Periapical healing of mandibular molars after root-end sealing with dentine-bonded composite

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Abstract

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Aim The purpose was to present the frequency of periapical healing in first and second/third mandibular molars, after root-end resections sealed with a dentine-bonded resin composite.

Methodology Root-end sealing of resected mandibular molar roots was made with dentine-bonded composite (Gluma-Retroplast) as a cover on the entire slightly hollowed root-end, in an attempt to prevent leakage.

Results Out of the 834 roots recalled between 6 months and 12.5 years postoperatively, 92% showed complete apical healing, 1% uncertain healing and 7% exhibited failure. The healing result of 681 first molar roots was not significantly different ($P = 0.21$) from that of 153 second/third molar roots, and there was no significant difference in healing between mesial and distal roots ($P = 0.32$ for first molars, $P = 0.86$ for second/third molars) or amongst six age groups ($P = 0.94$). In the patient group: 71–89 years, 36 roots showed an average of 97% with complete healing. Out of 25 failures who were retreated surgically, 80% showed complete healing when examined subsequently.

Conclusion Root-end sealing of mandibular molars with dentine-bonded resin composite is a promising technique giving 92% complete healing in cases examined between 6 months and 12 years postoperatively.

Keywords: dentine-bonded composite, endodontic surgery, mandibular molar, periapical healing, Retroplast.

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Introduction

Root-end sealing of mandibular molars is difficult to perform, because the roots are lingually inclined, and the buccal bone thick and compact, increasingly adjacent to the second and third molar. This, and the presence of the inferior dental nerve, may make root resection and root-end sealing of these teeth difficult. According to one endodontic textbook (Ingle & Bakland 1994) the buccal surgical approach in the posterior region of the mandible 'in some cases presents an almost impossible apical access through both cortical and medullar bone'. And furthermore, according to Barnes (1991) 'the roots are deeply placed and the operative problems formidable'.

Except for previous reports (Rud *et al.* 1989, 1996b) the literature gives only limited information on retrograde root-end filling of mandibular molar roots. The special operation technique (Rud *et al.* 1989, 1991a), using a dentine-bonded composite (Gluma and Retroplast) allows apical root-end sealing of mandibular molars, because a cavity preparation on the resected root-end is not needed. This is in contrast to alternatives such as IRM, MTA, Super-EBA and amalgam (Adamo *et al.* 1999).

The purpose of the study was to present the frequency of periapical healing of first and second/third mandibular molars, operated and sealed using a bonded composite resin (Rud *et al.* 1989, 1991a,b) and re-examined at various times postoperatively.

Materials and methods

From September 1984 to March 1997, patients with 726 mandibular molars with periradicular periodontitis were referred to the authors' (V. R. & J. R.) private practice, for root-end sealing with Gluma (Gluma desensitizer,

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*To our great sorrow, Dr Jørgen Rud, who was the driving force in this study, passed away during preparation of the manuscript.

Table 1 Cases not included in the results

Observation/action	No. of cases
Root fracture	57
Tooth extracted, retrograde sealed and reimplanted	12
Root denuded to apex because of marginal caries or filling	7
Iatrogenic perforation of the root done by the referring dentist	11
Total	87

Heraus Kulzer G.m.b.H., Werheim, Germany) and Retroplast™ (Retroplast Trading, Rønne, Denmark). Out of these, 87 cases were operated, but eliminated from this report for various reasons (Table 1), e.g. 11 mandibular molars with accidental perforations of the root, performed by the referring dentist.

The remaining patients representing 639 molars were initially recalled after approximately 1 year (0.5–1.5 years) and/or subsequently (>1.5 years). Patients with 520 molars responded to the recall, which was 84% of the cases. Of these, 422 (81%) were first molars, 92 (18%) second molars and six (1%) third molars. There were 59% females and 41% males, with a median age of 47 years (17–89 years).

Both mesial and distal roots on the same tooth were not always treated. Of the 520 molars examined, 834 roots were treated and these were examined as separate cases. Twenty-five surgical failures which were retreated were studied separately. No attention was taken to the quality of the previous root canal treatment or to the coronal seal.

Operation technique

Buccal access to the roots was obtained by an incision being made along the gingival margin of the teeth, from the distobuccal surface of the last molar to the mesiobuccal corner of the first premolar ending with an oblique vestibular extension. This extension was angled forward to facilitate suturing and to optimize blood supply to the anterior part of the flap. The buccal mucoperiosteal flap was raised from the bone, to enable observation of the area adjacent to the apices.

A section through a third molar shows that in some cases the buccal bone may be up to 12 mm wide. The approach was made by removing part of the buccal bone with a round bur; cooling was obtained with saline, leaving the roots covered with only a thin layer of bone, except in the apical region, where the bone was removed to allow access to the root-end (Fig. 1).

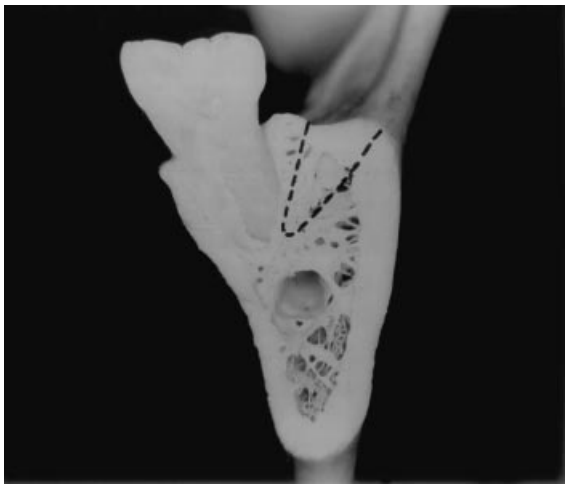

Figure 1 Cut through the mandible in the third molar region. Note the 12 mm wide buccal bone. The marks indicate removal of bone, to obtain access to the root-end.

The roots were resected with a round bur cooled with saline. The roots were resected until all root canals could be seen on the resected surface. Sometimes the resected surface was examined using an operation microscope. If possible a 90° resection of the root was undertaken. For mandibular molars with a difficult access, the resection was more oblique.

The bone cavity was cleaned with curettes and excavators and all granulation tissue was curetted meticulously. Care was taken to prevent damage to the inferior dental canal. If a suspicion existed that a periapical bone defect was open to the inferior dental canal, that area of the cavity was not curetted. The whole root-end was made slightly concave with a large round bur.

A haemostatic sponge (Spongostan, Johnson & Johnson, Ferrosan, Søborg, Denmark) was moistened with not more than 2–4 drops of 1% adrenaline and placed for about 2 min in the bone cavity. The surface of the sponge in the cavity was covered with gauze to prevent absorption by surrounding soft tissue. Adrenaline was not administered to patients with untreated hypertension, thyrotoxicosis or patients medicated with tricyclic antidepressives or MAO-inhibitors, as treatment with adrenaline in such cases may cause adverse reactions.

With a miniature brush (Quick Stick – Dentonova AB, Huddinge, Sweden) a solution of 0.5 mol L^{-1} EDTA, pH 7.4 was rubbed onto the resected, slightly concave root-end for 20 s. The root-end was rinsed with physiological saline and dried with compressed air. The dentine bonding agent Gluma Desensitizer (Hereaus Kulzer G.m.b.H., Wehrheim, Germany) was then applied to the root-end

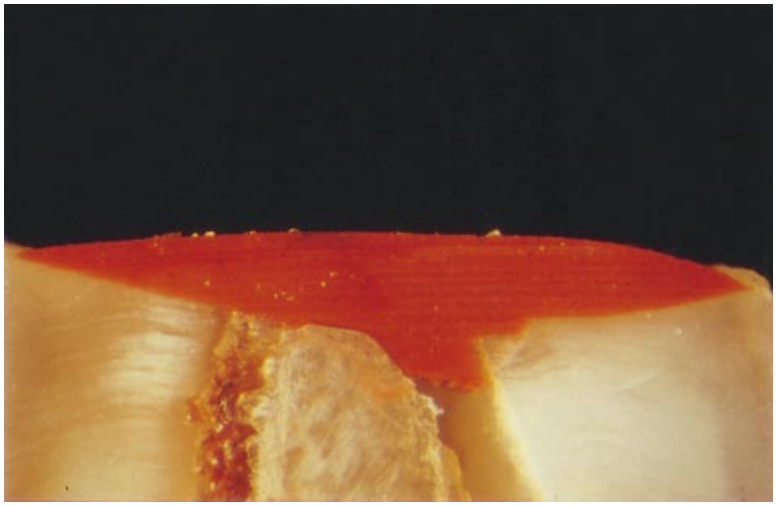

Figure 2 Retrograde seal with Retroplast and Gluma in a slightly hollowed root-end.

for 20 s and dried with compressed air. In case of contamination of the root-end with blood or saliva during the above procedure with Gluma Desensitizer, the whole procedure was repeated after repreparation of the root-end with a round bur.

Finally, the root-end was covered with Retroplast, a specially designed two-component autopolymerizing composite resin, previously described by the authors (Rud *et al*. 1996b). After mixing for 10 s on a mixing pad, small amounts of Retroplast were applied to the resected root-end with a small excavator. The entire resected root-end was covered, leaving the periodontal membrane free (Fig. 2). Two min after curing on the mixing pad, the unpolymerized air-inhibited surface layer was removed with 96% ethanol on a miniature brush followed by rinsing with saline. This procedure with ethanol was done twice.

Before suturing, the denuded bone was cleansed with a copious amount of saline, and the operation area was carefully inspected. Nonabsorbable 3/0 silk was used for suturing. As few sutures as possible were inserted, often just one or two sutures in the mesial oblique vestibular extension, leaving the marginal horizontal incision in place to allow good drainage. The sutures were removed after 2 days. A small number (7%) of the patients with subacute or acute symptoms were given 3 MIE penicillin in 6 days pre- or postoperatively. Amongst the referred 726 operated molars, half of them showed subacute or acute symptoms at the time of operation, including 14% with an abscess or pus found during the operation. Postoperative paraesthesia in the lip and/or chin from the inferior dental nerve were observed in 24 patients after operation of first mandibular molar, and in two patients after operation of second mandibular molar, at the time when sutures were removed. After a year only one patient still had paraesthesia symptoms.

Classification of the healing results

Periapical healing of individual roots were judged according to the following criteria. These are based on radiographic criteria proposed by Rud *et al*. (1972a) after histological and bacteriological studies. Incomplete healings with scar tissue were not seen in relation to mandibular molars. Furcal and lateral radiolucencies were not included in this report; this will be analysed in a separate report.

Complete healing

Reformation of a periodontal ligament space, the width up to twice normal apically, with a lamina dura. The apical bone cavity gradually filled-in with bone.

Uncertain healing

Decreased radiolucency compared to the postoperative or a previous follow-up radiograph, but without a compact bone border or lamina dura. If unchanged healing of this type was observed for 4 years, the case was regarded as a failure.

Failure

Unchanged or enlarged radiographic rarefaction compared with a postoperative or previous follow-up radiograph.

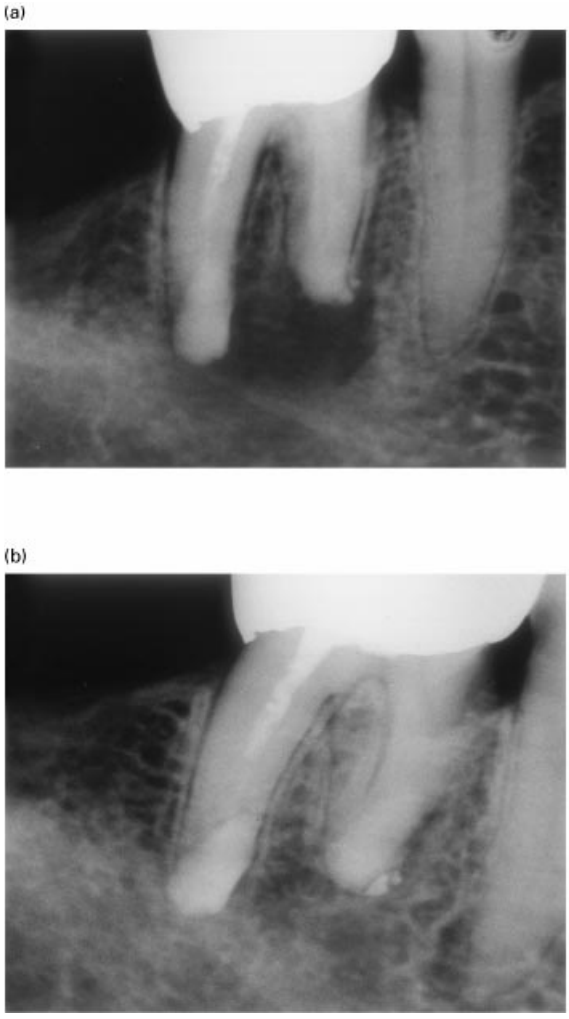

Figure 3 Periapical rarefaction from roots of first mandibular molar. Abscess. Eighty-nine-year-old female. a) Postoperatively. Retroplast on both root-ends; b) Six years later. Complete healing of root-ends.

Figure 4 Periapical rarefaction from first mandibular molar. Positive pulp viability of second premolar and second molar. Thirty-five-year-old female. a) Postoperatively; both root apices sealed with Retroplast. No curetting near roots of second premolar and second molar; b) One year later. Complete bone healing.

Furthermore, cases showing a loose Retroplast seal on a radiograph. Clinical signs originating from the operated area such as an abscess or an alveolar fistula also indicate failures.

Evaluation

The authors (J. R. and V. R.) evaluated in each case the radiographs independently. Where differences occurred, consensus was reached by discussion. The results were evaluated statistically using the χ^2-test (M × N two-tailed) (Wulff & Schlichting 1987).

Results

Examples of bone healing around mandibular molar apices are shown in Figs 3–5. Figure 3 shows complete apical healing of both roots of a first mandibular molar. In Figs 4 and 5 the periapical osteitis had spread in the bone, involving roots of the neighbouring teeth. Both root-ends of the mandibular molar were sealed with Retroplast. Curetting close to neighbouring roots was omitted. Note complete healing in both cases.

Table 2 shows frequencies of healing after periapical sealing. A total of 744 mandibular molar roots were

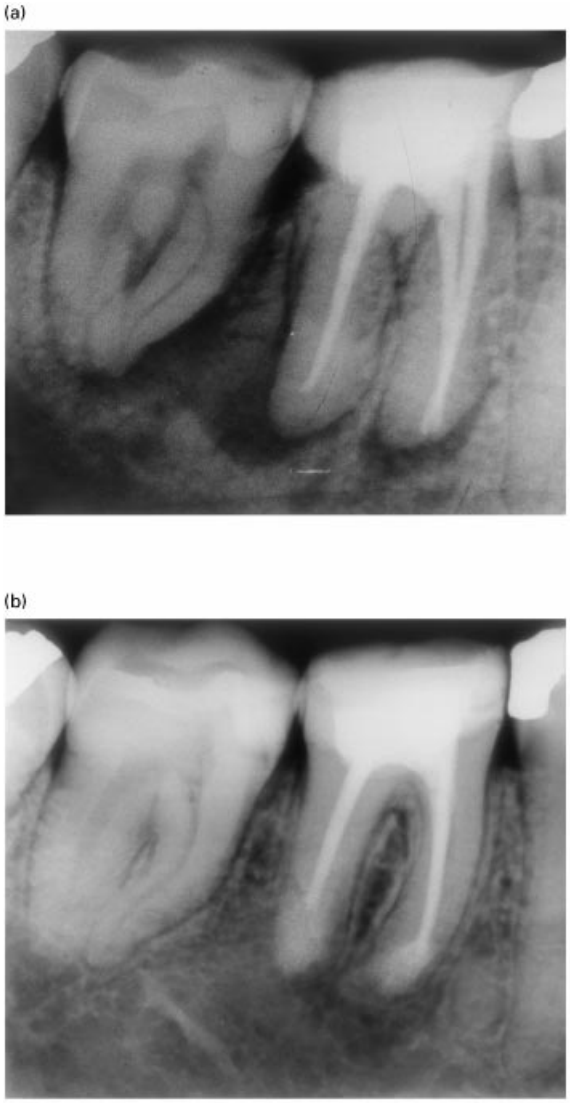

Figure 5 Proximal bone fistula mesially for second mandibular molar originating from apical periodontitis of the mandibular first molar. Thirty-nine-year-old female. a) Preoperatively; b) Retroplast seals of both first molar apices. No curetting along second molar. One year after operation. Complete healing around both molars.

recalled between 0.5 and 1.5 years after operation. A total of 625 roots showed complete healing at early recall. These were not recalled again. We expect that these continue to be complete healings (Rud *et al.* 1996a), as well as the 29 failures continuing to be failures. These are therefore transferred from early recall to final healing (see Table 2).

Ninety roots were examined for the first time after more than 1.5 years postoperatively (range 1.6–12.5, average 4.8 years). There were 79 roots with complete healing, 10 roots with failures, and one root with uncertain healing at 2 years 7 months after operation.

Table 2 Apical healing frequencies of mandibular molar roots retrograde sealed with Gluma and Retroplast

Healing category	Early recall 0.5–1.5 years	Late recall >1.5 years	From uncertain at early recall[a]	Final healing
Complete	625	79	67	771
Uncertain	90	1	4	5
Failure	29	10	19	58
Total	744	90	90	834

[a]Re-examinations of the 90 uncertain healings scored at early recall.

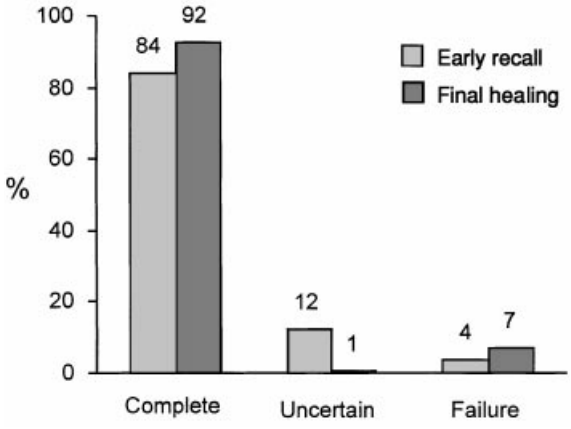

Figure 6 Distribution as a percentage of the healing results at early recall (744 roots) and at final healing (834 roots). The two groups differ significantly.

As uncertain healings should become either complete healings or failures, if re-examined after a sufficiently long time (Rud *et al.* 1972b), the 90 uncertain healings from early recall (between 0.5 and 1.5 years) were therefore recalled again between 1.5 years and 4 years (mean 3.1 years) after the operation. Here 67 were complete healings, four were still uncertain, and 19 were failures. These are transferred to the final healing. In this way, the final healing represents 771 complete healings, five uncertain and 58 failures (Table 2).

Figure 6 shows the distribution of early recall and final healing as a percentage. The difference was statistically significant ($\chi^2 = 97.3$, $P < 0.00001$).

The 834 mandibular roots (Table 2) included 681 first molar roots and 153 second/third molar roots. Figure 7 shows the healing results of these two types of molar roots as a percentage. As seen, complete healing comprised 94% of the cases with first mandibular molar

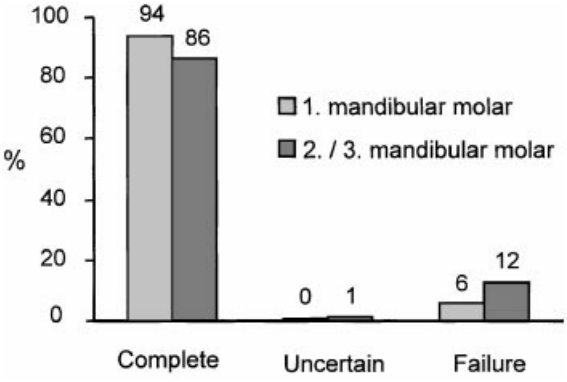

Figure 7 Distribution as a percentage of the healing results at final healing for first mandibular roots (422 roots) and for the combined second (92 roots) and third (six roots) mandibular roots. The two groups do not differ significantly.

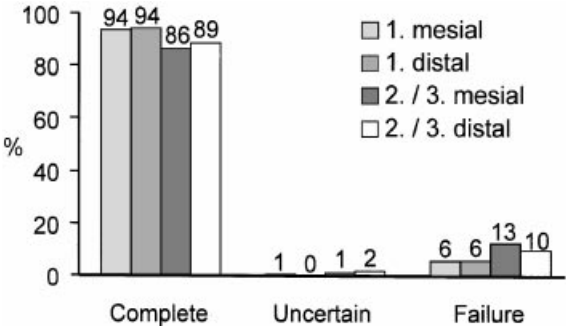

Figure 8 Distribution as a percentage of the healing results at final healing for first mesial and distal mandibular roots and for second/third mesial and distal mandibular roots. There is not significant difference between the result of mesial roots compared to that of distal roots.

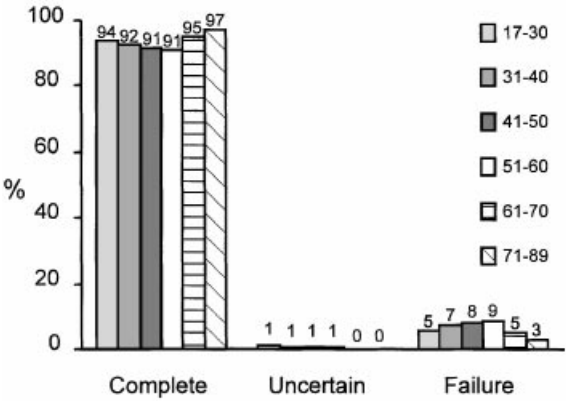

Figure 9 Distribution as a percentage of the healing results at final healing according to age. The groups do not differ significantly.

roots, and 86% of second/third mandibular molar roots. The two sets of results did not differ significantly ($\chi^2 = 3.08$, $P = 0.21$).

The 681 first molar roots included 386 mesial and 295 distal roots, and the 153 second/third molar roots comprised 88 mesial and 61 distal roots, and four with the mesial and distal roots fused to one single root. Figure 8 shows the distribution within these groups as a percentage. Statistical analysis revealed that the healing of mesial roots was not significantly different from that of distal roots. This was seen both for first molar roots ($\chi^2 = 2.3$, $P = 0.32$) and for second/third molar roots ($\chi^2 = 0.31$, $P = 0.86$).

Figure 9 shows the healing results at final healing according to the age of the patients. The age group 71–89 years comprised 36 roots and each of the remaining groups contained more than 92 roots. The groups did not differ significantly ($\chi^2 = 4.15$, $P = 0.94$).

Retreatment

Twenty-five failures recalled after 3 months to 5 years (mean 1.8 years) were retreated. The following may have caused these failures: in three cases part of the root canal was found uncovered; eight cases had a loose Retroplast seal, in five cases a persistent apical rarefaction was diagnosed, and in nine cases clinical symptoms were observed, such as fistula, pus or pain.

The 25 retreatment cases were recalled after 6 months to 11 years (mean 2.8 years). Of these, 20 (80%) showed complete healing and five (20%) were classified as failures.

Discussion

As previously reported (Rud *et al.* 1991a,b, 1996a, 1996b, 1997, 1998), sealing of root canals with a dentine bonding agent and a flowable resin composite (Gluma and Retroplast) will, in most cases, result in complete healing of apical inflammation. In the present and previous studies a slightly concave resection of the root was performed before application of the bonding agent and the resin composite. Such a preparation in dentine prevents the formation of contraction gaps during polymerization of the resin composite, because the volume of the composite in proportion to the bonded area is small (Feilzer *et al.* 1987, Hansen & Asmussen 1995). In a recent study by Adamo *et al.* (1999), no difference in leakage was found between root-end fillings of MTA, Super-EBA, dentine-bonded composite, and amalgam. This is not in agreement with previous findings (Rud

et al. 1989, Ambus & Munksgaard 1993), which showed that sealing of dentine-bonded composite is more efficient than with amalgam. The difference between the two studies can be explained by difference in cavity design. Adamo *et al.* (1999) used a butt-joint cavity design, which is a prerequisite for the formation of contraction gaps adjacent to composite fillings.

An efficient bonding implies that a tight apical seal can be obtained, preventing the flow of bacteria and toxins from the root canal and the dentinal tubules into surrounding tissue. This might explain the reason for the apparent success of the technique described. In this and in previous studies, the bonding agent, Gluma was used. Other bonding agents might be useful (Ambus & Munksgaard 1993), but the presence of glutaraldehyde in Gluma might be an advantage because of its disinfecting capability. In addition, it has been shown (Schüpbach *et al.* 1997) that the dentine tubules are blocked after application of Gluma because of a precipitation in the tubules.

In order to prevent outflow of bacteria and toxins, the sealing must cover root canals, accessory root canals, the apical delta, anastomoses between root canals and dentinal tubules. Therefore, a good seal of the resected root-end with a bonded composite, as used in our study, seems mandatory for obtaining a high success rate. This is in agreement with the results of Pinks & Beatty (1985), showing that a dentine-bonding agent applied to the resected root-end may block the dentinal tubules.

In addition, a concave root-end instead of a cavity has the following advantages: (i) it is possible to perform retrograde filling of mandibular roots despite anatomical difficulties (Ingle & Bakland 1994, Barnes 1991); (ii) it is possible to seal all apical communications from the root canal without covering the periodontal ligament space. This allows proliferation of root-cement and formation of new apical periodontal ligament space, with Sharpey's fibres, as previously reported (Andreasen *et al.* 1993).

Before root-end resection of mandibular molar roots, a considerable thick mass of cortical bone has to be removed, and it might take several years before the bone structure assumes a 'normal' radiographic appearance. The first sign of apical healing in such cases is the formation of a periapical ligament space with lamina dura. When this was seen, the result was listed as complete healing (Fig. 10). As seen in Table 2, five cases were still judged as uncertain healing, which corresponds to 1% of the cases. It seems appropriate to observe the outcome of retrograde fillings as the maximum time for cases with uncertain healing to develop into either complete healing or failures. According to a previous report

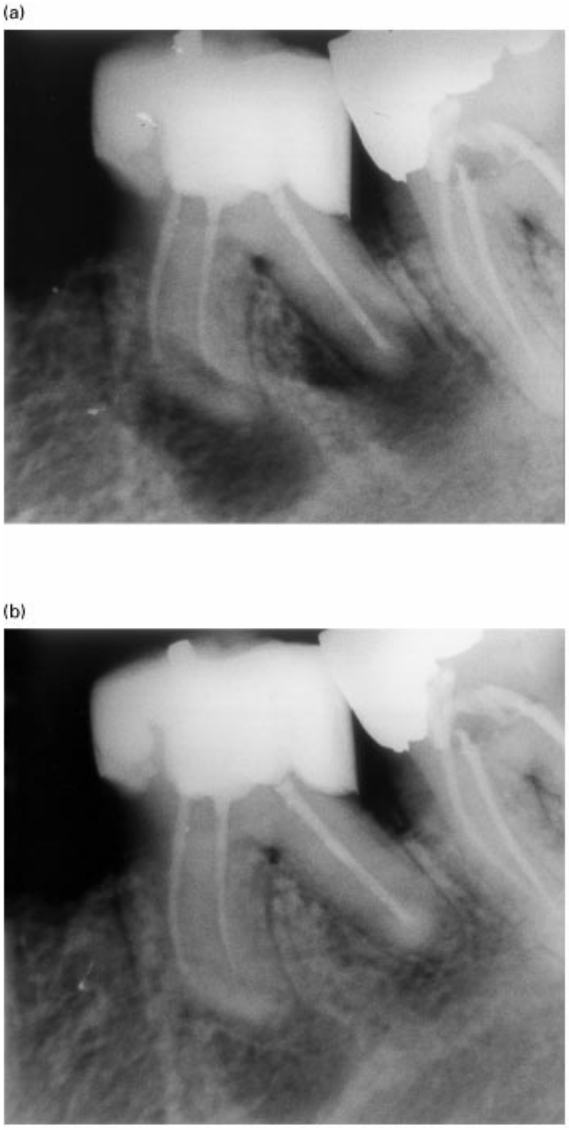

Figure 10 Formation of a periapical ligament space and lamina dura in a mandibular molar indicating complete healing. Reformation of cortical bone may occur later. Fifty-three-year-old male. a) preoperatively; b) one-year follow-up.

(Andreasen & Rud 1972), in which bacteriological and histological examinations were used, this might take 4 years postoperatively.

The healing of cases that were reoperated because of failure had 80% complete healing, when recalled. This is lower when compared to that of the main material (Table 2), but in agreement with the 76% with complete healing found after reoperations of failures in various tooth types (Rud *et al.* 1997). Failure might lead to extensive bone resorption, which might inhibit healing

subsequently. Surgical retreatment should therefore not be postponed for too long, in order that the remaining bone is sufficient.

The results showed that operations during an acute state of infection can be performed; penicillin was only used in 7% of the cases. The limited use of penicillin when operating in the acute state requires a nontraumatic operation technique, careful removal of infected tissue and loose suturing, which allows adequate drainage.

Conclusion

Root-end sealing of mandibular roots with a resin composite had a success rate of 92%; there was no significant difference between first and second or third molar roots. The results from distal and mesial roots did not differ significantly. The age of patients did not have a significant effect on healing.

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References

Adamo HL, Buruiana R, Schertzer Boylan R (1999) A comparison of MTA, Super-EBA, composite and amalgam as root-end filling materials using a bacterial microleakage model. *International Endodontic Journal* **32**, 197–203.

Ambus C, Munksgaard EC (1993) Dentin bonding agents and composite retro-grade root filling. *Journal of the American Dental Association* **6**, 35–8.

Andreasen JO, Munksgaard EC, Fredebo L, Rud J (1993) Periodontal tissue regeneration including cementogenesis adjacent to dentin-bonded retrograde composite fillings in humans. *Journal of Endodontics* **19**, 151–3.

Andreasen JO, Rud J (1972) Correlation between histology and radiography in the assessment of healing after endodontic surgery. *International Journal of Oral Surgery* **1**, 161–73.

Barnes IE (1991) *Surgical Endodontics. A Colour Manual*. London, UK: Butterworth – Heinemann, 62.

Feilzer AJ, De Gee AJ, Davidson CL (1987) Setting stress in composite resin in relation to configuration of the restoratives. *Journal of Dental Research* **66**, 1636–9.

Hansen EK, Asmussen E (1995) Cavity preparation for restorative resins used with dentin adhesives. *Scandinavian Journal of Dental Research* **93**, 474–9.

Ingle JI, Bakland LK (1994) *Endodontics*, 4th edn. Baltimore, MD, USA: Lea & Febiger, Williams & Wilkins, 705.

Pinks I, Beatty R (1985) The effect of a dentin bonding material as a reverse filling. *Journal of Dental Research* **65**, 259 (Abstract 805).

Rud J, Andreasen JO, Möller Jensen J-E (1972a) Radiographic criteria for the assessment of healing after endodontic surgery. *International Journal of Oral Surgery* **1**, 195–214.

Rud J, Andreasen JO, Möller Jensen J-E (1972b) A follow-up study of 1,000 cases treated by endodontic surgery. *International Journal of Oral Surgery* **1**, 215–28.

Rud J, Munksgaard EC, Andreasen JO, Rud V, Asmussen E (1989) Root filling with composite and a dentin bonding agent. I–VI. *Tandlaegebladet* **93**, 156–60,195–7,223–9,267–73,343–5,401–5.

Rud J, Munksgaard EC, Andreasen JO, Rud V, Asmussen E (1991a) Retrograde root filling with composite and dentin-bonding agent. 1. *Endodontics and Dental Traumatology* **7**, 118–25.

Rud J, Munksgaard EC, Andreasen JO, Rud V (1991b) Retrograde root filling with composite and dentin-bonding agent. 2. *Endodontics and Dental Traumatology* **7**, 126–31.

Rud J, Rud V, Munksgaard EC (1996a) Long-term evaluation of retrograde root filling with dentin-bonded resin composite. *Journal of Endodontics* **22**, 90–3.

Rud J, Rud V, Munksgaard EC (1996b) Retrograde root filling with dentin-bonded modified resin composite. *Journal of Endodontics* **22**, 477–80.

Rud J, Rud V, Munksgaard EC (1997) Effect of root canal contents on healing on teeth with dentin-bonded resin composite retrograde seal. *Journal of Endodontics* **23**, 535–41.

Rud J, Rud V, Munksgaard EC (1998) Retrograde sealing of accidental root perforations with dentin-bonded composite resin. *Journal of Endodontics* **24**, 671–7.

Schüpbach P, Lutz F, Finger WJ (1997) Closing of dentinal tubules by Gluma desensitizer. *European Journal of Oral Sciences* **105**, 414–21.

Wulff HB, Schlichting P (1987) *Medstat*. Copenhagen, Denmark: Astra.