Apical transportation revisited or ‘Where did the K-File go?’

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Abstract


Case report
This case report describes the outcome of a number of retreatments on a failed root filling in a maxillary first molar. The patient wanted all amalgams replaced by tooth-coloured Cerec® restorations, including one in a symptomless maxillary molar. This tooth had a pulpotomy or a poorly done root-canal treatment 10 years earlier. The molar was root-canal retreated before placing the Cerec® restoration and the palatal canal was filled 5 mm short of the radiographic apex. About 1 year later the patient presented with pain. Suspecting that a second mesiobuccal canal (MB-2) had not been located, a second non-surgical retreatment was instituted. MB-2 was not found and the palatal canal was retreated a third time, setting the working length 2 mm short of the radiographic apex. Because pain persisted palatally an apicectomy was performed and the tooth became symptomless. The resected palatal root apex was subsequently serially cross-sectioned, photographed and the canals analysed. Obvious apical transportation occurred during the cleaning and shaping procedures. Analyses of the canals showed that despite the retreatments, 11% of the canal cross-sectional area remained uncleaned although 7% of the root area was ‘shaped’. Radiographically, the obturated palatal canal appeared reasonably well centred. However, this was disproved by the cross-sections, indicating that in this case, the clinician did not know where the K-Files had ‘gone’. Apically, the obturated canal was certainly not within the natural canal. The pain located palatally was probably due to inadequate cleaning and shaping of the apical part of the root canal and its accessory canals.

Keywords: microscope, retreatment, root canal treatment failure.

Introduction
The number of root canal treatments has been increasing rapidly in the USA and the UK during the last 40 years (Chivian 1984, Dental Practice Board of England & Wales 1996). Even if the claimed high 90 to 97% success rate in root canal treatment is maintained, the need for root canal retreatment may be high (Ruddle 1997). Persistent pain, discomfort, swelling or fistulae alert patients that the endodontic therapy may have been inadequate whilst persistent signs and symptoms inform practitioners that a retreatment is indicated. Time-consuming non-surgical or surgical techniques do not always ensure success and may involve the removal of obturating materials and/or fractured instruments (Bergenholtz et al. 1979).

Attempts to clear obstructed canals and to optimize working lengths during retreatment can aggravate transportation and cause perforations whilst total removal of gutta-percha and sealer from root treated canals is difficult (Wilcox & Van Surksum 1991). On the other hand, only thorough cleaning and disinfecting root canal systems can ensure success. Larger, less flexible files are often used in retreatments, aggravating previous procedural errors such as zipping, ledging or...
perforation (Wilcox et al. 1987, Friedman et al. 1989). Furthermore, most canals are curved in at least one plane and conventional radiographs detail mesiodistal but not buccolingual or buccopalatal curvatures (Cunningham & Senia 1992). Irrespective of their natural curvatures, canals are deviated during re-instrumentation in the same direction as they were during the initial preparation (Wilcox 1989). On account of problems involved in retreatments their success rates are lower (70%) than those reported for initial root canal treatments (up to 97%; Heling & Tamshe 1970, Ashkenaz 1979, Smith et al. 1993).

This paper documents a case in which the initial root canal therapy and the subsequent conservative retreatments failed. Nevertheless, surgical intervention has in the short term been successful. In addition, post-operative analyses were carried out on the resected root apex to examine reasons why the conservative root canal treatments failed.

Case presentation

A 45-year-old male presented (3.3.94) to have all his amalgams replaced with tooth-coloured restorations. A root canal treatment was deemed necessary for the non-vital upper right first molar (tooth 16) before placing a Cerec® inlay (Mörmann & Krejci 1992). About 10 years earlier the patient presented elsewhere with pain in tooth 16 which was, at that time, successfully treated with either a pulpotomy or an incomplete root treatment before placing the amalgam. Tooth 16 remained symptomless for 10 years, tested negative to a CO₂ sensitivity test and the diagnostic radiograph (27.4.94) showed some opaque material in the pulp chamber and coronally in the palatal canal (Fig. 1a).

The mesiobuccal, distobuccal and palatal canals were then prepared using K-Flexofiles (Dentsply; Maillefer, Ballaigues, Switzerland) with 1% NaOCl as the irrigant and RC-Prep® (Premier Dental; Norristown, PA, USA). The technique employed was step-back with push-pull movements. The canals were laterally condensed during the same visit (8.3.95; post-operative, Fig. 1b) using the sealer AH 26 (DeFrey; Zurich, Switzerland) and gutta-percha cones (Roeko; Darmstadt, Germany). Initially, tooth 16 was symptomless and the Cerec® inlay was placed. However, 15 months later (3.6.96) the patient presented with pain localized to tooth 16. The tooth was negative to sensitivity testing, mildly tender to percussion, sensitive to palatal palpation whilst probing depths were within normal limits. Radiographically, no periapical radioluencies were noted, but the palatal canal was filled 5 mm short of the radiographic apex. A provisional diagnosis of a poorly root treated palatal canal and possibly a missed second mesiobuccal canal (MB-2) was made. Consequently, the patient was scheduled for a non-surgical second retreatment using an operating microscope.

A standard access cavity was prepared, the pulp chamber was cleared of all material and the three obturated canal orifices were located (19.11.96). Despite careful examination (OP) using a microscope (Seiler 150 FM: Bucha, Germany), and an ultrasonic unit (EMS 400; Nyon, Switzerland) equipped with special tips (CT-4; EIE Analytic, Orange, CA, USA) no MB-2 was located. It was then decided to retreat only the palatal root as the patient’s pain was localized palatally with no apparent buccal involvement.

The optimized retreatment working length was set 1 mm short of the radiographic apex (Fig. 1c) and the gutta-percha and sealer were removed using files and eucalyptol. However, the canal could only be prepared to 2 mm from the radiographic apex and not as desired although ultrasonic tips (SP-2; EIE Analytic, Orange, CA, USA) were also used in the attempt to bypass the ‘obstruction’. The apical stop was prepared with a size 60 master apical file and the canal was stepped-back, 1 mm between successive files (13.12.96). Finally, the canal was obturated using cold laterally condensed gutta-percha and AH 26 sealer (14.1.97). The post-operative radiograph confirmed the obturation to be 2 mm short of the radiographic apex (Fig. 1d), the access cavity was temporarily filled (Ketac Fil; Espe, Seefeld, Germany) and the patient dismissed.

Nine weeks after the second retreatment the patient still complained of pain palatally and it was then decided to resect the palatal apex. Following marginal and vertical incisions, palatal bone was removed without using the operating microscope and a standard apicectomy was carried out (3.2.97; OP). No retrograde filling was placed because the sectioned root appeared adequately sealed. Tooth 16 was pain free one week after surgery and has remained so 6 months post-operatively.

Sectioning the palatal root apex

The resected root apex (approximately 5–6 mm long) was stored in 0.1% thymol before being embedded in clear resin (Stycast; Emerson & Cuming, Westerlo-Oevel, Belgium) and mounted on a SEM carrier (Balzers:
Balzers, Liechtenstein). The resin block was trimmed manually until the apex was just visible and the root was then serially sectioned (Fig. 2) at low speed using a 0.5 mm thick diamond-coated disc at 1 mm feed (Isomet; Buehler, Evanston, IL, USA). Five serial sections, each approximately 0.5 mm thick were produced and each specimen was photographed (Tessovar; Leitz, Oberkochen, Germany) at low and high power, ×64 and ×128 original magnification, respectively, from its coronal and the apical surfaces. Sectioning the resected root in this way yielded nine surfaces (Fig. 3a to 5f), spanning a distance of 0.5–4.5 mm from the apex. A millimetre scale was included with each photograph for subsequent calibration. The most apical surface photographed was not sectioned but filed flat and 0.5 mm of the apex was accepted as having been removed.

Measurements were recorded from slides of the cut surfaces at ×64 original magnification using a digitizer and slide scanner (Horizon Plus; Agfa Gaevert, Leverkusen, Germany). These findings were then analysed using the computer programme 'Image 1.6' (NIH; Bethesda, MD, USA). Measurements of each photographed surface included (i) the area of the sectioned root, (ii) the area of the root canal filling and (iii) the area of any unfilled natural root canal.

Results

Photographs of serial cross-sections of the resected palatal root apex

The nine apical and coronal surfaces of the five serial sections are shown step-by-step in Fig. 3a to 5f. Fig. 3a, c and e; Fig. 4a, c and e; and Fig. 5a, c and e show the apical and coronal surfaces of the first section, the apical and coronal surfaces of the second
section, the apical and coronal surfaces of the third
section, the apical and coronal surfaces of the fifth
section, respectively, at low power (×64 original mag-
nification). Fig. 3b, d and f; Fig. 4b, d, and f; and
Fig. 5b, d and f show the corresponding surfaces at
higher power (×128 original magnification).

No distinctly shaped root canal nor root canal filling
was visible at sections cut 0.5, 1.0 and 1.5 mm from
the root apex (Fig. 3a–f). The uninstrumented main
canal and other portals of exit were present (Fig. 3a,
b). The coronal surface of this first section, 1.0 mm
from the apex (Fig. 3c, d) shows several canals in
cross-section containing opaque material. The
sectioned canals at these level probably represent the
apical delta of the palatal canal system.

A round prepared 'false' canal is first visible 2 mm from
the apex (Fig. 4a, b), and contains only sealer but no
gutta-percha cones. This shaped canal is located about
0.5 mm away from the unsheared oval natural canal,
confirming that apical transportation had occurred. The
distance between the unprepared natural canal and the
prepared 'false' canal decreased with increasing distance
from the apex (Fig. 4c, d and Fig. 4e, f). The transported
false canal was better obturated (Fig. 5a–f) with minimal
amounts of sealer and well condensed master and
accessory cones. The obturated canal at this level almost
totally obliterated the natural canal which contains
gutta-percha, sealer and necrotic pulp tissue remnants.

Measurements of cross-sections

The results of all the cross-sectional areas measured at
the various levels from the root apex are summarized in
Table 1. The cross sectional areas of the resected root
increased gradually from 1.33 mm² to 10.49 mm² at
distances of 0.5 mm to 4.5 mm from the apex, respec-
tively. In contrast, the areas of the root canal fillings
(0.6 mm²) remained almost constant between the
2.5 mm and 4.5 mm range. The area of the unshaped,
unfilled root canal varied from 0.03 mm² to 0.06 mm²
between the 2.5 mm to 4.5 mm levels.

Discussion

Root canal therapy in the case described failed initially
and after two subsequent retreatments. Although the
final surgical intervention resolved the pain or
discomfort associated with this tooth, serial sections of
the resected apex showed that apically, the canal was
neither adequately cleaned nor obturated. The apical
transportation was severe and at the point of resection,
portation, this part of the canal was filled with sealer only (Fig. 4a, b) whilst the lateral condensation was also inadequate even 3 mm from the apex (Fig. 4e, f).

Root canal failures are retreated surgically or nonsurgically from the outset, depending on the situation and the clinician’s philosophy. In the case described non-surgical intervention was selected initially because an untreated MB-2 was suspected. During the examination using an operating microscope no MB-2 was located (Carr 1992) and the palatal root was then resected because the pain was localized palatally and no periapical pathology was visible around the two obturated buccal root apices.

Removing obturating materials, reshaping canals and optimizing working lengths are major objectives during root canal retreatment. However, complete removal of all sealer and gutta-percha during retreatment is almost impossible (Wilcox et al. 1987) and any existing transportation can easily be aggravated. Nevertheless, the palatal root’s working length in the current case was optimized from being 5 mm to 2 mm short of the radiographic apex (Sjogren et al. 1990). Although no significant transportation was radiographically apparent in the current case (Fig. 1d), subsequent sectioning of the resected root showed that severe apical transportation had occurred (Fig. 4a to 5f). This substantiates difficulties in deciding, from radiographs, whether transportation has occurred in canals that appear well centred. This applies even if the radiographs are taken at varying projections. Obviously, a well-centred appearing canal does not guarantee that transportation has not occurred. In other words, when treating curved canals, clinicians are not always sure where their endodontic files have ‘gone’ even if they appear centred in the apical thirds. Nevertheless, a well-centred canal preparation is more desirable than an obviously transported canal. Only mesiodistal radiographs can confirm clinical centricity; this procedure is not currently routinely possible but may be so in the future.

Difficulty in maintaining the canal’s natural morphology during initial therapy or retreatment is partly because of the rigidity of conventional endodontic instruments, the curvature of the root canal and the radius of the curvature. In the current

Figure 4 The three paired sections (a to f) were taken at high and low power 2.0 mm, 2.5 mm and 3 mm from the root apex, respectively. They detail the instrumented ‘false’ canal (→), initially 0.5 mm away from, but progressively approximating the main canal (arrowed). The prepared canal is filled with sealer only in a and b, poorly laterally condensed with the blue-coloured master cone and sealer (c and d) and (e and f) details an indented master cone which is not filled with an accessory cone. The unprepared natural canal contains some unidentified material (arrowed).

Figure 5 The three paired sections (a to f) were taken at high and low power 2.0 mm, 2.5 mm and 3 mm from the root apex, respectively. They detail the instrumented ‘false’ canal (→) which progressively encroaches the main canal (arrowed). The ‘false’ canal is better laterally condensed than in the previous sections but the main canal still contains remnants of gutta-percha and sealer from a previous treatment and probably some remains of necrotic pulp tissue.
case 11.7% of the canal remained unprepared at the 3 mm level although 7.1% of the root cross-sectional area was removed during shaping (Fig. 4e, f). Furthermore, a size 60 Master Apical File had, at distances between 3 and 4.5 mm from the apex, had not removed all the gutta-percha and sealer placed previously (Fig. 4a to 5f). At the 2.5 mm level (Fig. 4b, c) the natural canal remained unshaped and uncleaned although 8.2% of the root cross-sectional area had been removed. Consequently, any microorganisms present in that canal were not removed during retreatment (Bergenholtz et al. 1979, Friedman & Stabholz 1986, Wilcox et al. 1987). Recent studies have shown that non-cutting pilot tips and rotating instruments do minimize the degree of canal transportation in curved canals (Roane et al. 1985, Short et al. 1997, Portenier et al. 1998).

Deciding whether to carry out surgical or non-surgical endodontic retreatment from pre-operative radiographs can be difficult (Fig. 1a). Clinicians vary in the types of treatments they suggest after examining radiographs of the same cases and also recommend different treatments after examining the same radiographs at different times (Gelfand et al. 1983). This poor consistency probably indicates that the criteria for non-surgical and surgical retreatment are not yet adequately defined (Bergenholtz et al. 1979, Friedman & Stabholz 1986). This may partly contribute to the fact that success rates after surgical retreatments are significantly lower than those reported for non-surgical retreatments (Hirsch et al. 1979, Allen et al. 1989, Friedman et al. 1991). The palatal root apex in this case was not resected using the operating microscope and a buccal approach. Instead, the palatal apex was accessed from the palate. A root-end filling was not placed in the current case because visual inspection of the resected root stump showed a centred, round, well-condensed canal. However, an unshaped and unfilled part of the natural canal was present which may have clinical relevance in the future. This finding suggests that resected stumps should always be examined with loupes or operating microscopes to ensure that root-end cavity preparation can be avoided. Although the post-operative period of the current case is short and the tooth remains symptomless, the prognosis may be compromised because a part of the natural canal has neither been correctly shaped nor obturated.

Conclusion

This case details a failed initial endodontic treatment of a maxillary molar followed by two subsequent failed retreatments. Although the final surgical intervention resolved the pain associated with the tooth, serial sections of the resected apex showed that the main canal in the retained palatal stump was probably not adequately cleaned. The resected palatal apex was transported, the canal was poorly shaped and poorly obturated and still contained remnants of a previous inadequate root filling. Although the root filling of the retained root appeared well condensed, this was disproved by examining the sections. This lends support to the fact that magnification should be used during apical resections, but certainly indicates that clinicians do not always know where their files and reamers go in relation to the canal even when they appear well-centred radiographically.

References


