Modern Endodontic Planning 2: Access and Strategy

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Modern Endodontic Planning Part 2: Access and Strategy

Abstract: Poor access and iatrogenic damage can result in failed root canal treatment. Understanding tooth anatomy improves access and ensures that the clinician is cleaning and shaping the whole root canal system. If a canal is missed treatment usually fails. This paper revisits tooth anatomy and discusses how to ensure that access is optimized, but not at the expense of precious tooth structure. The concept of multi-visit root canal treatment is also addressed with emphasis on the, often overlooked, aspect of temporization.
CPD/Clinical Relevance: Good anatomical knowledge of teeth is the cornerstone of endodontics. Once root treatment has begun the clinician must be logical about how many visits to take and how to temporize teeth between such visits.
Dental Update 2015; 42: 709-720

Root canal treatment is complex and time consuming. Good access facilitates placement of instruments, improves vision and limits iatrogenic damage. This makes the procedure more comfortable for both dentist and patient. Knowing what to expect after access removes surprises and helps support the biological goals of cleaning and shaping. This is only possible with a sound understanding of root canal anatomy and canal configurations. Finally, the clinician must give consideration to whether a multi-visit strategy is required and, if so, the importance of good temporization.

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Access

Accessing the root canal system can be one of the biggest challenges to successful root canal treatment. The ability to get instruments into the canal system unimpeded using a glide path without unnecessary damage to a tooth can facilitate endodontic treatment for the practitioner. Based on analysis of extracted teeth, a series of 'laws' have been developed to help dentists achieve these goals.[1]

To locate the pulp (Figure 1)

- Law of centrality: the pulp will be in the centre of the tooth.
- Law of the CEJ: the pulp will always be located at the level of the cemento-enamel junction (CEJ).
- Law of concentricity: the walls of the pulp chamber will be concentric (share the same centre) to the outer wall of the tooth.

The use of radiographs is essential to correlate canal position and the extent of access. The approach to the pulp should follow the long axis of the tooth and preserve as much coronal tissue as possible. Using these 'laws' demands good spatial awareness and access should optimally be achieved before the rubber dam is placed. It is often sensible to 'eyeball' the distance from cusp tip to CEJ with the selected bur before entering the tooth. If the bur is not going to depth, the access is too shallow. Conversely, if the bur is well beyond the CEJ and the pulp not located, stop instrumentation, reassess and take a radiograph.

The floor of the tooth is darker than the walls or the roof of the pulp chamber and, by definition, is located at or below the CEJ. Non-end-cutting burs (such as the *Endo Z bur*, Dentsply, Weybridge, UK) can be used to expand the coronal access safely and remove the chamber roof

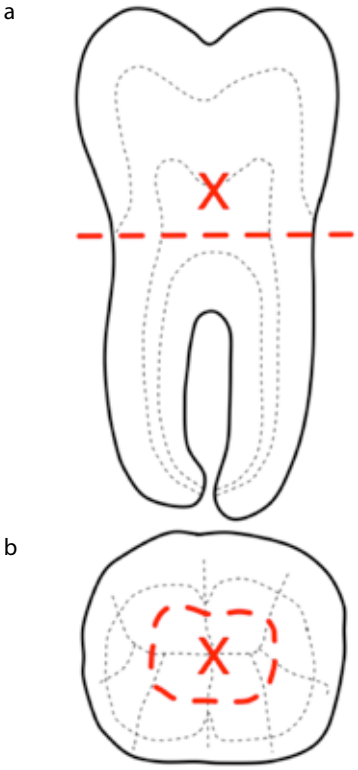

Figure 1. Pulp Location. **(a)** Centrality: the pulp (X) is found in the middle of the tooth at the level of the CEJ (---). **(b)** Concentricity: the walls of the pulp (---) are concentric with the outer perimeter of the tooth.

	Number of Canals (%)	
Tooth	**Maxilla**	**Mandible**
1	1 (100%)	1 (1 foramen 58%) 2 (1 foramen 40%) 2 (2 foramina 1.3%)
2		
3	1 (100%)	1 (94%) 2 (6%)
4	1 (6.2%) 2 (90.5%) 3 (1.1%)	1 (1 foramen 73.5%) 2 (1 foramen 6.5%) 2 (2 foramina 19.5%)
5	1 (40.3%) 2 (58.6%) 3 (1.1%)	1 (1 foramen 85.5%) 2 (1 foramen 1.5%) 2 (2 foramina 11.5%)
6	Mesio-buccal root 1 (1 foramen 38%) 2 (1 foramen 37%) 2 (2 foramina 25%)	Mesial Canal 1 (1 foramen 13%) 2 (1 foramen 49%) 2 (2 foramina 38%) Distal Canal 1 (70%) 2 (28.9%)
7	Mesio-buccal root 1 (1 foramen 63%) 2 (1 foramen 13%) 2 (2 foramina 24%)	Mesial Canal 1 (1 foramen 13%) 2 (1 foramen 49%) 2 (2 foramina 38%) Distal Canal 1 (1 foramen 92%) 2 (1 foramen 5%) 2 (2 foramina 3%)

Table 1. Differing teeth and the number of canals one may expect to find.[3]

remnants whilst protecting the pulpal floor. The DG16 probe remains invaluable in fine exploration of the pulp chamber and canal system. It is essential to remove the entire roof of the pulp chamber.

Once in the pulp chamber, canals must be identified. To locate the canals, further laws have been proposed[1] (Figure 2). It is important to note that these 'laws' should only be used as a guide to access and do not apply to upper first and second molars:

- Laws of symmetry: orifices are equidistant from and perpendicular to a line drawn in a mesio-distal direction through the pulp chamber floor. If a canal is found on this conceptual line there is unlikely to be a second canal in that root. Conversely, if there is a canal lingual to that line there is most likely a second canal, at a similar distance and perpendicular to that line, in the buccal aspect of the root.
- Law of colour change: the pulp chamber floor is always darker than the walls.
- Law of orifice location 1: located at the junction of walls and floor.
- Law of orifice location 2: located at angles in the floor-wall junction.
- Law of orifice location 3: located at the terminus of the developmental fusion lines.

Diamond-coated ultrasonic tips can be useful in removing dentine to facilitate canal access (Figure 3). It is also good practice to have smaller stainless steel K-files available, including finer ISO 06 and ISO 08 sizes. With these instruments, blockages and sclerosed regions may be successfully instrumented. Unfortunately, the rules of symmetry do not apply to maxillary molars, which are asymmetrical in shape, but the other rules may be applied. For maxillary molars, do not access distal to the oblique ridge, and expect to find the canals central to the cusp tips (Figures 4 and 5). Maxillary second molars tend to have a more ovoid pulp chamber extending from mesio-buccal to palatal rather than the more triangular appearance on the floor of the maxillary first molar.

Anatomy

Studies of extracted teeth reveal the anatomy of the pulpal system to be complex (Figure 6). Vertucci classified eight basic formations of canal structure (Figure 7).[2] Rather than remember a complex categorization, it is often easier to describe the canal system in numeric terms: a canal

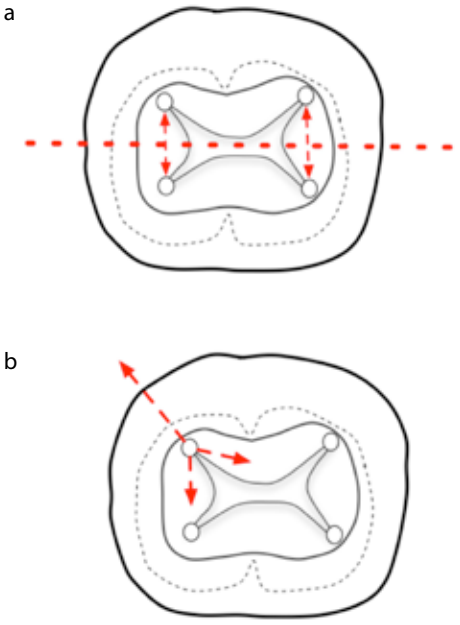

Figure 2. Canal location. **(a)** Symmetry (arrow symbols): canals are perpendicular to, and equidistant from, a line passing mesio-distally through the middle of the tooth. The colour of the pulp floor is always darker. **(b)** Canals (arrow symbols) are found at the terminus of incremental lines at the junction of floor and walls.

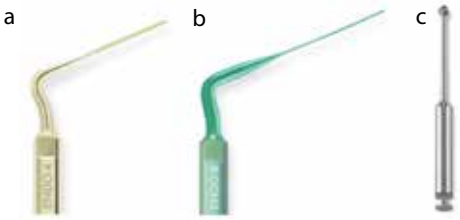

Figure 3. (a) Diamond-coated ultrasonic tips can be used to locate and access canals but can be very aggressive. **(b)** Titanium ultrasonic tips offer more control of dentine removal. For all ultrasonically activated tips, the power must be reduced to prevent these instruments breaking. **(c)** Long neck (LN) burs are useful for controlled removal of dentine whilst allowing improved visibility. (Images courtesy of Dentsply, Tulsa, USA.)

that bifurcates is a 1–2, or a canal that coalesces is a 2–1. This type of information is invaluable in communicating the difficulties of root canal treatment to the patient and when liaising with colleagues. Though the clinician cannot be expected to know the minute complexities of the canal pattern, recognition is important. If a canal appears radiographically patent coronally,

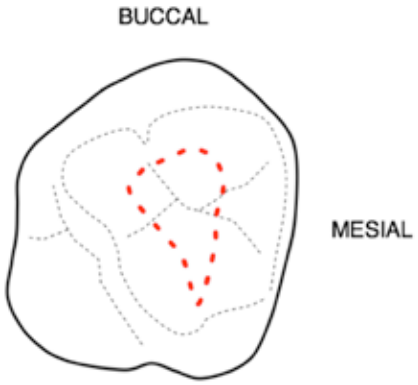

Figure 4. Upper molars require an asymmetric approach. Stay central to the major cusp tips and do not cross the oblique ridge. Upper 7s often follow a similar pattern but to a much more exaggerated form, ie shorter mesio-distal width.

but disappears apically, it may bifurcate (Vertucci V). If two lamina dura are evident radiographically, this suggests ovoid, dumbbell-shaped roots or even a second root, all of which indicate a second canal (Figure 8).

It is invaluable to know when a root is more likely to have more than one canal and, using the laws described above, recognize the need to find additional canals. For this reason it is important to have a working knowledge of the variations that may present in surgery. Table 1 presents some figures on the incidence of second canals throughout the dentition.[3] More than 40% of lower incisors have two canals: this often explains persisting pathology following treatment (Figure 9). It is useful to know that >50% of upper second premolars have two canals or that 10–20% of lower premolars have two canals.[3] All clinicians should look for a second mesio-buccal canal in upper first permanent molars; one study has suggested that this is present in >95% of cases.[4] It is also useful to be aware of the distinction between two and one foramina. Of lower first permanent molars, 49% have two mesial canals but only one foramen. Obturating becomes a problem when canals coalesce and this explains why both canals may allow instrument access to length, but upon insertion of a master point in the second canal it will not seat to the prepared length. (In this situation the clinician should simply cut the tip of the point so that it abuts gently against the first point – see Paper 5).

Other anatomical variations that must be considered include:

Additional roots (Radix entomolaris/radix paramolaris) (Figure 10)

These include additional disto-lingual and disto-buccal roots (respectively) on lower molars. An accessory cusp may be an early warning sign for an additional root. These can be conical, curved or double curved and may present in up to 14.4% of the population with a predisposition to certain ethnic groups (those with Mongoloid genetics).[5] Often, these are only revealed with parallax radiography or CBCT. If present, coronal access must be widened to follow the root form and standard endodontic treatment can follow. The clinician should be aware that these canals may be severely curved.

Pulp stones

These are discrete calcifications free within the pulp or attached to dentine. A true pulp stone is an odontoblast-lined ball of dentine. A false pulp stone is simply calcification of fibrous tissue and a denticle is a dentine ball that is cavitated with epithelial remnants. Multiple pulp stones may be present within teeth and are most commonly found in molars and restored teeth:[6] practically all may present as blockages to canal patency but can be readily removed. Care must be taken when these are present that they are not inadvertently pushed down canals where they can cause an iatrogenic blockage! Copious irrigation with hypochlorite and EDTA and the use of ultrasonics should dislodge these.

Pulpal obliteration (calcific metamorphosis/ pulpal sclerosis/dystrophic calcification)

Ageing results in the deposition of tertiary dentine. An inflammatory stimulus may result in generalized dystrophic calcification of the pulp system. This usually affects anterior teeth following trauma. Teeth are often yellow and may elicit unreliable responses to sensitivity testing due to an increase in the density of the dentine. Sclerosed anterior teeth may only become periapically involved in 8.5% of cases, therefore obliteration alone is not

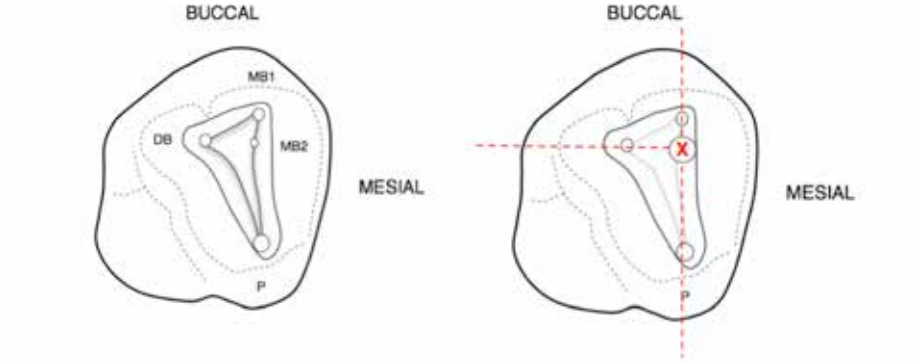

Figure 5. The search for MB2 begins by dropping an imaginary line from the DB canal perpendicular to a line connecting MB1 and P canals. The opening is usually covered by a lip of dentine. X marks the spot!

a–c

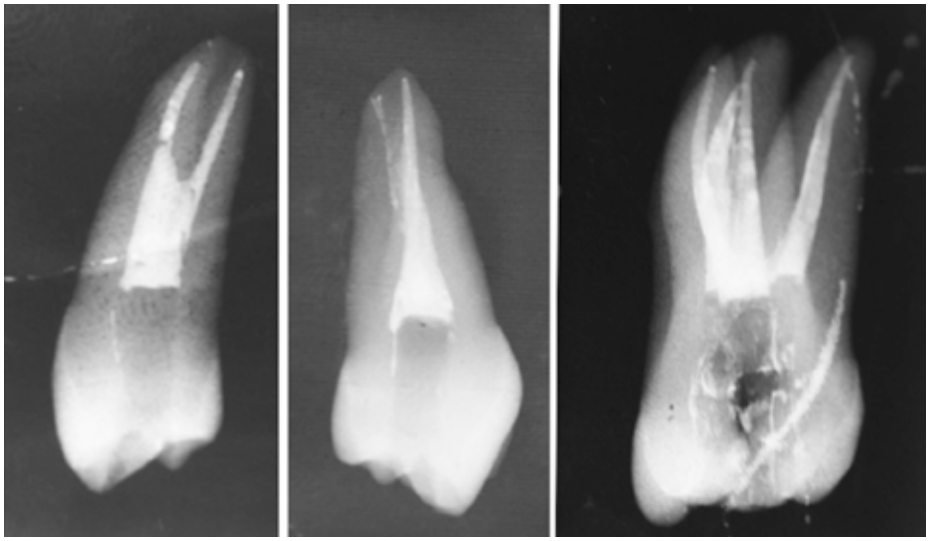

Figure 6. (a–c) Radiographs taken from a lateral view reveal the differences in canal morphology. A conventional radiograph would not have revealed the second canal, leaving a significant portion of the tooth untouched by instruments and failure likely.

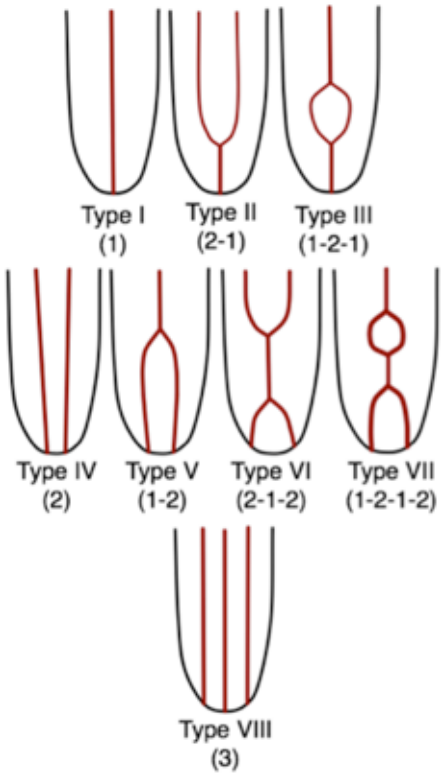

Figure 7. Vertucci's classification of canal morphology: 8 Classes. Clearly, it is impossible to clean and shape many such patterns.

necessarily an indication for endodontic intervention.[7] If there is evidence of sclerosis and periodical change, intervention may become necessary. These are invariably patent despite the radiographic appearance to the contrary.[8] Treatment involves using small files with a watch-winding motion and an irrigant that dissolves mineralized tissue (EDTA). Magnification, illumination and ultrasonics will help.[9]

Dens in dente (dens invaginalis)

This is a distortion of the enamel organ during development that can range in presentation from a small pit on the cingulum of incisors to a deep penetrating canal that opens apically. This canal may or may not connect with the pulp space.[10] The extent is often only quantified following CBCT examination. When present, root canal treatment of the invagination alone may suffice but, with deep extensions and endodontic involvement, treatment must include the canal and the tooth may require endodontic surgery.

Taurodontism

This is a deformation of the pulp chamber morphology resulting in an alteration of the ratio of pulp chamber height to root length.[11] Practically, the canal orifices are located more apically and this may complicate access. Good illumination and magnification are essential.

Once accessed, the focus of treatment moves towards working length determination and shaping. These will be covered in the next paper. This paper will now address the single vs multiple visit debate and give some consideration to the 'art of temporization'.

The single vs multiple visit debate

In necrotic teeth, the biological basis of endodontic therapy is the elimination of bacteria within the canal system. Differences of up to 26% could be found in the success rates of teeth with positive bacterial culture before obturation and those without.[12] It is incumbent upon the clinician to attempt to reduce or eliminate bacteria as part of the root canal treatment process. Performing treatment over multiple visits may help achieve such a goal; yet many clinicians favour a single visit approach involving chemo-

mechanical preparation and obturation in one appointment. Opinion is divided as to which is the better technique.

Two-visit strategy

The root canal system is complex.[2] Accessory and lateral canals are common in all teeth.[2,13] Canals may have isthmuses, fins and ramifications. Apically there may be multiple branches forming the apical delta. As a result, complete mechanical cleaning of the root canal system is impossible. Furthermore, studies have demonstrated persistent bacterial presence in root canals after cleaning and shaping.[12,14] The use of inter-appointment dressings, such as calcium hydroxide, may help eradication of residual bacteria and has been proposed as an important step in the chemo-mechanical disinfection of the canal system.[15] Thus, a two-visit approach has significant theoretical and practical benefits.

Should a two-visit strategy be chosen, the practitioner should aim for complete mechanical preparation on visit one followed by the placement of an intracanal medicament and final chemical lavage and obturation at visit two around 5–7 days later.[16]

Single-visit strategy

A negative bacterial culture before obturation is not always predictive of success and complete bacterial eradication is not possible. One could go to great lengths with a multi-visit approach and not improve the outcome.[12,14,17] Intracanal medicaments are only beneficial when in contact with bacteria, and this may not occur if they are not introduced throughout the canal system. Thus calcium hydroxide may not sterilize the canal and bacterial colonies may persist.[15,18] Multiple visits necessitate more appointments which demands greater time from the patient, greater cost and more dental exposure than many patients would want. Furthermore, the placement of a temporary restoration may act as a portal of entry for bacteria between visits, thus negating any benefit. It has been suggested that immediate obturation entombs any remaining bacteria and ensures that a good coronal seal is established immediately, preventing recolonization and improving success.[19]

The evidence, however, suggests that there is no difference in success between single and multiple visit strategies (Table 2).[20-23] Clinical scenarios do remain when it is logical to follow a defined strategy. In previously vital or non-infected teeth, single visit treatment should be practised wherever possible: bacterial eradication is not necessary and multiple visits may increase the likelihood of bacterial contamination. If there is pre-existing infection and frank periapical change, the clinician must be aware that a more robust disinfection is required. Thus it is up to the operator to decide, in conjunction with the patient, what strategy is better considering time, cost, personal experience, disease type and presentation. Complex re-treatments and teeth with complex anatomy may necessitate more time than a single visit would allow and, in these instances, a multiple-visit approach may be essential.

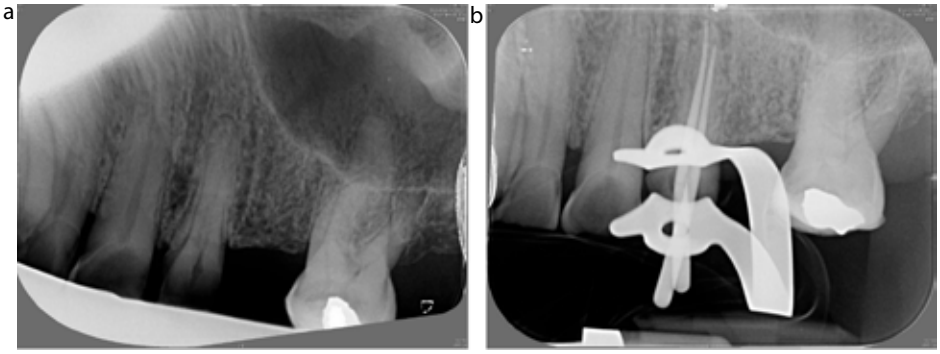

Figure 8. (a, b) Double lamina dura UL4 RR suggestive of second canal. This was confirmed intra-operatively.

Figure 9 (a) Persist periapical pathology following RCT. **(b)** A sagittal view CBCT reveals the presence of a second lingual canal. **(c)** Healing following re-treatment including the second canal.

Figure 10. Radix entomolaris (arrowed) on an extracted lower first molar.

Temporization

Should one elect for a multiple-visit strategy it is clearly essential that

Wahl 1995[20]	Single visit safe and effective
Field *et al* 2004[21]	Single visit viable
Sathorn *et al* 2005[22]	Single visit may be slightly more effective
Figini *et al* 2008[23]	Cochrane review assessing outcomes of single vs multiple visit root canal treatment. The primary outcome of the review was evidence of failure: loss of the tooth or periapcial disease. Secondary outcomes included aspects such as pain, swelling and sinus formation. More post-operative pain may be seen in single visit treatments.

Table 2. Is there evidence of a difference? There is great heterogeneity in the methods and quality of many studies precluding direct comparison.[20–23]

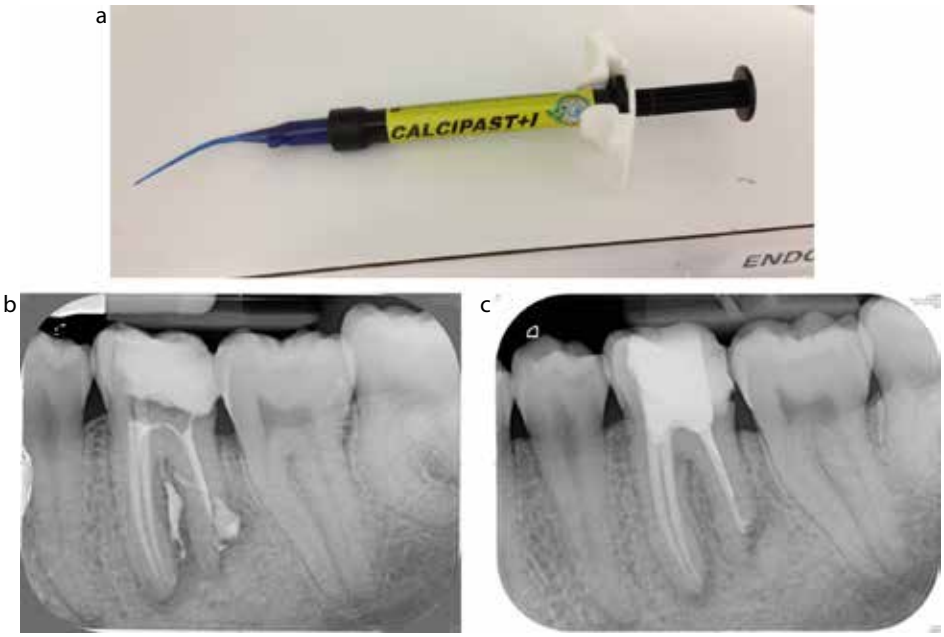

Figure 11. (a) *Calcipast+I* PD, Switzerland is calcium hydroxide and iodoform. The flexible cannula tip allows the placement of the dressing deep into the canal. **(b)** Following dressing the radiograph reveals *Calcipast* tracking through the periradicular tissues. **(c)** At 3 months following definitive obturation. Note the extensive healing already evident and full resorption of the extruded paste.

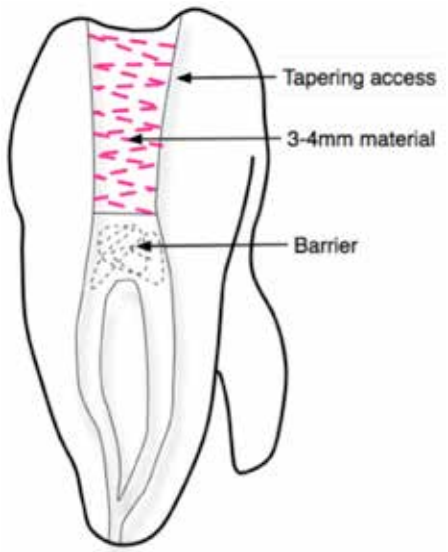

Figure 12. Ideal temporization: a barrier over the canals is placed and 3–4 mm of restorative material.

consideration is given to both the intracanal medicament and the temporary restorations placed.

Intracanal medicaments

Intracanal medicaments help:

1. Eliminate remaining bacteria;
2. Reduce inflammation;
3. Act as a barrier to entry of pathogens;
4. Dry 'wet' canals.

Benefits of intra-appointment dressing.[24]

Steroid-containing pastes (*Ledermix*) are often used in irreversibly inflamed teeth that are 'hot' but best practice should always involve supplementary local anaesthetic and extirpation of the pulp. Calcium hydroxide remains the gold standard for dressing root canals. There is a synergistic effect with calcium hydroxide and sodium hypochlorite thus there is no need to dry canals fully after irrigation and before dressing.[25] Calcium hydroxide with iodine potassium iodide may have additional antibacterial action and is available in a variety of forms.[26] Such medicaments can be introduced on flexible 'navi-tips' safely to the apex. All dressings are cytotoxic (at least for 48 hours) and if extruded patients must be informed, there may be some post-operative tenderness. Care should be taken to avoid extrusion adjacent to critical structures, most notably around the inferior dental canal when dressing lower 7s and 8s. Some dressings are radio-opaque and this can be of benefit diagnosing cracks and internal resorption (Figure 11). It is wise to take a post-dressing radiograph after placement. Not only does this indicate the shape and length of preparation, but it confirms that any extruded material is from the dressing, not the definitive obturation. Those pastes in silicone-based carriers (*Vitapex*, NeoDental International, USA) may be very troublesome to remove. A fine interdental brush may help remove dressings. When using iodine-containing medicaments it is prudent to check that the patient is not allergic to iodine.

The long-term use of calcium hydroxide within the canal system has been shown to reduce the fracture resistance of dentine.[27] As such its use should be limited to short duration, ideally for no more than 4–6 weeks.

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