Access cavity preparation

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IN BRIEF
- Suggests the access cavity is arguably the most important technical stage in root canal preparation.
- Highlights common features in root canal anatomy.
- Outlines basic principles for locating root canals and producing a good access cavity.

PRACTICE

Each stage of root canal treatment should be carried out to the highest possible standard. The access cavity is arguably the most important technical stage, as subsequent preparation of the root canal(s) can be severely comprised if this is not well executed. Inadequate access can lead to canals being left untreated, poorly disinfected, difficult to shape and obturate, and may ultimately lead to the failure of the treatment. This paper highlights common features in root canal anatomy and outlines basic principles for locating root canals and producing a good access cavity. It also explores each phase of the preparation in detail and offers suggestions of instruments that have been specifically designed to overcome potential difficulties in the process. Good access design and preparation will result in an operative environment which will facilitate cleaning, shaping and obturation of the root canal system in order to maximise success.

INTRODUCTION

The fundamental aim of root canal treatment is to remove bacteria and to treat apical periodontitis using biomechanical preparation, infection control and complete obturation of the root canal system.[1] In order to be able to effectively carry out any of the above technical stages adequate access to the root canal system is required. An access cavity is defined as 'The opening prepared in a tooth to gain entrance to the root canal system for the purpose of cleaning, shaping and obturating'.[2] Essentially, the access cavity is vital for allowing the effective cleaning, shaping and obturation of the root canal system.

Traditionally the technical stages of root canal therapy have been described as 'clean, shape and fill'. The significance of the access cavity in this process is too frequently overlooked. As the key technical phase governing the success/ease of the subsequent treatment stages, it is of paramount importance. A poorly executed access cavity will compromise the remaining technical stages and result in an increased risk of procedural errors or failure to carry out a satisfactory treatment. A root canal treatment may fail, for example, due to an untreated canal; however, rather than this being a failure of adequate preparation, it could be ascribed to inadequate access and an inability to locate the untreated root canal. It is therefore suggested that the technical objectives of orthograde endodontic therapy should be considered as follows:

1. Access
2. Clean
3. Shape
4. Fill.

PRE-OPERATIVE ASSESSMENT

In order to be able to carry out successful endodontic treatment, it is fundamentally important to have an adequate understanding of the canal anatomy of the tooth being treated and of the potential anatomical variations that may be encountered.[3] The complexity of the root canal system, demonstrated in 1925 by Hess and Zurcher[4] has since been confirmed by more modern techniques using microcomputer tomography.[5] While it is not possible to determine the exact number of root canals in a tooth until access preparation is complete, careful clinical and radiographic assessment is essential to gain as much pre-operative information as possible. The orifice of the root canal generally lies under the cingulum in anterior teeth and under the cusp tip in posterior teeth. In a significant number of teeth these anatomical landmarks will have been lost as a result of restorative procedures where natural tooth substance has been replaced by restorative material such as a crown. The angulation of the tooth, roots and alveolar contour, therefore, can provide additional information as to the likely location of the root canal(s). The clinical examination may reveal that the angulation of the crown to root(s) is dramatically different; in a tooth restored with a crown, it may mean that the crown needs to be removed or that the access cavity is not exclusively placed on the occlusal surface (posterior teeth) or lingual/palatal (anterior teeth). Pre-operative periapical radiographs will provide information on the size of the pulp chamber and the amount of dentine that makes up the pulp chamber roof and floor. This will give an indication of the amount of coronal/restorative material to be penetrated to gain access to the pulp chamber. The radiograph will also indicate the long axis of the tooth and roots, the location and degree of curvature in the root, the length of root, and likely ease of location of the root canals. Consideration should be given to the use of a second radiograph taken at a different horizontal angle (parallax view) as this may aid in assessing for the presence of additional roots and root canals.[6] Cone beam computed tomography (CBCT) has become increasingly popular in endodontics; a recent review suggests that this technique has higher specificity and sensitivity than intraoral periapical radiography, both *in vitro* and *in vivo*.[7] In 2011 the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology issued a joint position statement on the use of CBCT

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in endodontics. It stated that 'CBCT must not be used routinely for endodontic diagnosis or for screening purposes in the absence of clinical signs and symptoms'. In terms of access cavity preparation, it suggested that CBCT is indicated to identify potential accessory canals in teeth with suspected complex morphology based on conventional imaging, and identification of root canal system anomalies and root curvature.[8]

The anatomy of specific teeth with more complex root canal systems will now be considered:

Lower incisors

While 41.4% of lower incisors have two canal orifices, only 1.3% remain separate to the apex and have two apical foramina; the majority of the two canals fuse in the apical region of the tooth.[9] The access cavity is commonly prepared in such a way so that the lingual canal can be missed, it should extend from the cingulum to the incisal edge to ensure that this does not occur (Figs 1a-c). In the case of maxillary incisors this has been described as the incisal straight-line access cavity.[10] It is imperative to recognise that the most common reason of root canal treatment failure in a lower incisor is due to microorganisms proliferating in the untreated canal.

Lower premolars

The majority of these teeth have only one canal; in some teeth, however, the root canal divides in the mid to apical third (Fig. 2). Parallax radiographs are important to help ascertain the anatomy of such root canal systems.

Lower molars

An initial study investigating the anatomy of these teeth varies between two to four canals. Two canals were present in 6.9% of teeth, three canals in 64.4%, and four canals in 28.9%.[11] However, a more detailed study into the anatomy of the lower first permanent molar shows that the anatomy of these teeth varies with ethnicity and that approximately 1% will have five canals, with three canals in the mesial root and two in the distal.[12] A significant number of molars will have two canals in the distal root, one buccal and one lingual. While the orifices of the canals will be visible on the floor of the pulp chamber, a significant number of second canals will be located at a sub-orifice level; as such, careful evaluation and assessment of the anatomy of the distal root is necessary (Figs 3a and b). On rare occasions, a third mesial canal may also be present. Further to the incidence of multiple root canals listed above, lower second molars with a single 'c' shaped canal have also been reported.[13] This can lead to difficulties in the preparation of the canal system, as the anatomy of the pulp chamber floor may not always be replicated to the apex of the tooth.[14]

Upper premolars

The majority of upper first premolars have two canals. It is rare for there to be either one canal (8.6%) or three canals (1.6%). If there are three canals, normally there will be two buccal canals and one palatal. Upper second premolars can have the one of the following configurations: one canal (48.66%), two canals (50.64%) or three canals (0.66%).[15]

Upper molars

The majority of upper molars have four canals, with one found in each root and a second present in the mesial root. The complexity and anatomical ethnic variation has been reported by Cleghorn *et al.*[16] Retrospective analysis of clinical location and treatment of the second mesiobuccal canal have been reported as 93% for upper first molars and 70% for upper second molars.[17] The access cavity should be prepared in such a way that the location of the second canal can be attempted (Figs 4a and b). On rare occasions a third canal in the mesiobuccal root can be found (Figs 5a and b).

TECHNICAL ASPECTS OF ACCESS CAVITY PREPARATION

Many publications include diagrams or pictures of an 'ideal' access cavity in relation to a sound tooth. It is unlikely, however, that many access cavities will exactly match this ideal as the vast majority are in fact created in teeth where a significant amount of dentine and enamel has been replaced by restorative materials. It is therefore important that it is the anatomy of the pulp chamber that is being treated, and not a preconceived idea held by the operator, which dictates the outline of the access cavity. The aims of the access cavity can be considered as follows:

- Removal of the entire roof of the pulp chamber in order to inspect the pulp floor
- Creation of tapered cavity walls
- Creation of a smooth unimpeded pathway for instruments to canal orifices
- Preservation of natural tooth substance consistent with the above.

The authors do not subscribe to the view that all orifices should be visible in the mirror head at one time, as excessive dentine may be removed to achieve this. If the access cavity is created entirely in a metallic restoration the outline of the

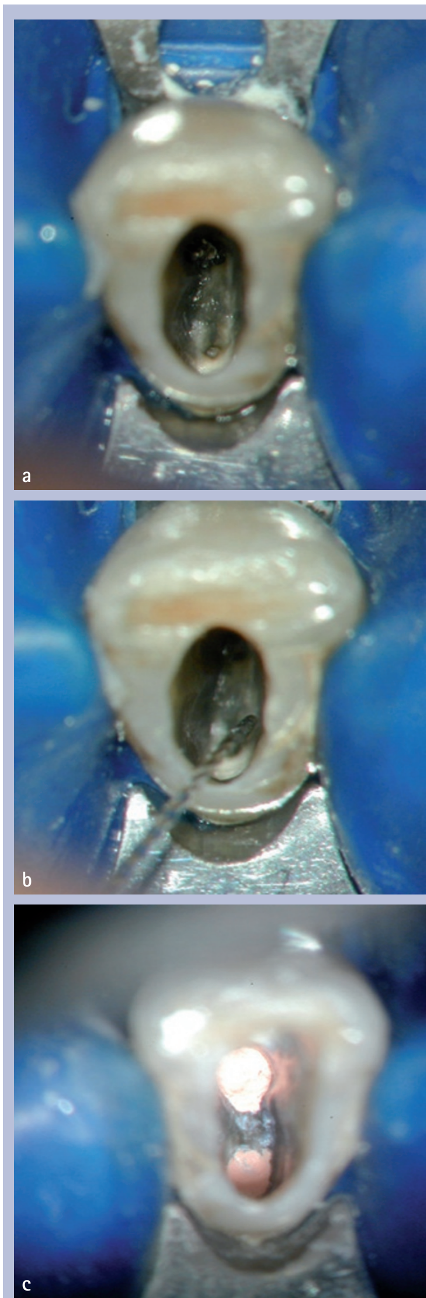

Fig. 1 Access cavity in lower incisor which shows a) initial identification of the lingual canal underneath cingulum; b) initial negotiation of the canal with a size 6 file and c) successful obturation of both buccal and lingual canals

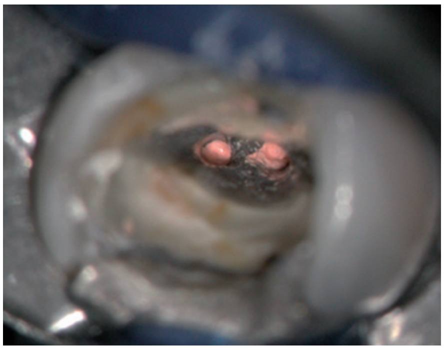
Fig. 2 Apical obturation of a lower premolar with a root canal system that divides in the apical region of the tooth (Weine type IV)

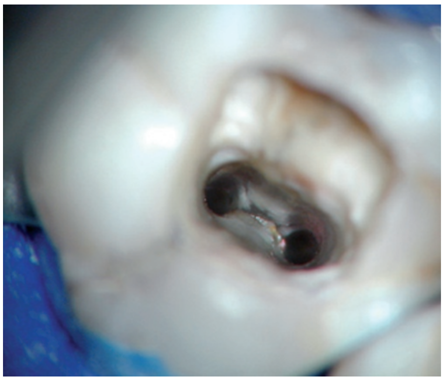

Fig. 3a Distal root of lower molar with a Weine type IV root canal system with a sub-orifice division into two canals

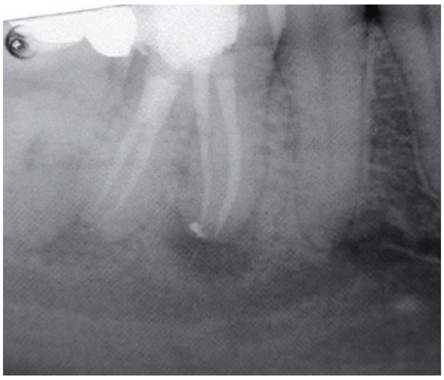

Fig. 3b Post-operative radiograph clearly showing the Weine type IV canal configuration

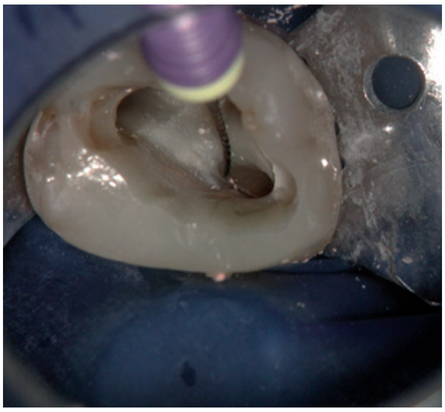

Fig. 4a Upper first molar showing MB2 canal located with a #10 file

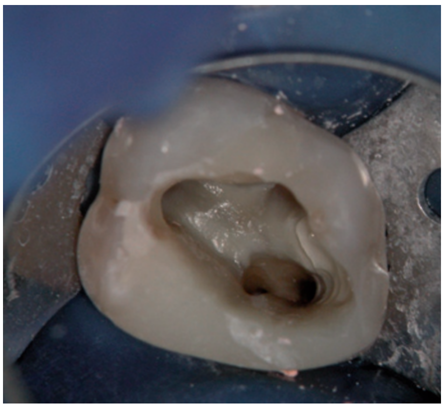

Fig. 4b Completed access cavity showing four canal orifices

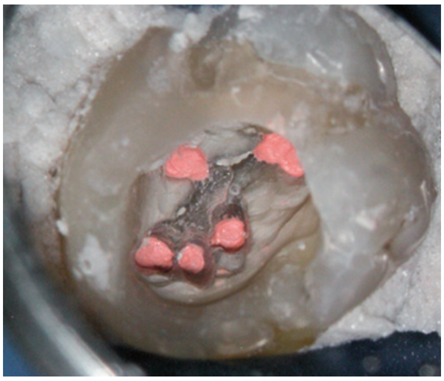

Fig. 5a Obturation of an upper first molar with three mesial canals

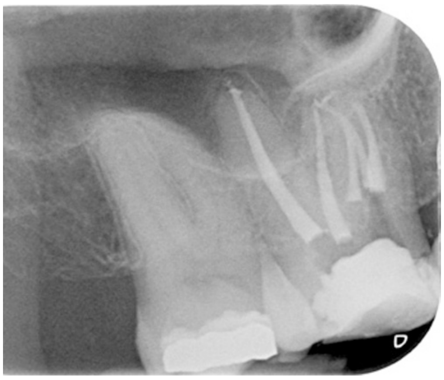

Fig. 5b Post-operative radiograph of the completed case

access cavity should be larger and the taper increased. This will avoid the risk of canal blockage by metal shards formed from the restoration during instrumentation.

The technical aspects of root canal preparation will be considered in four phases:

- Initial cavity opening
- Pulp chamber penetration and enlargement
- Canal identification
- Cavity finishing.

Initial cavity opening

A wide range of burs, ultrasonic tips and kits exist to aid in the creation of the ideal access cavity, with specific designs for cutting through various materials and tissues. When selecting a cutting instrument, it is important to consider what exactly is going to be cut. Although great advances have been made in ultrasonic technology and specialised cutting tips, it must be remembered that these instruments will only cut small volumes of tooth tissue. As such, the traditional high-speed handpiece will still be needed to carry out the vast majority of the work in this initial stage. The choice of which bur medium is to be used should be based on the material or tissue to be cut (Table 1). Extra attention should be paid to the preparation of an access cavity through ceramic or metal-ceramic crowns as ceramic can shatter or delaminate from its substructure. It is wise to treat the penetration of the crown as a separate step and choose an according bur to remove each layer of prosthetic material.

Based on the pre-operative assessment already made, the centre of the pulp chamber should be the target of the initial penetration. The outline of the access cavity will then be determined by the shape of the pulp chamber and should not be governed by a preconceived shape in the mind of the operator. The following generalisations of the pulp chamber anatomy, as suggested by Krasner and Rankow[18] can be used as a guide:

1. The pulp chamber is always at the centre of the tooth at the level of the cement-enamel junction (CEJ) (Fig. 6a)
2. The walls of the pulp chamber are always concentric to the external surface of the crown at the CEJ (Fig. 6b)
3. The distance from the external surface of the clinical crown to the wall of the pulp chamber are the same throughout the circumference of the tooth at the level of the CEJ (Fig. 6c).

Some operators favour beginning the access cavity without the use of a rubber dam to ensure that the long axis of the tooth can be clearly seen in relation to the crown/root trunk angulation, alveolus and the adjacent teeth. Others prefer to commence access preparation with the rubber dam in place. This is usually a decision based on the experience of the operator and the anatomy of the tooth. Should access begin without a rubber dam in place, a reference point must be chosen within the pulp chamber and the rubber dam then applied; this can then be done with confidence that the risk of

Table 1 Bur medium selection based on tissue or material to be cut

	Diamond	Tungsten carbide	Steel
Enamel	✓	×	×
Dentine	✓	✓	✓
Ceramics (traditional and reinforced)	✓	×	×
Metal (amalgam, precious and non-precious metal)	✓	✓	×

perforation has been minimised. The initial access cavity opening is made with a round bur so as to allow it to be used obliquely and so the tip of the bur can be clearly seen. Specific kits have been developed that include the necessary burs for carrying out an access cavity in most situations; examples can be seen in Figures 7a-c. These kits also contain burs to manage different prosthetic materials (Table 1). A key principle to follow when selecting burs for different materials is that the bur should cut cleanly with little vibration. Although diamond burs can be used to cut through ceramic, coarse burs can produce excessive vibration and lead to ceramic fracture or delamination. Initial penetration of ceramic should be made with a fine to medium grit diamond bur, used in a sweeping fashion to effectively sand away the desired portion of the restoration. If the operator feels vibration, the bur is probably too coarse and another type should be selected. With more frequent use of zirconia restorations, problems in cutting though this material have been experienced. Traditional burs are inclined to blunt rapidly while the diamonds tend to be stripped from the shaft of the bur. Bur manufacturers have responded to these issues through the development of burs such as the Komet® ZR-Diamond™ (Komet, USA), which enhances the resilience of the bur and allows for increased adhesiveness of the diamonds to the blank. Burs with the specific purpose of cleanly cutting through metal have also been developed. The cross cut tungsten carbide Transmetal bur (Denstply Maillefer, Switzerland) (Fig. 8) for example, reduces vibration, thereby lowering the risk of ceramic fracture or delamination when cutting though metal-ceramic crowns. Care should be taken to avoid cutting through pins when possible, as this cutting may lead to loss of the restoration and may also create significant vibration. In cases of acute periapical periodontitis, the bur selected should be chosen to reduce vibration during access preparation.

In many cases, the tooth requiring root canal therapy will be restored with a cast restoration. Based on pre-operative assessment, a decision is made on whether to retain the cast restoration or to remove it as part of the endodontic procedure. While retaining the crown will aid the placement of the rubber dam, the original anatomy of the tooth will have already been lost, which already makes canal location more difficult. In the event that caries are found during the access cavity preparation, the crown will need to be removed in order to assess the remaining amount of sound coronal dentine and the restorability of the tooth. If the crown does have to be removed, the simplest method

Fig. 6 Horizontal cross section of extracted human molars at cement-enamel junction (CEJ) demonstrating: a) the pulp chamber is always at the centre of the tooth at the level of the CEJ; b) the walls of the pulp chamber are always concentric to the external surface of the crown and c) the distance from the external surface of the clinical crown to the wall of the pulp chamber are the same throughout the circumference of the tooth

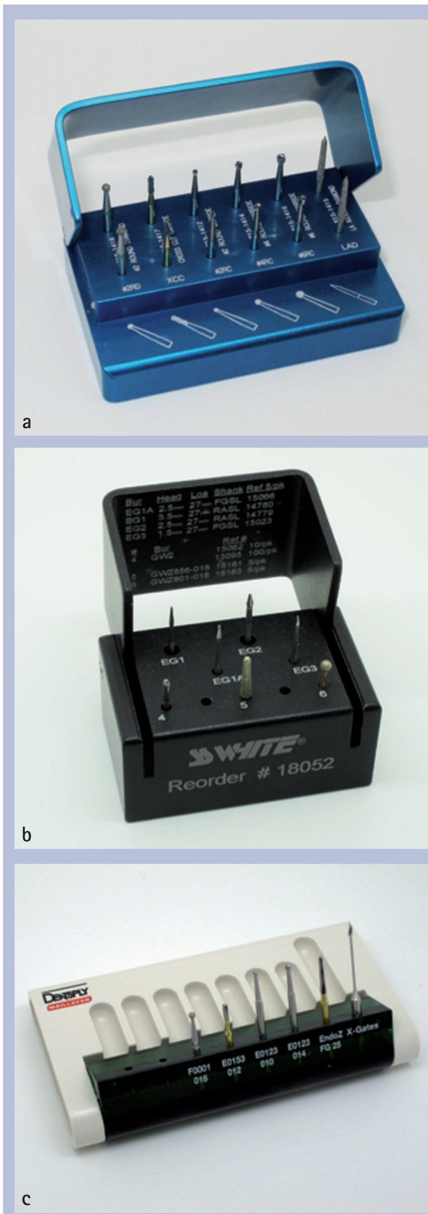

Fig. 7 Endodontic access kits: a) LA Axxess Kit (SybronEndo, California, USA); b) EndoGuide® Anterior/Bicuspid Kit (SS White, New Jersey, USA) and c) Cavity Access Set (Dentsply Maillefer, Ballaigues, Switzerland)

Fig. 8 Transmetal cross cut bur

involves cutting a groove in the buccal surface of the crown and placing an instrument such as a flat plastic into the groove to loosen it. A variety of devices have been designed to aid in the removal of the intact restoration, such as the Metalift and WAM key. It is preferable to avoid using devices which involve 'tapping off' the restoration due to the risk of fracturing dentine and the resulting potential of the tooth being rendered unrestorable. It is far better to sacrifice the restoration than the tooth.

As the round diamond or tungsten carbide bur advances towards the pulp chamber, consideration must be given to what will be the final axial wall of the access cavity. As the round bur will not leave clean, flat, axial walls, finishing space has to be accounted for in respect to the to further preparation which is carried out with burs that have long cutting sides. The access cavity should be widened to ensure that water can cool the end of the bur and the floor of the

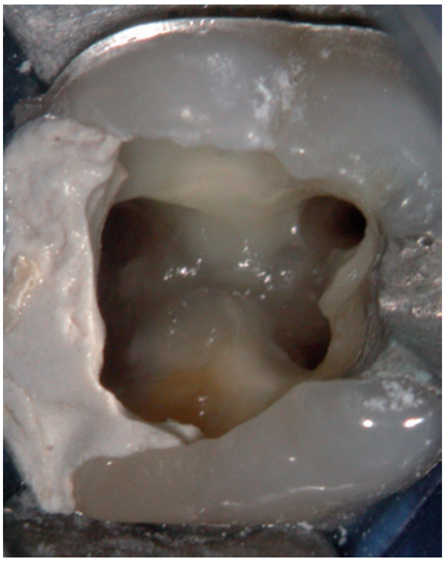

Fig. 9 Access cavity showing the difference in colour of dentine on the walls of the tooth and the floor of the pulp chamber

Fig. 10 Access cavity preparation in a extracted tooth sectioned in a vertical orientation. a) Sectioned tooth showing the pulp chamber; b) Round diamond bur used in initial access cavity preparation; c) Initial penetration of the pulp chamber; d) Steel rose head bur used to plane in an upward direction away from the pulp floor; e) Safe ended diamond bur used to refine the access cavity preparation; f) Completed access cavity showing subtle flare towards occlusal surface

cavity can be seen. It should advance on an equal plane so that when the pulp roof is penetrated, the pulp roof is mostly thinned to an approximately even thickness.

Pulp chamber penetration and enlargement

Once the advancing bur penetrates the pulp roof of a large pulp chamber, there is a marked change in resistance felt by the operator; this change can be described as somewhat akin to a sudden loss of footing while walking. If the pulp chamber is small, this sensation will be absent. It is the responsibility of the operator to determine when the pulp space has been entered, by measuring the depth of penetration with relation to the pre-operative radiograph and preventing pulp floor perforation. Initial signs of reference for determining location within the pulp chamber are as follows:

- Pulp floor dentine appears darker than coronal dentine (Fig. 9)
- Tertiary dentine takes on an icy white greyish appearance, somewhat similar to dirty snow and can often obscure the pulp chamber floor and canal orifices
- Exploration with the probe will enable canal orifice/depressions to be felt.

Controlled removal of the pulp roof can be carried out with a steel or tungsten carbide round bur by engaging the pulp roof and moving in an upward lateral fashion until it is removed (Figs 10a-f). Safe ended burs can then be used to enlarge the assess cavity such as the Endo-Z FG bur (Dentsply Maillefer, Switzerland) or the non-end cutting diamond tapered bur (Figs 10a-f) to taper and smooth the axial walls and widen the access cavity to the periphery of the pulp chamber.

Canal identification

Canal identification can be simplified by following several key rules of root canal anatomy based on Krasner and Rankow[18]

Law of colour change

The colour of the pulp chamber floor is always darker than the canal walls (Fig. 9).

Law of symmetry

Barring maxillary molars, the orifices of the canals are equidistant and lie perpendicular from a central line drawn in a mesiodistal direction through the pulp chamber floor (Fig. 11).

Laws of orifice location one

The orifices of the root canals are always located at the junction of the walls and the floor.

Laws of orifice location two

The orifices of the root canals are located at the terminus of the developmental root fusion lines (DRFL), commonly known as the dentine map or grey tracks.

Inevitably, there are occasions when location of the root canal is difficult. While extensive anatomical knowledge and adherence to the aforementioned laws are central to identification, there are several instruments that can aid in this process. Light and magnification are vital tools for

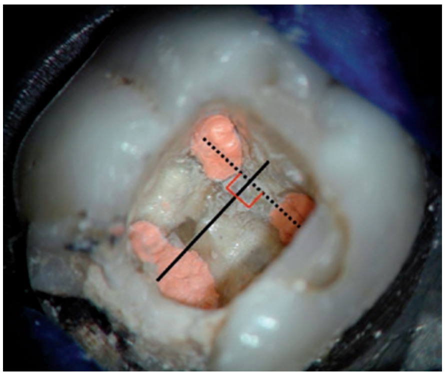

Fig. 11 Access cavity showing the orifices of the canals are equidistant and lie perpendicular from a central line drawn in a mesiodistal direction through the centre of the pulp chamber floor. The orifice of the distal canal lies on this line, indicating there is one distal canal in this tooth. If the orifice does not lie on this line, a second orifice will be on the opposite side of the line as with the mesial root

Fig. 12 DG16 endodontic explorer

Fig. 13a LN bur

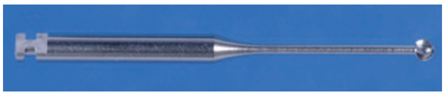

Fig. 13b Goose neck bur

Fig. 14a Variety of ultrasonic tips used in access cavity preparation

Fig. 14b Start-X ultrasonic tips (Dentsply Maillefer, Ballaigues, Switzerland)

Fig. 15 Methylene blue used to aid canal location

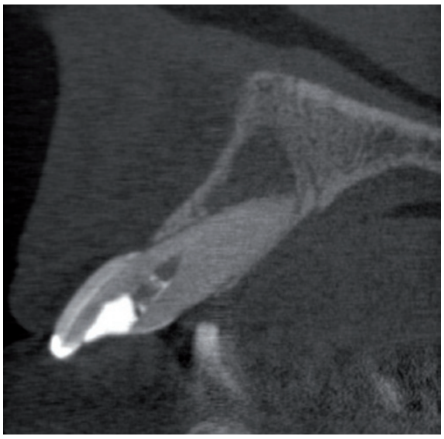

Fig. 16a A conebeam scan used to aid the location of a sclerosed canal in an upper central incisor, after the initial attempt failed to locate the canal

Fig. 16b Periapical radiograph of the completed completed case showing successful location and treatment of the root canal

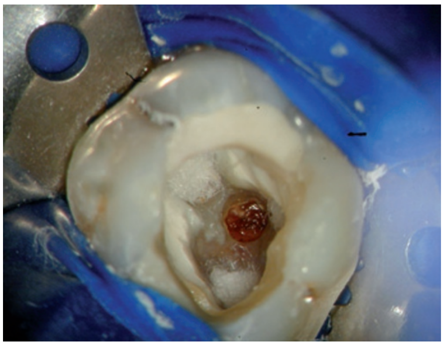

Fig. 17a Perforation of the pulp floor due to poor depth control during access cavity preparation

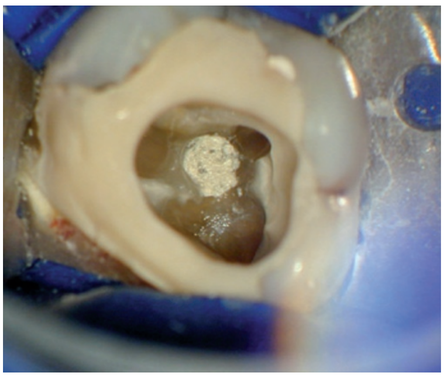

Fig. 17b Repair of the perforation with MTA and the located root canals

the endodontist. Although the microscope may not be viable for the general dental practitioner, loupe magnification should be considered a standard tool. In order to make use of all of the operator's senses, a sharp probe with a long terminal shank, such as the DG 16 probe (Fig. 12), should be used to feel the contours of the pulp floor and identify any orifices. Burs with long shanks such as the LN bur or the goose neck bur (Figs 13a and b) distance the head of the handpiece from the line of sight of the operator, thus enabling a clear vision of the cutting tip of the bur. Ultrasonic tips (Figs 14a and b) driven in a piezo ultrasonic device are less aggressive than burs driven in an air motor and enable small volumes of dentine to be removed with a clear line of sight. Other useful methods include: observing the appearance of the sodium hypochlorite irrigant in the pulp chamber and then locating the source of effervescence (colloquially known as the champagne or bubble test), methylene blue dye (Fig. 15) and transillumination. More recently CBCT has been used to detect the presence of canal anatomy and identify its location (Figs 16a and b).

Access cavity modification

To complete the access cavity, the axial walls should be smoothed and flared to ensure that no coronal dentine will impede straight-line access for instrumentation of the apical part of the canal. If a multiple visit treatment approach is adopted, the most coronal aspect of the axial walls should be flared towards the occlusal surface, to ensure good resistance form for the temporary restoration.[19] Although the access cavity has been broken into distinct stages here, it is purely for descriptive purposes. This should be considered a dynamic process and at no point throughout the root canal treatment should the operator be put off from returning to a prior stage in order to improve the standard of treatment.

TROUBLE SHOOTING

1. Failure to analyse the pre-operative radiograph adequately

This can result in removal of dentine away from the pulp camber and the canal orifices, weakening the tooth and risking perforating the pulp floor or wall. As many practitioners now use digital radiography, one advantage of using a celluloid film has been lost; the use of a traditional radiographic film allowed the operator to place the bur close to the radiograph and estimate the approximate depth of the bur required for gaining access to the pulp chamber and floor. If this is overlooked it can lead to perforation of the floor of the pulp (Figs 17a and b).

2. Cavity is too small or in wrong place

A common problem with access cavities is that they are frequently made too small and do not relate to the anatomical features of the crown of the tooth. Commonly, access cavities resemble traditional access cavities designed for restorative procedures such as Black's cavity design. As an access cavity, these are often too small and do not allow for the location of all canals (Fig. 18).

3. Cuspal protection

If, during access cavity preparation, there is a concern that the remaining tooth is at risk of fracture, an orthodontic band can be placed to reduce the risk of fracture and possible loss of the tooth. The band may be left in place until the tooth is prepared for cuspal protection.

4. Sclerosed canals

In cases of sclerosis in multi rooted teeth it is best to go 'for the pulp horns' or the part of the pulp chamber that has the greatest volume on the pre-operative radiograph. While this may not lead directly to location of the root canal system, it should allow the practitioner to find the pulp chamber and use the reference points described earlier (Figs 19a and b). Another strategy is to commence canal location in the area of the largest canal – that is, the palatal canal of maxillary molars and the distal canal in mandibular molars.

5. Indirect restorations

If the anatomy of a tooth has been radically altered by an indirect restoration, consideration should be given to aligning an endodontic or periodontal probe with the mesial surface of the mesial root and commencing the access cavity preparation with the bur in the same alignment.

6. Hyperaemic pulps

In cases of acute pulpitis initial access to the pulp chamber results in profuse bleeding, which can be difficult to control. It is practically impossible to work in the confined space of the pulp chamber if it is filled with a pool of blood (Fig. 20), and visual identification of the orifice of the root canals can be difficult. If a fast handpiece is used, a safe-ended bur is recommended. Employing this technique will result in little chance of pulp floor perforation. Copious irrigation with sodium hypochorite and/or local anaesthetic that contains a vasoconstrictor will aid haemostasis in such cases. Exploration of the pulp chamber floor is not recommended until the bleeding is controlled.

CONCLUSION

The access cavity is arguably the most important technical stage in root canal treatment. It is imperative that the pulp chamber is entirely de-roofed to ensure that all root canals can be found and that no recesses remain for microorganisms to proliferate in and mature. It should allow an unimpeded pathway for instrumentation and should not compromise preparation of the apical third of the canal. Failure to produce an adequate access cavity can lead to difficulty in locating and negotiating root canals, which in turn will result in inadequate cleaning and shaping of the root canal system. Ultimately, if the basic principles of access cavity design discussed here are overlooked, the chance of a successful treatment outcome will be reduced from the very first technical stage of the root canal treatment.

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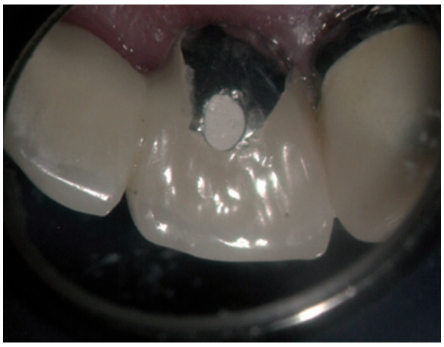

Fig. 18 Inadequate access cavity in a upper central incisor too small and in the wrong position

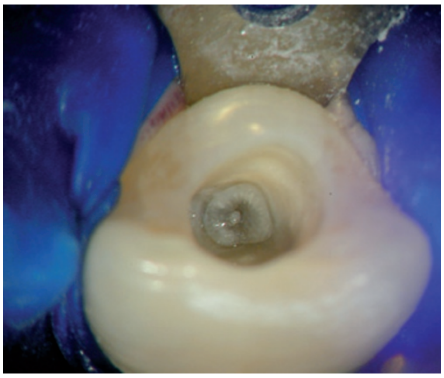

Fig. 19a Access cavity in an upper incisor with correct orientation allowing excellent visualisation

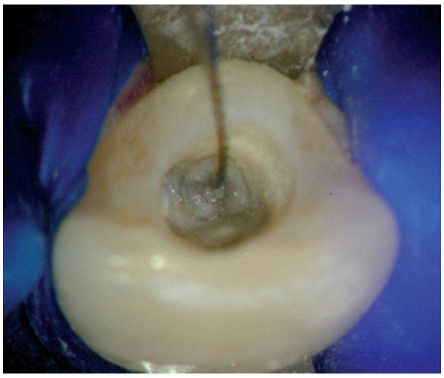

Fig. 19b Although the canal is sclerosed it can still be located and negotiated with a small file

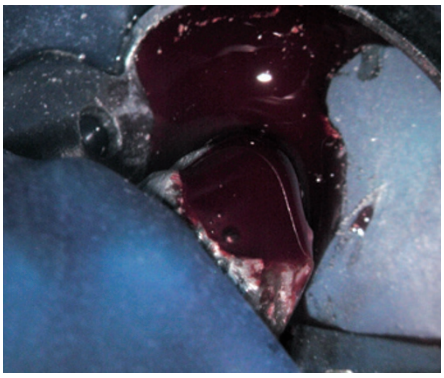

Fig. 20 Initial access in a tooth with a hyperaemic pulp. Care must be taken during initial instrumentation to avoid perforation