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Management of the open (immature) apex. 2. Non-vital teeth

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Introduction

As opposed to treatment modalities which are designed to preserve pulpal integrity to allow for normal root lengthening and closure – apexogenesis (Dannenberg 1974, Tenca & Tsamtsouris 1978, Gutmann & Heaton 1981) – apexification procedures are intended to stimulate a productive reparative response in the case of the non-vital pulp, with or without apical pathosis, in order to achieve apical closure prior to endodontic treatment. Heretofore, the management of the immature apex in non-vital teeth was limited to custom-fitting the filling material (Stewart 1963), paste fills (Friend 1967) and apical surgery (Ingle 1965). All of these procedures suffer from inherent technical constraints and tend to be compromises in treatment (Bradley 1977); therefore, the need for biological treatment of the non-vital tooth with an immature apex is apparent and treatment should be directed to this end.

Materials and rationale

Various materials have been used to induce apical closure or healing in the non-vital tooth with an immature apex. These include antiseptic pastes (Bouchon 1966, Cooke & Rowbotham 1960, Holland *et al.* 1971), antibiotic pastes (Ball 1964) and root canal sealers (Friend 1966, 1967). Recent attempts to induce apical closure with a resorbable tricalcium phosphate ceramic in monkey teeth by Koenigs *et al.* (1975) and in human teeth by Roberts & Brilliant (1975) have been partially successful.

A high level of clinical success has been reported with the use of calcium hydroxide and camphorated *p*-monochlorophenol paste (Frank 1966, Steiner *et al.* 1968, Van Hassel & Natkin 1970, Dylewski 1971), calcium hydroxide and metacresylacetate (Klein & Levy 1974), calcium hydroxide and saline (Citrome *et al.* 1979, Biesterfeld & Taintor 1980), calcium hydroxide and distilled water (Binnie & Rowe 1973, Holland *et al.* 1978) and calcium hydroxide in a methylcellulose base (Heithersay 1970). The common denominator in all of these studies is the use of calcium hydroxide either to induce apical healing and closure or to create an environment conducive to healing.

Various modes of action have been attributed to calcium hydroxide and its ability to promote a productive reparative response. These include a high hydroxyl ion concentration (Masterton 1966, Schroder & Granath 1972), a high pH (Berman 1958, Fisher 1972), tissue coagulation in contact with calcium hydroxide (Berman & Massler 1958, Massler 1972, Schroder & Granath 1972, Schroder & Sundstrom 1974), high calcium ion concentration at the precapillary sphincters and decreased plasma flow (Heithersay 1975), action upon enzymatic pathways during collagen formation (Heithersay 1975) and particle size of calcium hydroxide (Roberts & Brilliant 1975). As the calcium ions of the dressing do not enter into the hard tissue that is formed (Sciaky & Pisanti 1960, Pisanti & Sciaky 1964), the exact mechanism whereby calcium hydroxide may induce apical healing and closure has yet to be elucidated. What is

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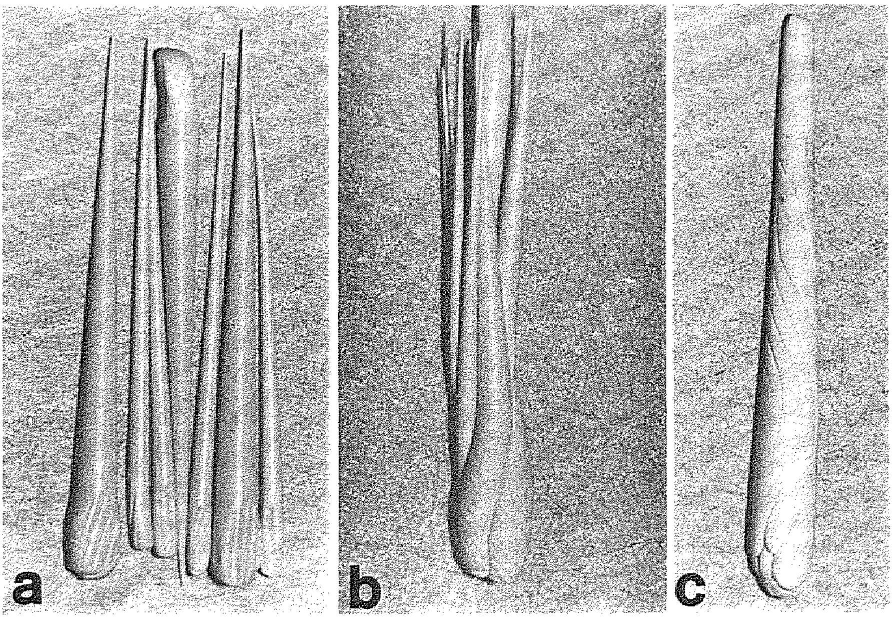


Fig. 1. A custom cone can be made by fusing two, three, or more large cones. **a** The cones are softened, **b** fused together and **c** rolled between two glass slabs to the desired size and taper.

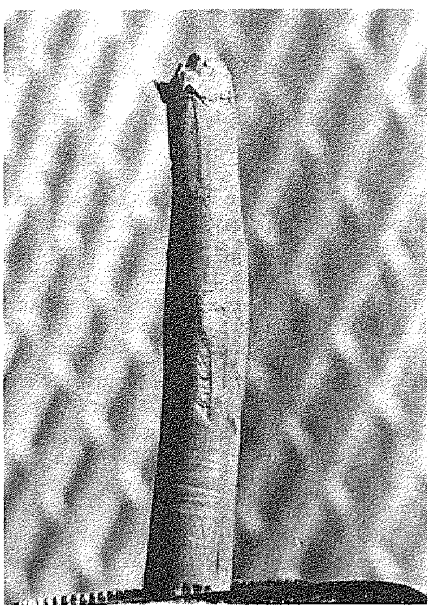


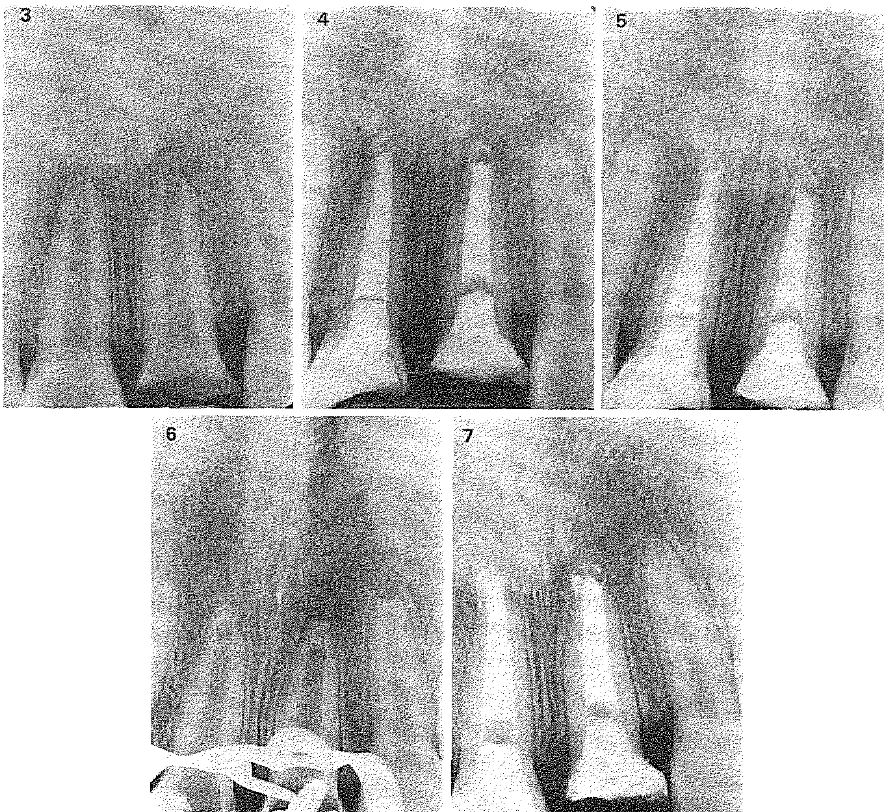
Fig. 2. The custom cone may be softened in warm water in the apical one-third and adapted to the internal shape of the canal.

clear, however, is the fact that thorough cleansing of the immature root is necessary to establish an environment conducive to healing. In all probability, it is the combination of canal debridement, chemo-mechanical cleansing and the placement of a calcium hydroxide dressing which allows for a favourable apical response.

The nature and type of tissue that is formed apically usually exists as a cap, bridge or ingrown wedge, and may consist of cementum, bone, dentine or, as Dylewski (1971) terms it, 'osteodentine'. While radiographically appearing complete, often this type of healing is porous or weak in certain areas as the developing root diaphragm in the labiolingual plane lags behind that in the mesiodistal plane of the immature root (Friend 1967, Duell 1973). Careful clinical evaluation of the apical healing during treatment is recommended and will be addressed in the techniques of this treatment.

Technique of apexification

The following technique will provide a



Case No. 1

Fig. 3. Periapical lesions associated with pulpless maxillary central incisors in a 13-year-old male following trauma.

Fig. 4. Four months following the insertion of a calcium hydroxide/barium sulphate paste (5 : 1 respectively). Sterile saline was used as the vehicle in the right incisor and camphorated *p*-monochlorophenol was used in the left incisor. Radiographic evidence of slight healing without calcific bridging is present.

Fig. 5. Twelve months following the insertion of calcium hydroxide, both teeth exhibit radiographic evidence of healing and apical calcific bridge formation.

Fig. 6. Immediately following removal of paste from the canals. Clinically, both teeth demonstrated solid apical closure when probed.

Fig. 7. Immediately following canal obturation with gutta-percha and Grossman's sealer. Note small areas of sealer extrusion through the porous apical barrier.

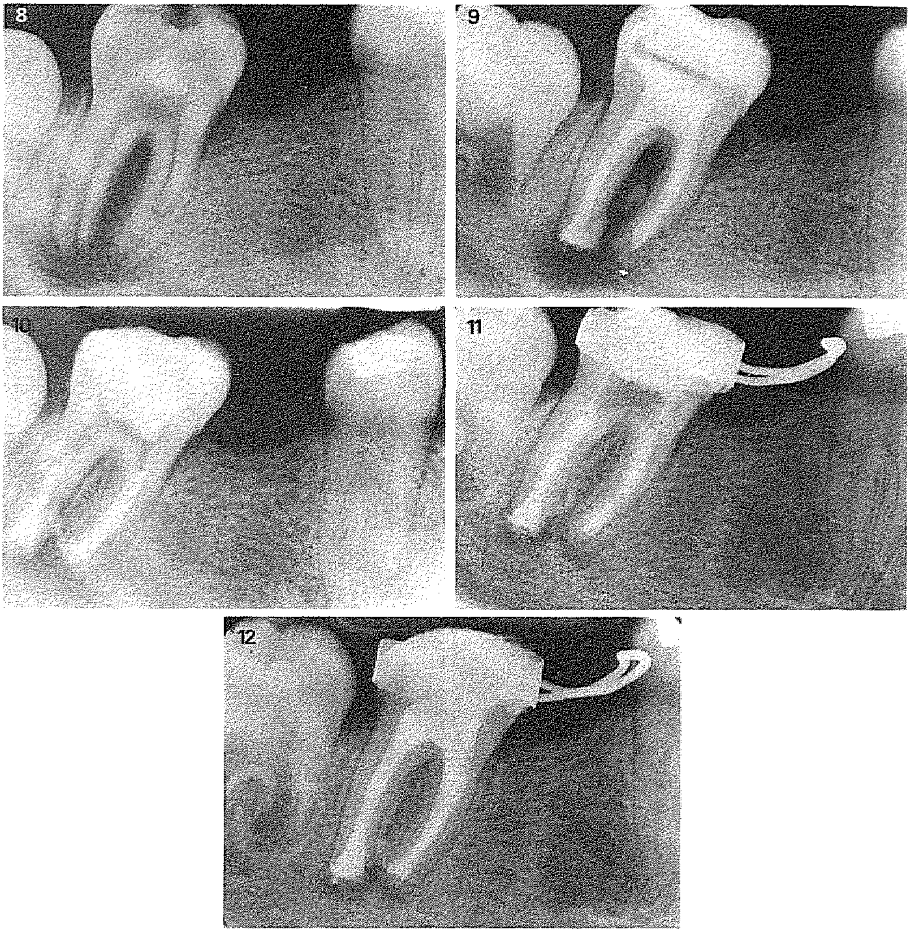
general approach to all apexification cases, whether anterior or posterior, and should be modified by the individual practitioner, as appropriate, given a patient with a specific set of circumstances.

1 Whenever possible, the tooth should be isolated with a rubber dam.

2 The access opening should a provide an unrestricted access to the root canal walls and apex; and b remove all tooth structure which may be weakened or may harbour necrotic debris.

3 Pre-measure the tooth radiographically, making sure the radiograph is not severely foreshortened or elongated. Always try to stay short of the fragile root canal walls at the apex until a length has been determined. In addition, use larger instruments to secure the length determination.

4 Once root length is established,



Case No. 2

Fig. 8. A large periapical lesion associated with a pulpless mandibular left first molar in a 14-year-old female. Note bone destruction in the furcation.

Fig. 9. Immediately following canal debridement and the placement of calcium hydroxide/barium sulphate (5 : 1 respectively) paste, using sterile saline solution.

Fig. 10. Seven months following the initial placement of the calcium hydroxide paste. The coronal paste had washed out due to loss of the temporary filling. Note osseous repair in the periapical and furcation areas. While calcific bridging was evident radiographically, when probed, distal root closure was incomplete. All canals were recleaned and repacked with calcium hydroxide/barium sulphate paste.

Fig. 11. Seven months after the second application of calcium hydroxide paste, there are both radiographic and clinical signs of increased periapical healing.

Fig. 12. The paste was removed and the canals were obturated with gutta-percha and Grossman's sealer. Note the small puff of sealer exiting from the apex of the distal root.

preferably 1.0 – 2.0 mm from the most apical extent of the root wall, the canal is biomechanically cleansed in a serial fashion using dilute sodium hypochlorite (2.5% or less) or a sterile saline and K-type or Hedstrom files. Care must be taken to avoid removal of too much tooth structure which will weaken an already compromised tooth. It is not uncommon to have to clean a canal which is much larger than existing available instruments (> 140).

5 The canal may be dried using X-coarse paper points in reverse or by wrapping sterile cotton around the largest file.

6 If the patient is asymptomatic, the prepared canal may be filled using one of two techniques: a a commercial, injectible calcium hydroxide paste may be used or calcium hydroxide powder (5 parts) and barium sulphate (1 part) may be mixed with any of the previously mentioned vehicles into a thick paste, placed in a 3–6 cm syringe with 13–15 gauge needle, and injected; or b the calcium hydroxide/barium sulphate paste may be placed into the canal using a combination of a large custom pre-fit gutta-percha cone and/or large root canal pluggers. Although care should be taken not to extrude any appreciable amount of material past the apex, the periapical tissues appear to tolerate this material quite well.

7 It is critical to provide an impervious coronal seal to prevent salivary and bacterial contamination. This may consist of double-sealing the access, a stainless-steel crown, etc. In addition, where needed, extra measures may be required to protect the tooth against fracture.

8 Radiographic examination should be scheduled every 8–12 weeks to observe any apical changes. Some clinicians recommend changing the dressing at each examination interval. However, this approach may disturb or delay the reparative process already begun. If, after 6–9 months, there does not appear to be dramatic radiographic changes in apical closure, one may choose to remove the calcium hydroxide dressing through voluminous flushing with irrigant, and check for a barrier with a size 35–50 K-type file. Occasionally, a thin, non-opaque bridge may form at the apex, which although not apparent radiographically, provides a definite apical stop conducive to canal obturation procedures. If no barrier is present, proceed to refill the canal with a new mix of calcium hydroxide. Root closure generally occurs between 3 and 24 months. Failure to do so may indicate an overlooked aetiology, i.e. vertical fracture, persistent apical cyst (West 1980).

Treatment following apexification

Once apical closure or an apical barrier is achieved and the patient is asymptomatic, the root canal should be obturated with a solid-core filling material and sealer as follows:

1 Isolate with a rubber dam and establish access to the canal space.

2 Flush the canal of calcium hydroxide remnants and carefully establish the length of the tooth. Instrument only to freshen the walls and remove excess residual paste.

3 Usually, the canal is highly irregular and its size exceeds that of any available standardized gutta-percha cone. Therefore, a custom cone of two, three, or more large cones is fabricated by softening the cones (Fig. 1a), fusing them together (Fig. 1b) and evenly rolling them between two glass slabs to the desired size and taper (Fig. 1c). It is also recommended that this cone be softened in warm water in the apical one-third and custom-adapted to the internal shape of the canal (Fig. 2). This will ensure better adaptation to the canal's internal and apical irregularities.

4 Any acceptable root canal sealer may be used with the custom master cone, along with the operator's preferred filling technique. Ideally, vertical condensation with warm gutta-percha (Schilder 1967) will enable the operator to achieve a close adaptation with the gutta-percha and sealer.

5 Following canal obturation, an appropriate permanent restoration may be placed.

Case reports

Reports of two cases are given in Figs 3–12. Figs 3–7 illustrate treatment of Case No. 1, a 13-year-old male, and Figs 8–12 illustrate treatment of Case No. 2, a 14-year-old female.

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