was filled with MTA. A humid cotton pellet was place above the MTA and the cavity was sealed with IRM (Fig. 5).

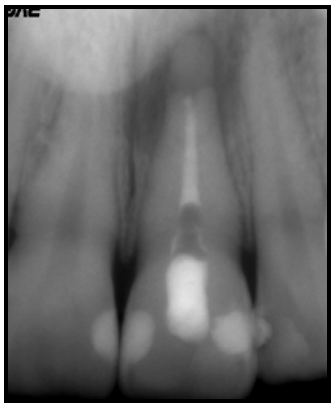

Fig. 5 Application of MTA

3rd appointment: 16.11.2006
Rubberdam was applied; disinfected with chlorhexidine-ethanol and the IRM was removed and replaced with an occlusal composite filling (Fig. 6).

Fig. 6 Final radiograph tooth 21

Three carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the distal aspect from the maxillary right central incisor extending to maxillary left lateral incisor (Fig. 4). Two vertical releasing incisions were made.
The flap was carefully reflected and an osteotomy was accomplished using a round bur 10 mm from the crown margin to expose the root tip (Fig. 7).

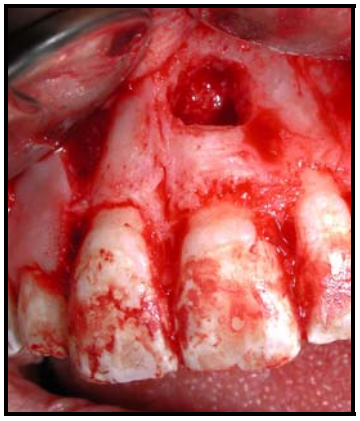

Fig. 7 Reflected gingiva

Fig. 8 Removed root tip

The fractured root tip could be removed (Fig. 8), and a control radiograph was taken (Fig. 9). The flap was repositioned and retained with six sutures (Fig. 10).

Fig. 9 Control radiograph

Fig. 10 Buccal view

4th appointment: 23.11.2006
Postoperatively the patient was asymptomatic. Healing of the mucogingival flap was satisfactory (Fig. 11).

Fig. 11 One week postoperative

5 months control: 19.04.2007
The patient was asymptomatic. Clinical examination revealed no pathology and the radiograph showed almost complete bone regeneration (Fig. 12).

Fig. 12 5 months follow-up tooth 21

Discussion
The patient was presented with an apical root fracture. The coronal part was treated with an orthograde root filling, while the apical part was removed surgically. Due to the fracture, the vascularisation of the coronal part of the root was probably interrupted and subsequently infected. The infection in the main canal was eliminated by cleaning and disinfection. The symptoms subsided after the treatment.
The removal of the apical part can be discussed, as it is assumed that this part of the root usually remains uninfected. The removed part of the root showed rounded edges which may indicate the presence of a chronic inflammatory process (Fig. 8).

A radicular fracture involves cementum, dentin and pulp and can be located in either the radicular apparatus only (root fracture) or the coronal portion of the tooth (coronal–root fracture) (Bender & Freedland 1983; Andreasen & Andreasen 1990).
The prevalence of this sort of fracture ranges between 2% and 7%, depending on whether primary or permanent teeth are involved *(*Andreasen & Andreasen 1990; Forsberg &

Tedestam 1993). The central incisors are most commonly involved, making up 80% of cases (Andreasen & Andreasen 1990; Forsberg & Tedestam 1993). The most affected age range is 3–4 years for primary tooth involvement and 11–20 years for permanent teeth involvement (Cavalleri & Zerman 1995*).* Thus root fractures are rare in incompletely formed permanent teeth. Associated injuries (bone, dental, oral and peri-oral soft tissues) often complicate the clinical presentation of these traumas, making diagnosis and treatment a significant challenge (Wadhwani 2000; Kahabuka *et al.* 1998; Robertson 1998; Kaba & Marechaux 1989). It can be misdiagnosed clinically as a subluxation or luxation injury and radiographically misread if eccentric radiographs are not taken.

In a study by Andreasen *et al.* (2004) the effect of various treatment procedures on 400 root-fractured teeth was analyzed. Treatment delay, i.e. treatment later than 24 h after injury, did not change the root fracture healing pattern, healing with hard tissue between fragments, interposition of bone and/or periodontal ligament (PDL) or pulp necrosis. When initial displacement did not exceed 1 mm, optimal repositioning appeared to significantly enhance both the likelihood of pulpal healing and hard tissue repair. Significant differences in healing were found among the different splinting techniques (Andreasen *et al* 2004).
Root fracture healing is by its nature a complicated event, being very dependent upon pulpal and periodontal healing processes and bacteria entering the coronal part of the pulp, which subsequently will arrest healing processes in the fracture area. Under optimal conditions (no displacement of the coronal fragment), healing processes will take place by differentiated odontoblasts and cementoblasts whereby hard tissue union between the fragments will happen (Andreasen & Hjorting-Hansen 1967). With limited dislocation between fragments, competition between pulpal and PDL healing takes place; and preference will be given to PDL healing, whereby cementum will be formed on each fragment and an extension of the lateral PDL will enter the fracture line (Andreasen & Hjorting-Hansen 1967; Andreasen *et al.* 1989).
In a study by Cvek *et al.* (2001), 48 teeth (23%) of the analyzed 208 teeth presented pulp necrosis and inflammatory changes between fragments. Similar findings were found in a study by Caliskan & Pehlivan (1996). They evaluated 56 root-fractured permanent incisors clinically and radiographically for 2 to 31 years and 21 (37.5 %) teeth presented pulp necrosis. Poor outcomes are more likely when excessive space is present between the fractured roots, on fully formed teeth or after delayed splinting (Robertson 1998; Kaba & Marechaux 1989).

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Case 17. Chronic apical periodontitis, Tooth 13

Retreatment and apicectomy

Fig. 1 Frontal view.

Referral
A 63-year old asian man (Fig. 1) was referred January 2003 to the postgraduate endodontic clinic at the University of Oslo from the student clinic for treatment of maxillary right canine.

Medical history:
Non-contributory, the patient does not take any medication.

Dental History & Chief Complaint

The patient consulted the student clinic for treatment of tooth 31 and tooth 35. He complained of pain in the region of the maxillary right canine and was referred to the postgraduate clinic for treatment.

Clinical examination
Preoperative photos showed the region from maxillary right first premolar to maxillary right central incisor (Fig. 2 & 3).

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig 2 Buccal view tooth 13

Fig. 3 Occlusal view tooth 13

Maxillary right first premolar: had a crown
Maxillary right canine: had a crown and was tender to percussion.
Maxillary right central incisor: had a mesial composite filling

Radiographic examination
Preoperative radiograph showed the region from maxillary right first premolar to maxillary right canine (Fig. 4).

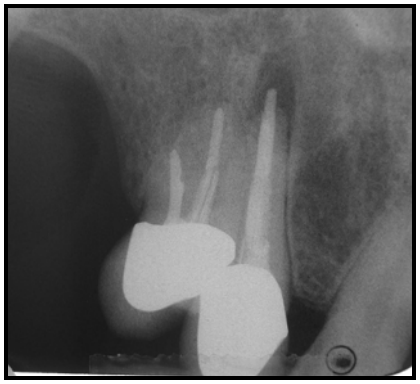


Fig 4. Preoperative radiograph tooth 13

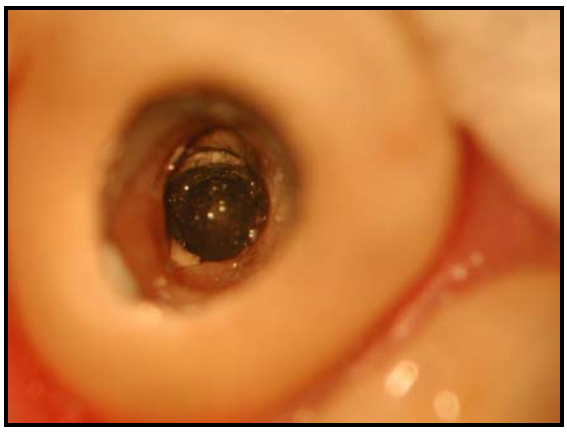
Maxillary right first premolar: had a crown. A radioopaque rootfilling material was observed in 2 canals. The lamina dura can be followed without disruption.
Maxillary right canine: had a MOD composite filling. A radioopaque rootfilling material was observed in the root. The lamina dura could be followed undisrupted around the root until the apex region where a radiolucent lesion of approx. 8 mm in diameter was observed. Approx. 2 mm excess of gutta-percha was exceeding into the lesion.

The marginal bone was within normal limits.

Diagnosis
Root filled maxillary right canine with chronic apical periodontitis.

Treatment plan:
Retreatment with subsequent apicectomy.

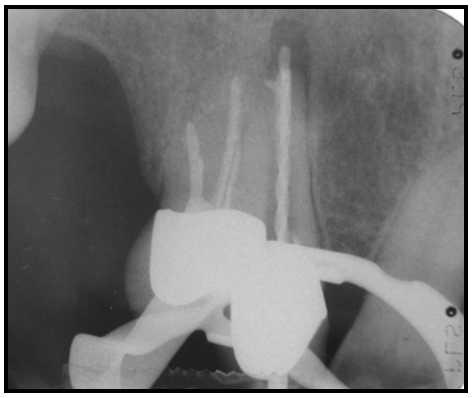
Orthograde retreatment:
1st appointment: 29.01.2003



Access cavity was prepared and a carbon post was localized (Fig. 5). The cavity was sealed with IRM.

Fig. 5 Occlusal view tooth 13

2nd appointment: 19.02.2003
The IRM filling and carbon post using a round bur was removed. The gutta-percha was removed without chloroform. An attempt was made to remove the gutta-percha cone in one piece, this was not possible and the 2 mm excess of gutta-percha in the periapical lesion remained. A working length radiograph was taken with a NiTi file nr 60 / 23 mm (Fig. 6).



The canal was instrumented to size 90. During instrumentation the canals were irrigated with 1% NaOCl and a final rinse was done with 17% EDTA. The canals were dried with paper points and packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.

Fig. 6 Working length radiograph tooth 13

3rd appointment: 20.05.2003 (3 months later)

The tooth 13 was still tender to percussion and it was decided to fill the canal and perform an apicetomy.

Rubberdam was applied, disinfected with chlorhexidine-ethanol and IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 7).

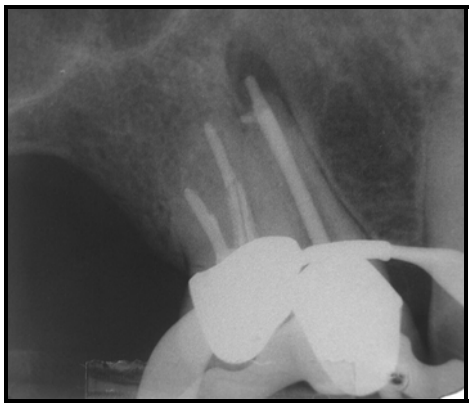


Fig. 7 Master cone radiograph

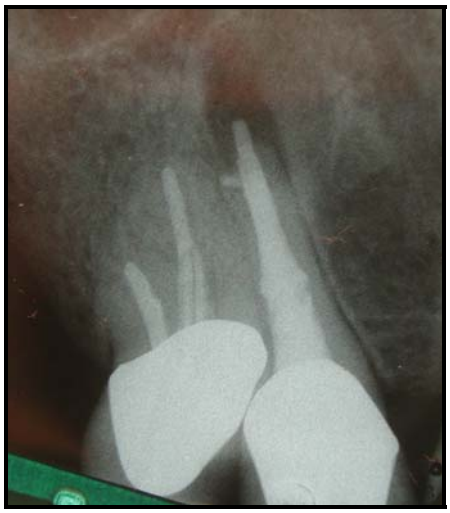


Fig. 8 Final radiograph tooth 13

The canal was dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 8).

Surgical treatment
4th appointment: 24.09.2003
4 carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the distal aspect from the maxillary right first molar area extending anterioraly to the mesiobuccal line angle of the maxillary right central incisor. A vertical releasing incision was made starting from the mesiobuccal line angle of the maxillary right incisor.

The flap was carefully reflected and osteotomy with a round bur was accomplished 12 mm from the crown margin to expose the root tip (Fig, 10). A pathological tissue was removed and sent for histological examination in a formaldehyde carrier (Fig. 11).

Fig. 10 Reflected gingiva

Fig. 11 Removed lesion

The retrograde preparation was carried out with the piezoelectric Satalec ultrasound device using the tip CT under constant cooling with sterile saline (Fig. 12).

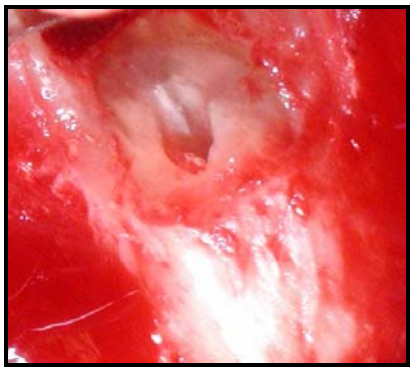


Fig. 12 Retrograde preparation

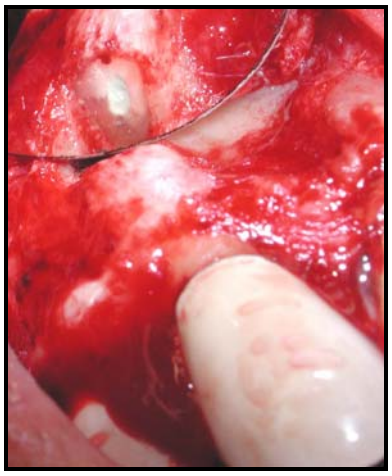


Fig. 13 MTA retrograde filling

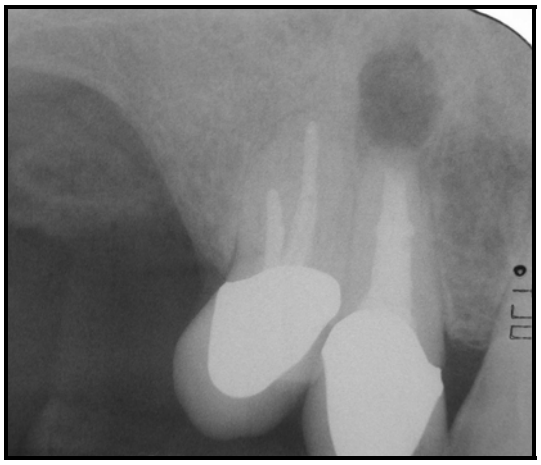


Fig. 14 Control radiograph tooth 13

White MTA was placed as a retrograde filling using a plastic instrument as a carrier and was condensed with a microplugger (Fig. 13).

A control radiograph was taken which showed that the exceeding gutta-percha point was removed and that the MTA filling was tight (Fig. 14).

The site was carefully irrigated with sterile saline. The flap was repositioned and 6 sutures were placed (Fig. 15 & 16). The patient was prescribed antibiotics (Apocillin 660 mg x 4 for 6 days) and Corsodyl®.

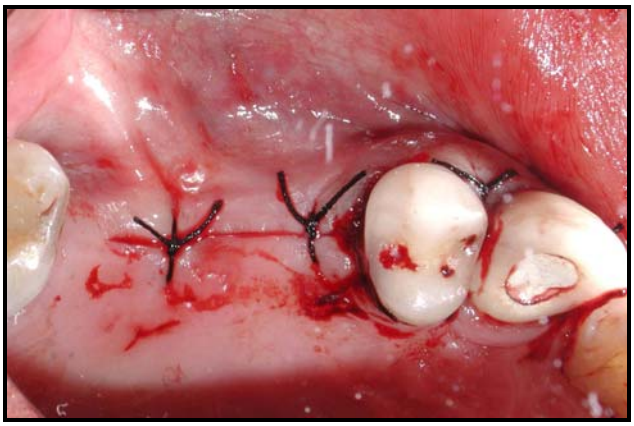


Fig. 15 Buccal view

Fig. 16 Occlusal view

5th appointment: 2.10.2003 (one week later)
The patient was asymptomatic.
The healing of the muco-gingival tissue was not satisfactory. The patient presented a swelling of the muco-gingival mucosa (Fig. 17).

Fig. 17 Buccal view

Pathological examination

The pathological examination revealed AH plus, cellulose fibers and calcium phosphate.

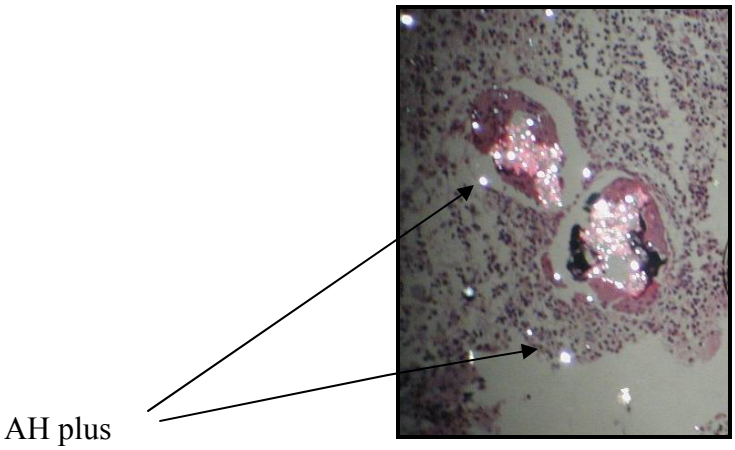


Fig. 18 AH plus

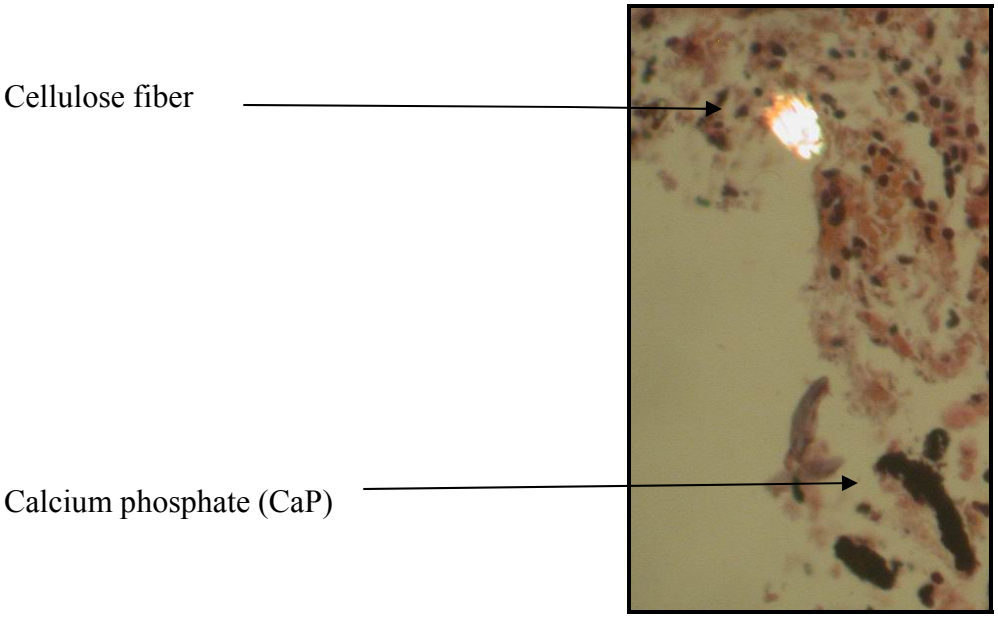


Fig. 19 Cellulose fibers and CaP

Prognosis

The prognosis of the tooth was assumed to be good.

One-year follow-up: 21.09.2004
Patient was asymptomatic.

Fig. 20 1 year follow-up

2 years follow-up: 31.10.2005
Patient was asymptomatic.

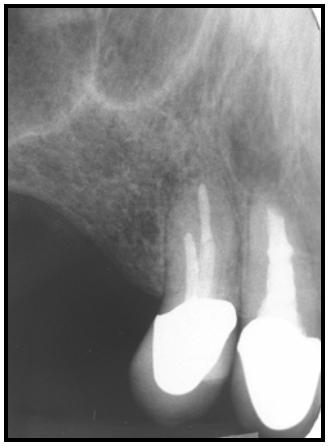


Fig. 21 2 years follow-up

3-years follow-up: 7.11.2006
The patient was asymptomatic and complete bone healing was observed radiographically (Fig. 24).

Fig. 22 Buccal view

Fig. 23 Occlusal view

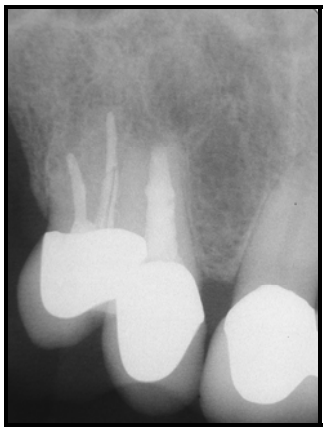


Fig. 24 Control radiograph tooth 13

Discussion

In the present case, the tooth 13 had been previously root filled and presented apical periodontitis. In addition, approx. 2 mm excess of gutta-percha was exceeding into the lesion. It was assumed that during retreatment it will not be possible to remove the excess gutta-percha and apical surgery was included in the treatment plan.
The histological analysis showed the presence of AH plus, cellulose fibers and CaP in the periapical lesion. Successful surgical removal of the extruded gutta-percha with surrounding granulation tissue incited proper healing and resolution of the symptoms.

The aim of endodontic treatment is to encourage the healing of apical periodontitis, or to prevent it from occurring if it was not present prior to treatment. Apical periodontitis is a general term used to describe an inflammatory response to irritation caused by the contents of a root canal system and it has several distinct forms. The most common is a granuloma but this can develop into other disease entities such as an abscess, a periapical pocket cyst or a true cyst, all of which are presented as radiolucencies. However, periapical radiolucencies may also be caused by extra-radicular infections, foreign body reactions and periapical scars, or they may be due to other tumours and cysts that have not originated from pulp disease.
Teeth that require retreatment with apical periodontitis have a success rate between 48-78 % (Bergenholtz *et al.* 1979; Farzaneh *et al.* 2004; Sjögren *et al.* 1990; Sundqvist *et al.* 1998). The outcome of endodontic treatment is dependent on a number of factors. One factor is the technical quality of the root filling, for which there is a strong association with the outcome of endodontic treatment in adults (Petersson *et al.* 1986; Eckerbom *et al.* 1987; Odesjo *et al.* 1990; Sjögren *et al.* 1990; Kirkevang *et al.* 2000). Another factor is the length of the root filling. If the endodontic treatment is too short, 43 to 65% of the teeth present apical periodontitis, and if the endodontic treatment was too long, about 57 to 75% of the teeth showed periapical lesions (Eriksen *et al.* 1988; Eriksen & Bjertness 1991; De Cleen *et al.* 1993; Saunders *et al.* 1997).
The most frequently used root canal filling material is gutta-percha in the form of cones. The widely held view that it is biocompatible and well tolerated by human tissues is

inconsistent with the clinical observation that extruded gutta-percha is associated with delayed healing of the periapex (Kerekes & Tronstad 1979, Nair *et al.* 1990, Sjögren *et al.* 1990). In an animal study it was shown that mouse peritoneal macrophages release factors which have bone resorbing activity when exposed to gutta-percha particles (Sjögren *et al.* 1998). This was due to the increased production of IL-1α. In another studies using subcutaneously implanted Teflon cages in guinea pigs, it was shown that large pieces of gutta-percha were well encapsulated and the surrounding tissue was free of inflammation (Sjögren *et al.* 1995). Contrary, fine particles of gutta-percha or rosin-chloroform treated gutta-percha evoked an intense localized tissue response (Sjögren *et al.* 1995). This response was characterized by the presence of macrophages and multinucleated giant cells. It was speculated that the accumulation of macrophages around gutta-percha may be an important factor in the impairment of healing of periapical periodontitis when teeth are root filled with excess material. In a study by Koppang *et al.* (1989), it was shown that the histological sections of eight periapical lesions contained cellulose fibers. It was speculated that they originated from endodontic paper points and could be hold responsible for the perpetuation of the periapical lesion. Although the presence of microbial infection is the primary cause of root canal failure in well-treated teeth, foreign body reaction to extruded root canal filling materials can maintain the disease and symptoms.

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Case 18. Acute apical periodontitis, Tooth 26

Retreatment and apicectomy

Fig. 1 Frontal view

Referral
A 43-year old white female (Fig. 1) was referred November 2002 to the postgraduate endodontic clinic at the University of Oslo by her General Practitioner for treatment of maxillary left first molar.

Medical history:
Non-contributory.

Chief complain:
The patient consulted her General Practitioner for pain from maxillary left first molar. An access cavity (tooth 26) was prepared upon diagnosis of acute apical periodontitis. However, The GP could not localize the mesio-buccal canal.

Clinical examination
Preoperative photos showed the region from maxillary left canine to maxillary left second molar (Fig. 2 & 3)

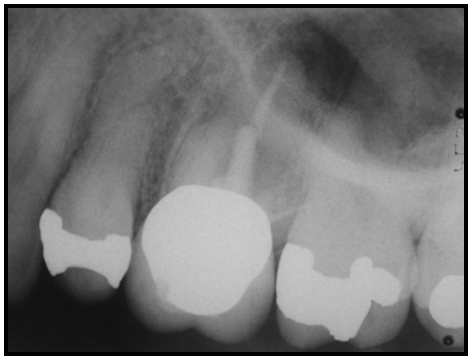
No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig. 2 Buccal view

Fig. 3 Occlusal view

Maxillary left canine: was intact
Maxillary left first premolar: had a MOD amalgam filling and a discoloration.
Maxillary left first molar: had a crown and was tender to percussion and palpation. An occlusal access cavity had been prepared through the crown which had been sealed with IRM.
Maxillary left second molar: had a MOD amalgam filling

Radiographic examination
Preoperative radiograph showed the region from maxillary left first premolar to maxillary left second molar (Fig. 4).



Maxillary left first premolar: had a MOD amalgam filling. The lamina dura could be followed around the root without disruption.

Fig. 4 Preoperative radiograph, tooth 26

Maxillary left first molar: had a crown. Radiographically root filling material could be seen in the palatinal and disto-buccal canals. A post was located in the palatinal root. The lamina dura could be followed around the mesio-buccal root until it widened into a radiolucent lesion of approx. 8 mm.

Maxillary left second molar: had a MO amalgam filling. The lamina dura could be followed around the root without disruption.

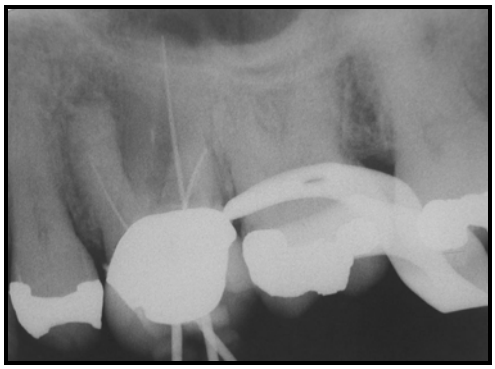
The marginal bone was within normal limits.

Diagnosis:
Root filled maxillary left first molar with chronic apical periodontitis.

Treatment:
Retreatment.

Treatment:
1st appointment: 27.11.2002
The IRM filling was removed and the mesio-buccal canal could be found with help of a microscope. The post in the palatinal canal was removed with the help of piezoelectric Satalec ultrasound.
Rubber dam was applied and disinfected with chlorhexidine-ethanol solution. A file was introduced into the mesio-buccal canal; it was not possible to negotiate further than 19 mm. NaOCl was used to rinse and $Ca(OH)_2$ was applied and the cavity was sealed with IRM.

2nd appointment: 3.12.02 (1 week)
Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The gutta-percha was removed from the palatinal and disto-buccal canals with chloroform and a working length radiograph was taken (Fig. 5)



The working length radiograph showed 3 files with the following lengths:
Mesio-buccal K-flex file nr15 / 19 mm
Disto-buccal NiTi file nr 45 / 19.5 mm
Palatinal NiTi file nr 45 / 20.5 mm.
During instrumentation the canals were irrigated with 1% NaOCl and 17% EDTA.

Fig. 5 Working length radiograph

The mesio-buccal and disto-buccal canals were instrumented to size 45, the palatinal canal to size 60. The canals were dried with paper points, and packed with calcium

hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.

3rd appointment: 7.01.2003 (1 month later)
The patient presented with pain and swelling buccally of the maxillary left first molar.

Rubberdam was applied and disinfected with chlorhexidine-ethanol solution. The IRM filling and $Ca(OH)_2$ were removed. With the help of a microscope the mesio-palatinal canal could be found, but it could only be negotiated 2-3 mm. With the help of a microscope the tooth was examined for infraction line; no infraction line could be found. The canals were packed with calcium hydroxide with the help of Lentulo spiral and paper points. The access cavity was cleaned with chlorhexidine-ethanol solution and was sealed with IRM.
The patient was prescribed antibiotics (Apocillin 660 mg x 4 for 6 days)

4th appointment: 18.02.2003 (5 weeks later)
Tooth was asymptomatic. Rubberdam was applied, disinfected with chlorhexidine-ethanol and the IRM was removed. After removing the calcium hydroxide with NiTi files and 1 % NaOCl and 17% EDTA, a master cone radiograph was taken (Fig. 6).

The canals were dried with sterile paper points and filled with AH plus and gutta-percha with a cold lateral condensation technique. After removing excess of gutta-percha, the cavity was sealed with IRM (Fig. 7).

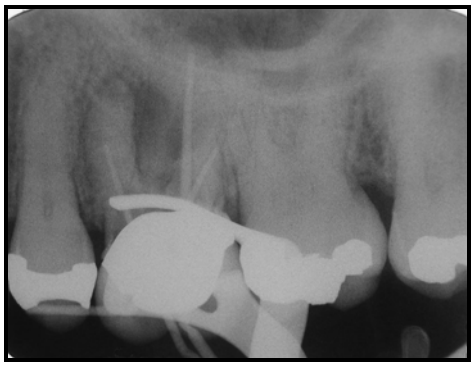


Fig. 6 Master cone radiograph

Fig. 7 Final radiograph tooth 26

5th appointment: 26.03.03 (5 weeks later)
The patient had symptoms with a swelling buccally of the maxillary left first molar. No periodontal pocket was probed and no facture line was observed.
It was decided to perform an apicectomy. The patient was prescribed again antibiotics (Apocillin 660 mg x 4 for 6 days).

6th appointment: 21.05.2003

5 carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the distal aspect from the maxillary left second molar extending anteriorly to the mesiobuccal line angle of the maxillary left canine. A vertical releasing incision was made starting from the mesiobuccal line angle of the maxillary left canine.

The flap was carefully reflected and osteotomy with a round bur was accomplished 8 mm from the crown margin to expose the root tip of the mesio-buccal root (Fig. 8).

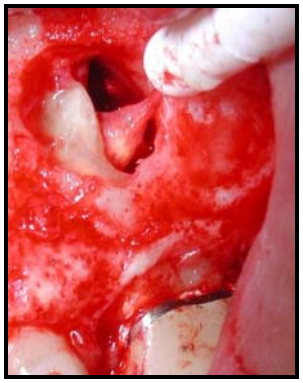


Fig. 8 Mesio-buccal root

Fig. 9 Removed granulation tissue

Granulation tissue was removed and a lot of pus was drained (Fig. (8 & 9). The granulation tissue was sent for histological examination in a formaldehyde carrier.

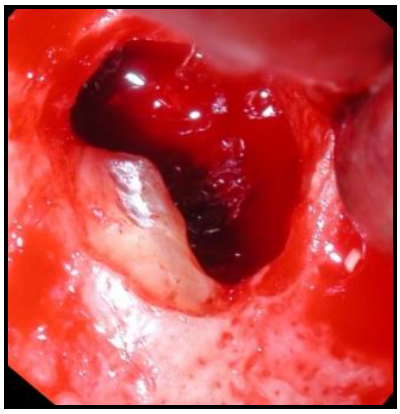


Fig. 10 Retrograde IRM filling

With a high-speed hard metal bur 4 mm of the mesio-buccal root tip were removed and with the help of a microscope 2 canals were observed.

A retrograde preparation was carried out with the piezoelectric Satalec ultrasound device using the tip CT under constant cooling with sterile saline. The cavity was extended between the two canals and 3 mm deep into the canals.

IRM was placed as a retrograde filling using a plastic instrument as a carrier and was condensed with a microplugger (Fig. 10).
The site was then carefully irrigated with sterile saline. The flap was repositioned and 5 sutures were placed (Fig. 12). Apocillin 660 mg (1+1+2 for 6 days) and Corsodyl® were prescribed.

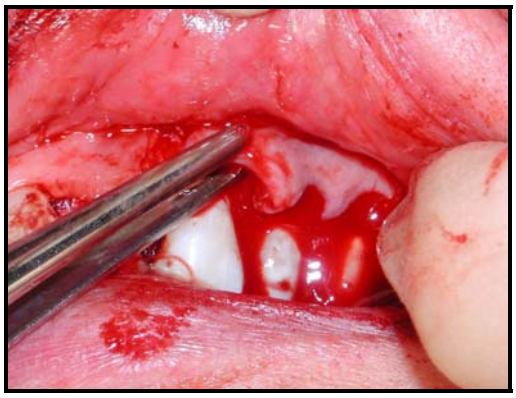


Fig. 11 Adaptation of the flap

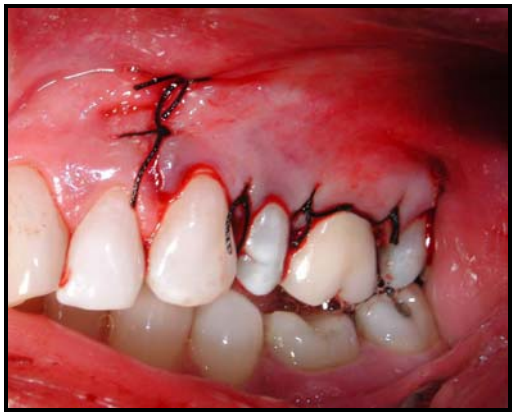


Fig. 12 Buccal view

Fig. 13 Control radiograph

The postoperative radiograph (Fig. 13) showed the extent of the resected root and the retrograde filling material in the mesio-buccal canal of the tooth.

Histology
Histological diagnosis was radicular cyst with moderate chronic and sub-acute inflammation.

One week follow-up: 27.05.2003

The patient returned one week later to the clinic for removal of the sutures. The patient was asymptomatic. The sutures were removed.
The healing of the muco-gingival tissue was satisfactory (Fig. 14).

Fig. 14 One week follow-up

Prognosis:
The prognosis of the apical surgery was assumed to be good.

4 months follow-up:

The patient returned 4 months later. She was asymptomatic and no tenderness to percussion or palpation was registered. A control radiograph was taken (Fig. 15).

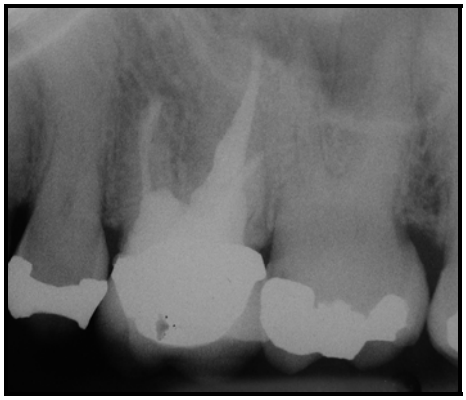
Fig. 15 4 months follow-up tooth 26

1 year follow-up:

The patient was asymptomatic and no swelling could be seen. Radiographically bone healing was observed (Fig. 16).

Fig. 16 One year follow-up tooth 26

2 years follow-up:



The patient was asymptomatic and no swelling could be seen. Bone regeneration was observed radiographically (Fig. 17).

Fig. 17 2 years follow-up tooth 26

Discussion:

In the present case the mesiobuccal and mesiopalatinal roots could not be negotiated to the correct working length. The histological analysis revealed the presence of radicular cyst. It can be speculated if the lesion would have subsided after correct instrumentation.

Apical periodontitis is an inflammatory disorder of periradicular tissues caused by persistent microbial infection within the root canal system of the affected tooth (Kakehashi *et al.* 1966; Sundqvist 1976; Fabricius *et al.* 1982). When the treatment is done properly, healing of the periapical lesion usually occurs with hard tissue regeneration, that is characterized by reduction of the radiolucency on follow-up radiographs (Byström *et al.* 1987; Sjögren *et al.* 1990; Sjögren *et al.* 1997; Kerekes & Tronstad 1979; Sundqvist *et al.* 1998). Inadequate instrumentation is one of the factors that adversely affect the outcome of the treatment (Chugal *et al.* 2003; Sjögren *et al.* 1990).

Nevertheless, even after standard treatment, a complete bone regeneration or reduction of the apical radiolucency does not occur in all root canal-treated teeth. Such cases of non-resolving periapical radiolucencies are also referred to as endodontic failures. Intraradicular infection, extraradicular infection or foreign body reaction could be the cause of persisting apical periodontitis.Results of studies have shown that the presence of cysts can also adversely affect the outcome of conventional root canal therapy (Nair *et al.* 1993; Nair *et al.* 1996).

A cyst is a cavity with epithelial lining filled by fluid or semisolid material surrounded by a dense connective tissue. The epithelial lining of the cyst derives from the proliferation of the epithelial rests of Malassez and is regarded as being a direct effect of the inflammatory process (Ten Cate 1972; Valderhaug 1974).
There are two distinct categories of radicular cysts, namely, those containing cavities completely enclosed in epithelial lining – true cyst, and those containing epithelium-lined cavities that are open to the root canals – bay cyst or periapical pocket cyst (Nair *et al.* 1996; Simon 1980). It was suggested that pocket cysts may heal after root canal therapy but the true cysts are less likely to be resolved by conventional root canal treatment (Nair *et al.* 1993; Nair *et al.* 1996).
In a study by Nair *et al.* (1996) serial sectioning was used and an overall 52% of the lesions (n = 256) were found to be epithelialized, but only 15% were actually periapical cysts. This is in contradiction with the assumed high incidence of periapical cysts. Periapical cysts are a direct sequel to chronic apical periodontitis, but not every chronic lesion develops into a cyst.

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Case 19. Cervical root resorption, Tooth 21

Surgical repair of the resorption lesion

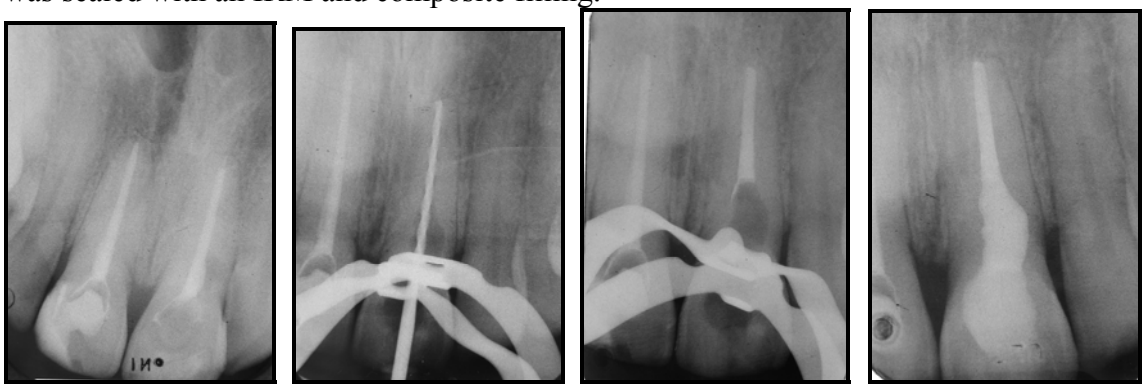
Fig. 1 Frontal view

Referral
A 30-year old white male (Fig. 1) was examined in October 2003 at the postgraduate endodontic clinic at the University of Oslo, after having received a root canal treatment at the same department 6 months before.

Medical history
Non-contributory.

Dental History & Chief complaint
The patient had a sport trauma of the upper front teeth 15 years earlier which resulted in endodontic treatment of the two central incisors.
In April 2003 the patient received treatment at the postgraduate endodontic clinic for cervical root resorption of the maxillary left central incisor and was since then without symptoms.

Previous treatment: April 2003
The root filling was removed and $Ca(OH)_2$ was applied for one week. The root was filled with gutta-percha and AH plus using lateral condensation technique. The access cavity was sealed with an IRM and composite filling.



The patient was unsatisfied with the discoloration of the two central incisors and was therefore referred to the student clinic at the Dental Faculty for further prosthodontic treatment. However, the patient did not receive any treatment during this period of time and returned to the postgraduate endodontic clinic for a scheduled control of tooth 21.

Clinical examination
Preoperative photo showed the region from maxillary right canine to maxillary left canine (Fig. 2).

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.
No pain to percussion or to palpation was found.

Fig. 2 Frontal view

Maxillary right & left canine: intact
Maxillary right & left lateral incisor: intact
Maxillary right & left central incisor: The teeth were discoloured. Composite build-up could be seen buccally on both teeth.

A pocket distally of tooth 21 of 9 mm was probed (Fig. 3).

Probing depths of the other sites of tooth 21 were within normal limits.
No pain to percussion or to palpation was found.

Fig. 3 Close-up

Radiographic examination
Preoperative radiograph showed the region from maxillary right central incisor to maxillary left lateral incisor (Fig. 4).

Fig. 4 Preoperative radiograph

Maxillary right central incisor: had a root filling material and a palatinal filling. The lamina dura could be followed around the root without disruption.

Maxillary left central incisor: had a root filling material and an occlusal filling. A radiolucency could be seen at the height of the marginal bone level extending from the root filling distally to the tooth margins. The lamina dura could be followed around the root without disruption.
Maxillary left lateral incisor: intact

Diagnosis
Root filled maxillary left central incisor with cervical resorption.

Treatment plan:
Orthograde renewal of the top filling and surgical repair of the resorption lesion.

1st appointment: 8.10.2003
The composite and the IRM filling were removed. The lesion was exposed and bleeding was observed (Fig. 5).

The bleeding could be stopped with chlorhexidine-ethanol solution and a communication to the gingiva could be seen.
The cavity was filled with white MTA. The filling was covered with a humid cotton pellet and the cavity was sealed with IRM.

Fig. 5 Cavity close-up tooth 21

2nd appointment: 12.11.2003
The IRM filling and the cotton pellet were removed and the access cavity was sealed with an IRM filling.
Three carpules of Xylocaine with adrenalin were used to establish anesthesia. An intrasulcular incision was made by using a scalpel starting from the mesial aspect from the maxillary left canine extending anterior to maxillary right lateral incisor (Fig. 6). A vertical releasing incision was made starting from the mesiobuccal line angle of the maxillary left canine.

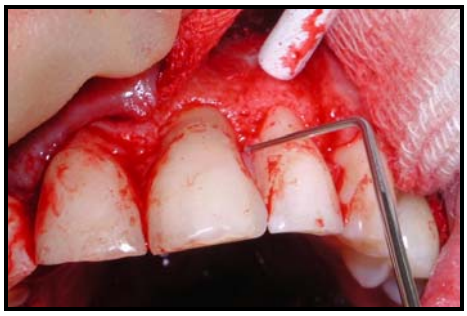


Fig. 6 Reflected gingiva

The flap was carefully reflected and an osteotomy with a round bur was accomplished between the tooth 21 and 22 in order to access the site of resorption (Fig. 7).

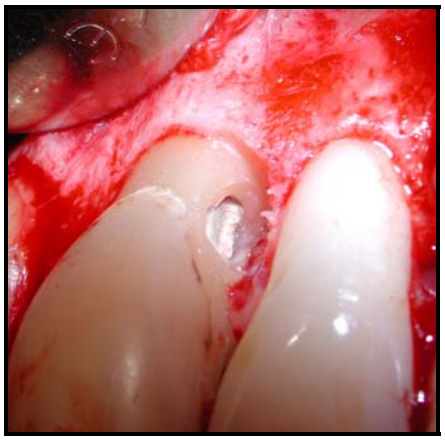


Fig. 7 Cavity preparation

Fig. 8 Application of composite

The cavity was prepared exposing the white MTA. Acid etch and adhesive were used before applying a composite.

Fig. 9 Buccal view

The site was then carefully irrigated with sterile saline. The flap was repositioned with 5 sutures (Fig. 9).

A control radiograph was taken showing the postoperative result (Fig. 10).

Fig. 10 Control radiograph tooth 21

The patient was referred to a prosthodontist for further treatment of the maxillary right and left central incisor.

Prognosis:
The prognosis was assumed to be uncertain.

One-year control: 14.09.2004
No further prosthodontic treatment was done since the risk of a crown fracture was evaluated to be high. The patient was therefore informed about the possibility of an implant treatment. The patient was however asymptomatic and did not want any further treatment.

Fig. 11 Control radiograph

3-years control: 16.11.2006
The patient had no symptoms. Tooth 21 showed no signs of pathology (Fig. 13).

Fig. 12 Front view

Fig. 13 Control radiograph

Tooth 11 showed signs of root resorption in the marginal area. The patient was informed and he wished no conservative treatment for tooth 11. However, he decided to replace 11 and 21 with implants.

Discussion:
Both front teeth presented discoloration and the patient wished a treatment to improve the aesthetical aspect. Because of the localization of the resorption lesion, no crown could be placed. An alternative treatment would have been internal bleaching of the teeth and porcelain veneers. However, it has been shown that an adverse effect of internal tooth bleaching is cervical root resorption (Cvek & Lindvall 1985; Friedman *et al.* 1988), therefore such treatment was not an option. At the final follow-up radiograph, the maxillary right central incisor presented a newly formed resorption lesion. The patient wished no further conservative treatment since it would not make any aesthetical improvement. He therefore decided to extract both central incisors and replace them with single-tooth implants.

External root resorption may occur after injury of the precementum, apical to the epithelial attachment, followed by bacterial stimulation originating from the periodontal sulcus. Injury may be caused by dental trauma, and chemical irritation may be caused by bleaching agents, e.g. hydrogen peroxide 30%, orthodontic treatment, or periodontal procedures.
Invasive cervical resorption is relatively uncommon and a clinical challenging condition. The invading tissue arises from the periodontal ligament, but differs from the periodontal tissues in both structures and behaviour. For invasion to occur, a defect in the cementum

or cementoid layer is likely to be required (Vincentelli *et al.* 1973; Hammarström & Lindskog 1992). This may be of developmental origin in a small zone near the cervical area, or the result of a physical or chemical trauma. Such a cementum-cementoid deficiency allows direct contact between dentin and the potentially resorptive cells of the periodontium.

Besides extraction, different approaches have been suggested by several authors for the treatment of cervical external root resorptions of various origins. Arresting the resorption may be attempted by means of subgingival curettage, but with a 'high failure rate due to recurrence, or rather persistence, of the resorptive tissue' (Heithersay 1985a). The use of calcium hydroxide to neutralize external resorption has been suggested. Exposure of the resorption defects for the purpose of restoration has been recommended by means of orthodontic extrusion (Latcham 1986), intentional replantation (Heithersay 1985) or osteotomy by contouring the alveolar crest 2 mm apical to the defect margins (Meister, Jr. *et al.* 1986). Regarding the restoration of the resorptive defects, glass-ionomers (Heithersay 1985) or light-cured resin composite materials have been recommended, recognizing, however, that any subgingival restoration may well cause periodontal complications (Heithersay 1985; Meister, Jr. *et al.* 1986).

It is important that most external cervical resorptive lesions not be treated as endodontic problems. In many cases, this resorptive condition may be treated without sacrificing the pulpal vitality.

Surgical treatment of invasive cervical resorption has generally involved periodontal flap reflection, curettage, restoration of the defect with composite resin (Cvek M 1981; Goodman & Wolffe 1980) and glass-ionomer cement (Cvek M 1981; Heithersay 1985). Periodontal reattachment cannot be expected with composite resin and is unlikely with glass-ionomer cement. However, studies have shown that this might happen in the presence of MTA (Pitt Ford *et al.* 1995; Koh *et al.* 1997; Baek *et al.* 2005).

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Case 20. Neuropathic pain, Tooth 27

Fig. 1 Frontal view

Referral
A 43-year old white male (Fig. 1) was referred November 2002 to the postgraduate endodontic clinic, University of Oslo for treatment of maxillary left second molar.

Medical history:
Non-contributory, the patient does not take any medication.

Dental History & Chief complaint
The patient received a root filling of the maxillary left first molar in 2002 by an endodontist because of pain (no known diagnosis). After the treatment no pathology could be detected at the root tips of 26; however, due to persisting pain the tooth was extracted in 2004. A bridge 25-27 was made, both teeth with healthy pulp.
The patient was referred in February 2005 to the specialist clinic for treatment of the maxillary left second molar. The treatment was initiated by the General Practitioner, pain symptoms did not disappear.
At the private clinic limited to endodontics the following treatment was done. Rubber dam was applied, working length checked, number of found canals controlled and $Ca(OH)_2$ packed into the canals. The patient returned 3 weeks later and was still complaining about diffuse pain in area 27. The root filling was accomplished and the patient was referred to the post-graduate endodontic clinic, Faculty of Dentistry, University of Oslo for evaluation/treatment of neuropathic symptoms.

Clinical examination
Preoperative photos showed the region from maxillary left second premolar to maxillary left second molar (Fig. 2 & 3)

No pathology was found extra-orally.
Normal oral mucosa was observed.
Probing depths were within normal limits.

Fig.2 Buccal view tooth 27

Fig. 3 Occlusal view tooth 27

Maxillary left first premolar: the tooth was intact.
Maxillary left second premolar to second molar: metallo-ceramic bridge.
Maxillary left second molar: had an occlusal IRM filling. The tooth was not tender to percussion; however, the patient felt the percussion differently compared to the other teeth.

All neighboring teeth were positive to Endo-Ice®.
No tenderness to palpation could be found.

Radiographic examination
Preoperative radiograph showed the region from maxillary left first premolar to maxillary left second molar (Fig. 4).

Fig. 4 Preoperative radiograph tooth 27

Maxillary left first premolar: was a pillar of the bridge and the lamina dura could be followed around the root without disruption.
Maxillary left first molar: missing
Maxillary left second molar: was a pillar of the bridge. Radiographically a root filling material could be observed in 3 canals and the lamina dura could be followed around the roots without disruption.

The marginal bone level was within normal limits.

The Orthopantomograph showed no pathology (Fig 5).

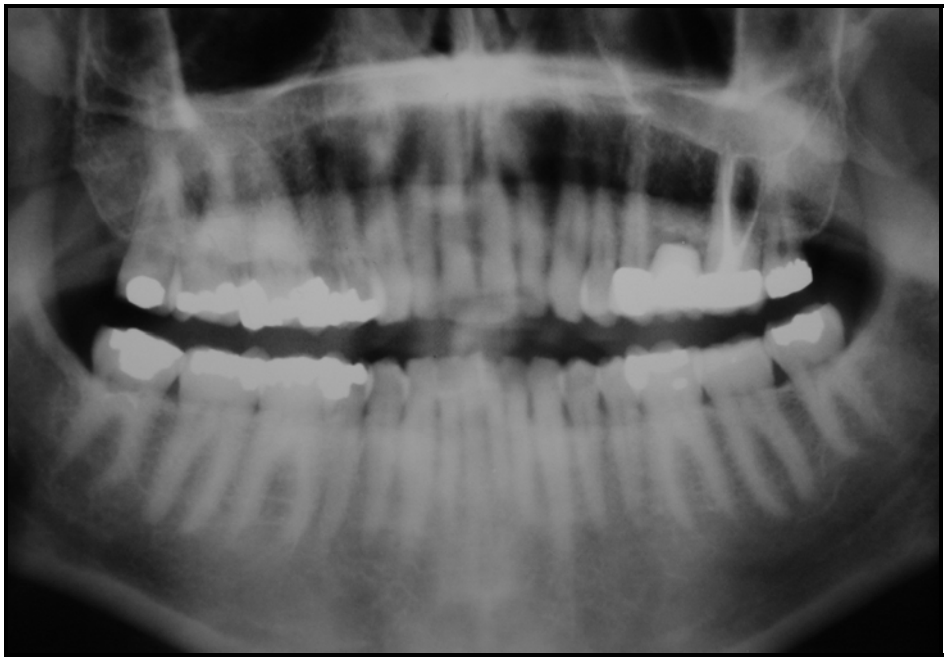

Fig. 5 OPG

Tentative Diagnosis:
Neuropathic pain

Treatment:
Referral to pain clinic

The patient was referred to the Maxillo-facial Department, Ullevål Hospital, Oslo for confirmation of the diagnosis and further treatment.

26.05.2005
The diagnosis of atypical facial pain (G 50.0) was confirmed and the patient was sent for a CT scan. The patient was informed about the diagnosis and informed about the possibility of symptomatic treatment by medication (Rivotril®). However, he did not want to take any medication.

20.06.2005
The CT showed no pathology. The patient complained about bad periods and was referred to the pain clinic at the State Hospital in Oslo.

Discussion
Neuropathic pain in the head and neck region is common and can result in multiple unnecessary dental treatments. The fact that neuropathic pain can present exclusively intraorally in the absence of obvious infection or trauma can be confusing to both patients and clinicians (Zakrzewska 2002)
The presenting toothache may be a heterotopic symptom of another disorder; that is, it is perceived to originate from a site different from the tissue that is actually the source of pain. This differs from primary pain, in which the perceived site of pain is the actual tissue from which the pain originates.
Neuropathic pain actually arises from the abnormalities in the neural structures themselves. The clinical examination generally reveals no somatic tissue damage, and the response to stimulation of the tissue is disproportionate to the stimulus (allodyny).
Neuropathic pain can be categorised into four categories.

1) Neuralgia: Trigeminal Neuralgia (TN) is an excruciating short-lasting (<2 minutes), unilateral facial pain that may be spontaneous or triggered by gentle, innocuous stimuli and separated by pain-free intervals of varying duration.
2) Neuroma is a proliferative mass of disorganized neural tissue at the site of a traumatically or surgically transected nerve.
3) Neuritis is a condition caused by inflammation of a nerve or nerves secondary to injury or viral or bacterial infection.
4) Neuropathy is a localized, sustained, nonepisodic pain secondary to an injury or change in a neural structure.

Epidemiologic information indicates that 3 – 6 % of patient develop atypical facial pain after endodontic treatment (Campbell *et al.* 1990; Marbach *et al.* 1982).
The pain is chronic; however, the patient's sleep is undisturbed and there are brief symptom-free periods on waking (Marbach 1996). The patient has also difficulties to localize the pain (Marbach 1993a; Marbach 1993b; Marbach 1996).

Tricyclic antidepressants (TCA), alone or in association with phenothiazines, have been prescribed with good results (Bates, Jr. & Stewart 1991; Battrum & Gutmann 1996; Lilly & Law 1997; Marbach 1993a). Although these are mood-altering medications, their effectiveness is attributed to their ability to produce a low-grade analgesia in low doses.

Undesirable side effects require that TCAs be titrated to the lowest clinically effective dose and discontinued if pain subsides.
Topical application of capsaicin to painful tissues has also been investigated as a treatment for neuropathic pain (Epstein & Marcoe 1994; Rumsfield & West 1991; Bernstein 1987). Pain reduction is archieved because C fibers depleted of Substance P have a reduced ability to stimulate second-order neurons that relay pain signals to the central nerveous system (Okeson 2000).
Rivotril ® is a clonazepam. Its pharmacological profile is similar to other anxiolytic/sedative benzodiazepines. Its basic anticonvulsive properties are also similar to those of other diazepines. It is especially used for burning mouth syndrome.

In the present case the patient seek for treatment because of toothache in the area of the maxillary left first molar. After the endodontic treatment was finished, the symptoms had not yet been resolved. The tooth was extracted 2 years later and a bridge was placed from 25-27. Because of persisting pain, the General Practitioner started endodontic treatment of the maxillary left second molar; however, the pain did not subside.
After each treatment, pain symptoms tended to be reduced for a short period of time and then returned to its original or even increased intensity level. This is a typical clinical presentation of a case with an undiagnosed neuropathy.

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