

Case Studies in Modern Molar Endodontic Access and Directed Dentin Conservation

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KEYWORDS

• Maxillary • Composite • Pulp horn • Molar

The following case studies provide insight into the integration of the principles set forward in the preceding article. Each case is evaluated first on the endorestorative principles that form the basis of the modern endo-endorestorative–prosthodontic continuum. Endorestorative needs should, whenever possible, trump previous notions of endodontic needs.

Case 1 is provided by Dr Clark, and cases 2 to 6 are provided by Dr Khademi. Dr Clark's provides a stark contrast between the old and new models of endodontic access and shaping. Dr Clark then risks avoiding postplacement but also avoids the mutilating effects of a full crown by instead providing a minimally invasive restorative technique using direct composite to permanently splint the tooth for ideal function.

Case 2 shows the possibilities in a maxillary molar when an emphasis is made on banking of coronal and pericervical dentin (PCD). The conscientious preservation of tooth structure during access and endodontic shaping allows a second, and possibly third, prosthesis (crown) during the patient's lifetime.

Case 3 is an ideal study of the realities of day to day endodontic access. This thought provoking access teaches that the authors are not accessing a crown, but accessing the root through the crown. This tipped and rotated maxillary molar; is also mutilated and coronally altered with a PFM crown creating a mirage that could easily lead to gouging and even perforation unless the operator follows the disciplined approach outlined in the text.

Case 4 is an access through another PFM crown. The importance of proper access-ing through full crowns should not be underestimated, as the pulpal death rate from a full crown procedure has been documented in some studies to be well over 20%.

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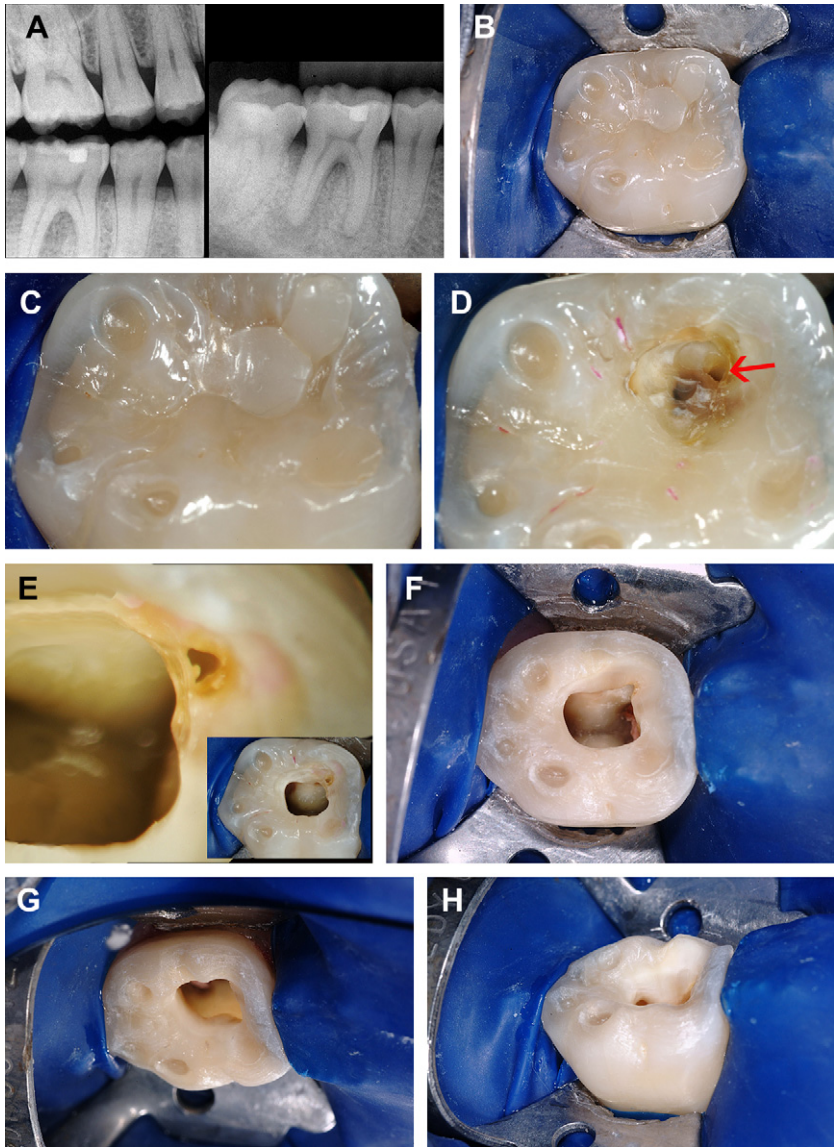


Fig. 1. (A–T) Case 1, the nonmutilated lower first molar to receive a direct composite onlay.

This maxillary first molar demonstrates 6 canal systems, three in the mesio-buccal root alone. The aggressive lateral removal of PCD to access the MB-2 canal system is the only such example shown in the chapter, and is warranted because the enormous amount of dentin present in this unique zone and the dangers associated with the extremely high curve of the MB-2.

Case 5 is a hallmark of both non traditional and carefully individualized access. It is the best example of capitulation to the hierarchy of tooth needs of all the cases presented in the chapter.

Case 6 demonstrates the futility of the round bur in endodontic access. The roof of the calcified lower molar chamber is sawed off and broken loose with a tapering

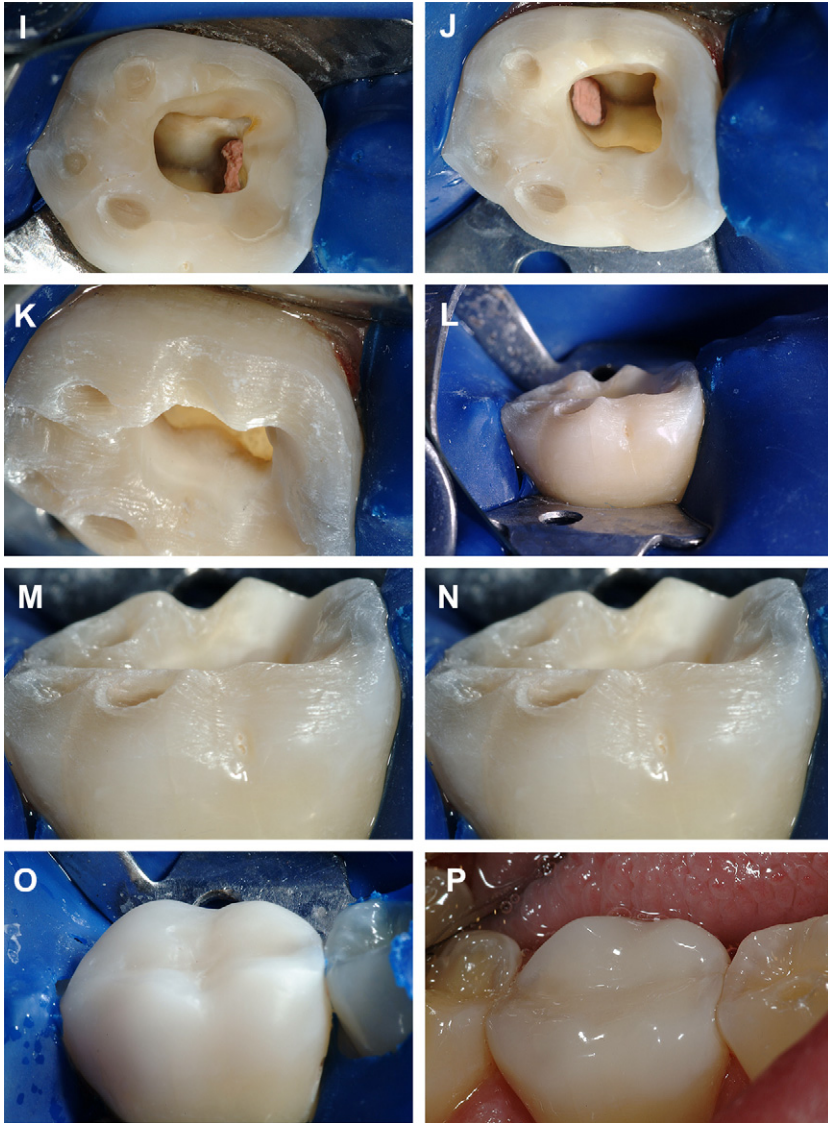


Fig. 1. (continued)

diamond or carbide followed by a prying excavator, not blindly and clumsily burrowed into with a round bur.

The reader is encouraged to visit and revisit these cases to fully absorb the anatomic and restorative techniques that are simultaneously presented in this very unique method of case presentation.

CASE 1: THE NONMUTILATED LOWER FIRST MOLAR TO RECEIVE A DIRECT COMPOSITE ONLAY

The preoperative bitewing (**Fig. 1A**) depicts what seems to be a very shallow and minimally invasive class I composite, but the periapical radiograph reveals periapical

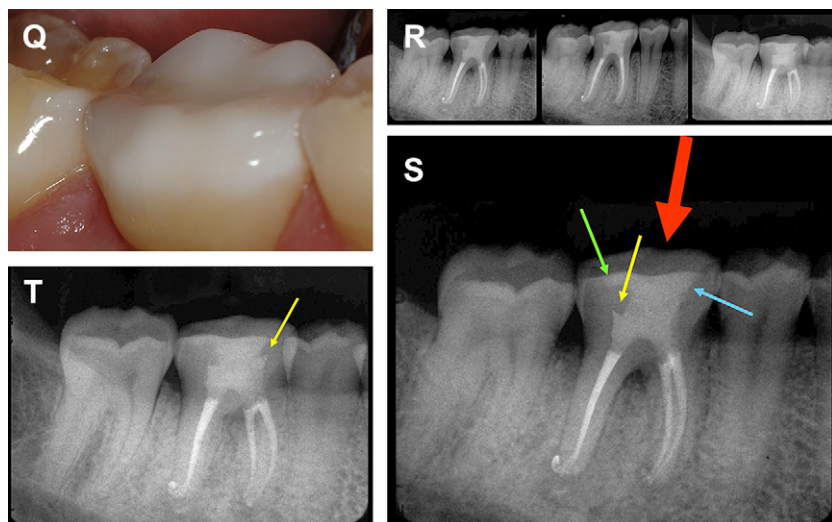


Fig. 1. (continued)

infections, indicating that the pulp must have been exposed at the time of treatment. **Fig. 1B** shows a low-magnification view of the occlusal surface of tooth No. 30. **Fig. 1C** is a high-magnification view ($\times 8$) of the occlusal surface. The composite restoration seems to be minimally invasive and relatively well sealed. **Fig. 1D** shows that as a saucer-shaped cut is made to explore the composite restoration and to begin endodontic access, the bur is angled at 45° instead of being parallel to the long axis of the tooth. There was a lack of bond and carious invasion along the wall of the composite restoration. This is an extremely common problem for the parallel-sided composite preparations of today. Previously exposed mesiolingual (ML) pulp horn is highlighted with red arrow.

Fig. 1E shows a $\times 24$ magnification view, revealing that there is no such thing as a small pulp exposure. The pulp chamber is now accessed by leveraging into the chamber through the filling and caries base of operation. A small sacrifice of additional enamel with a 45° enamel wall would have allowed an ideal restorative seal and could have aided the clinician to avoid burrowing into and subsequently failing to recognize the pulp horn. Similarly, a 45° opening through the enamel for endodontic access allows better visualization, better enamel engagement, improved C factor, and improved ability to splint the tooth with direct composite. **Fig. 1F–J** were captured with a traditional flash (as opposed to coaxial microscopic light) to demonstrate the good access and lighting that is possible when delicate flattening and a 45° initial penetration is performed. In spite of what initially seems to be an insufficient cervical enlargement of the chamber, the cavosurface preparation allows reasonable endodontic access and light while maintaining generous cervical dentin.

Multiple angles of the anatomic shortening of the corona of the tooth are shown in **Fig. 1K, L**. As discussed later, it is of utmost importance to retain large islands of enamel on the occlusal of the molar tooth to avoid overreliance on dentin bonding to retain the bonded onlay. A clearance range of 1 to 2 mm is adequate for proper strength of modern microfilled composites. The rough polish of the composite onlay is demonstrated in **Fig. 1O**. **Fig. 1P, Q** shows the final polish after occlusal adjustment. Dr Clark is confident that the patient would enjoy a 10- to 20-year service from the

restoration. It is the least invasive of all of the options required to splint the endodontically treated molar.

Three differently angled radiographs of the finished cusp tip-to-apex endodontic treatment are shown in **Fig. 1R**. **Fig. 1S** shows the first angled radiograph. The green arrow marks the 1.25-mm cuspal coverage, whereas the yellow arrow marks the soffit of dentin that was maintained and the filled pulp horn. The blue arrow marks the 45° cut through the enamel, and the large red arrow marks the mesialized access angle, which is situationally correct because the caries and filling material were encountered in the mesial portion of the tooth—a perfect example of the filling- and caries-leveraged access.

Fig. 1T shows the second angled radiograph with the yellow arrow marking the mesial soffit. After a 6-week calcium hydroxide treatment, there was an improvement (decrease) in the size of the radiographic lesions, especially the distal ones. The series of photographs, **Fig. 1A–Q**, shows an ideal bucco-occlusal-lingual composite onlay preparation, composite placement, matte finish, and final finish after occlusion was adjusted.

The chamber was carefully layered with flowable composite (Filtek Supreme Flow A-1; 3M, St Paul, MN, USA), mitigating the difficult C-factor problems by allowing the layers (2-mm increments) to touch only 1 or 2 cavity walls and never all the 4 walls at once. The cusps were built carefully with paste composite (Filtek Supreme Plus A-1 body [3M]) was used with patient consent to show contrast for the photographs for a bright result) to avoid cross tooth contact during photo-polymerization of the composite. The distobuccal (DB) and distal cusps were built together with the ML cusp then photo polymerized. Then the distolingual (DL) cusp was built with the mesio-buccal (MB) cusp then photo polymerized. Although a discussion of restoratives is beyond the scope of this article, the modern version of endodontic access is constantly mindful of the restorative needs of the tooth, and that is why this brief synopsis on the composite onlay is included, to demonstrate how the ideal access leads to the ideal restoration.

CASE 2

This case demonstrates the access and restorative technique for an upper molar deemed suitable for final restoration with a bonded porcelain onlay or a composite onlay (**Fig. 2A, B**). The initial presentation of the case was a somewhat calcified molar with some slight cracking and ditching of the enamel, coincident with the natural anatomic grooves. The cusps were flattened 2 mm with wheel diamond, and the central groove area was slightly flattened. This was planned to be a 2-step procedure, which presents temporization issues if a 45° initial penetration is made, because nonbonded materials generally need to be at a 90° angle. Thus, the calla lily-shaped portion of the access is delayed until the final restorative is placed. After removing the amalgam, a residual pulp horn is noted at the MB (**Fig. 2C**). The chamber is troughed out as previously described, using Clark/Khademi (CK) burs (SS White burs Inc, NJ, USA) or ultrasonics, and 3 initial point of negotiations (PONs) are located, and an initial trough for the MB2 is made using a CK bur (**Fig. 2D**). If the opening permits, the notching for access to the MB2 can be reduced, or as in this case, nearly eliminated (**Fig. 2E**). Calcium hydroxide is placed, Cavit (3M, St Paul, MN, USA) is placed deeply with no sponge or cotton pellet, and 2–3-mm unbonded flowable composite veneer is placed over the Cavit (**Fig. 2F**). At the second visit, the procedure is completed, the chamber is cleaned up, and the calla lily portion of the access is completed (**Fig. 2G**). Separate dentin- and enamel-bonding steps are then performed (**Fig. 2H**). A small amount of flowable composite is placed over the gutta-percha and worked

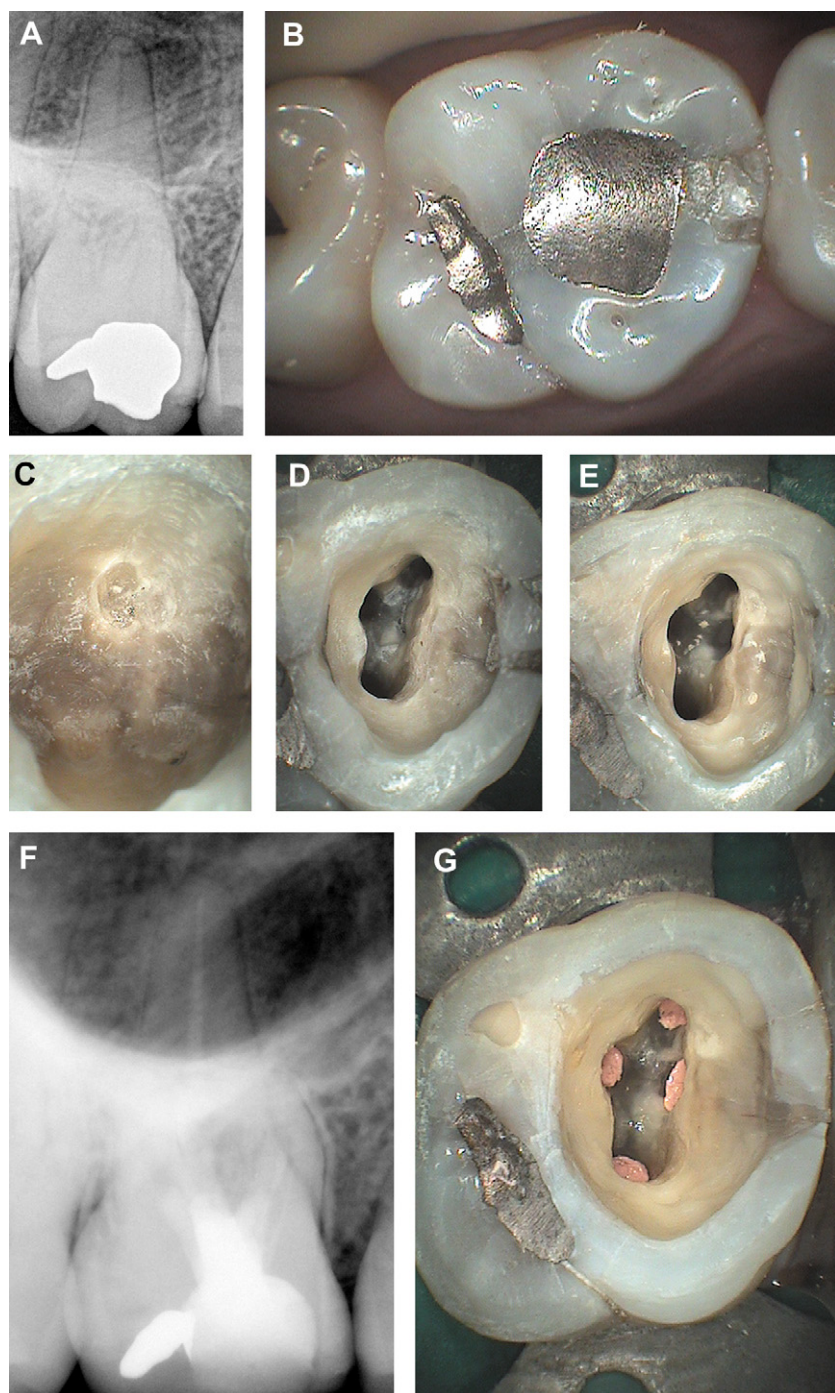


Fig. 2. (A–O) Case 2, the access and restorative technique for an upper molar deemed suitable for final restoration with a bonded porcelain onlay or composite onlay restoration.

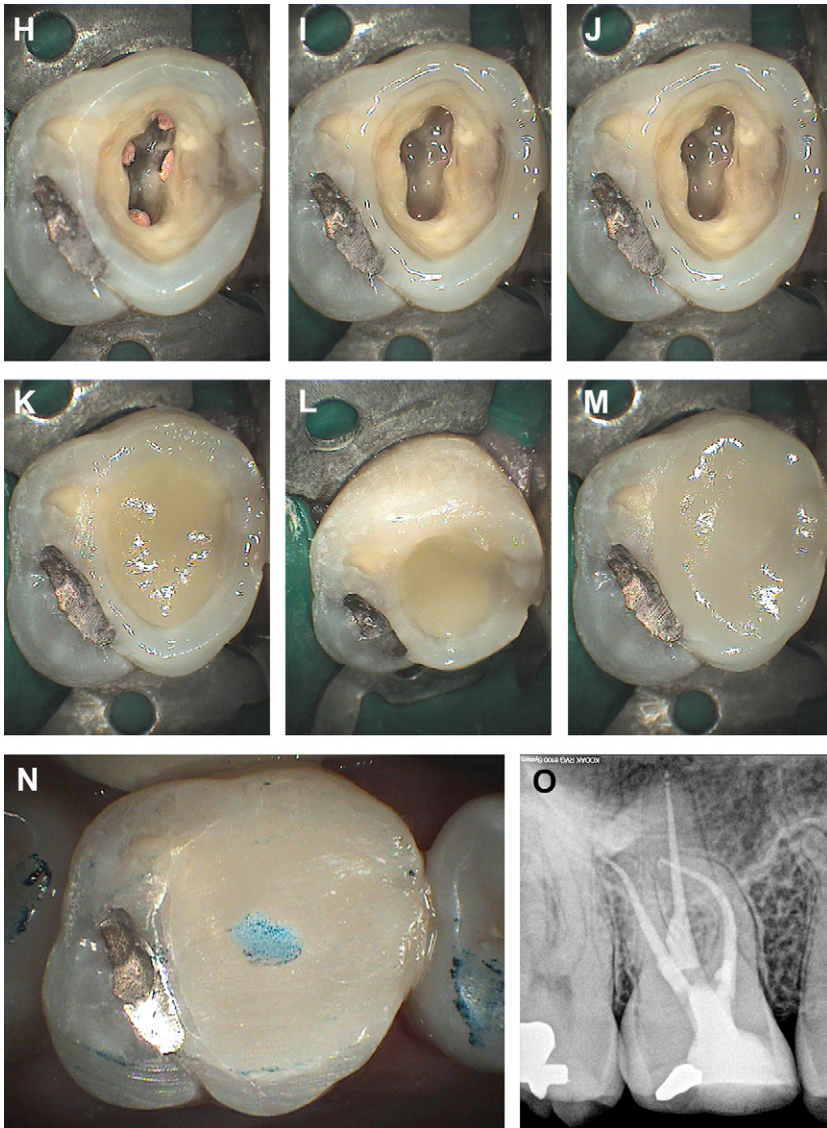


Fig. 2. (continued)

into the enamel periphery and cured (Fig. 2I). PhotoCore (Kuraray America, Inc, New York, NY, USA) is placed in the cervical portion of the access and cured (Fig. 2J). A second increment of PhotoCore is placed with the objective of creating a nearly C-factor-1 bowl for the final increment of PhotoCore (Fig. 2K); Fig. 2L shows a different view of the bowl configuration of the final increment of PhotoCore. The final increment of PhotoCore is placed and brushed to the enamel periphery (Fig. 2M). Occlusion is adjusted to completely eliminate any excursive contacts. Ideal occlusion in this type of case is a light single centric stop on restorative (Fig. 2N). The final radiograph shows

a narrow “waist” to the access, which constricts from the level of the alveolar crest until it steps out to where the original amalgam was and then reflares again for maximal enamel engagement at the cavosurface (Fig. 2O). The flattening and the calla lily cavosurface have made this tooth safer than in the traditional methods; however, it is not safe until the cusps are physically onlaid with restorative material.

CASE 3: THE UPPER FIRST MOLAR WITH A PORCELAIN-FUSED-TO-METAL CROWN

This case of the upper molar (Fig. 3A) highlights several issues encountered in real clinical cases. The tooth in this case has rotated and drifted mesially, has a PFM

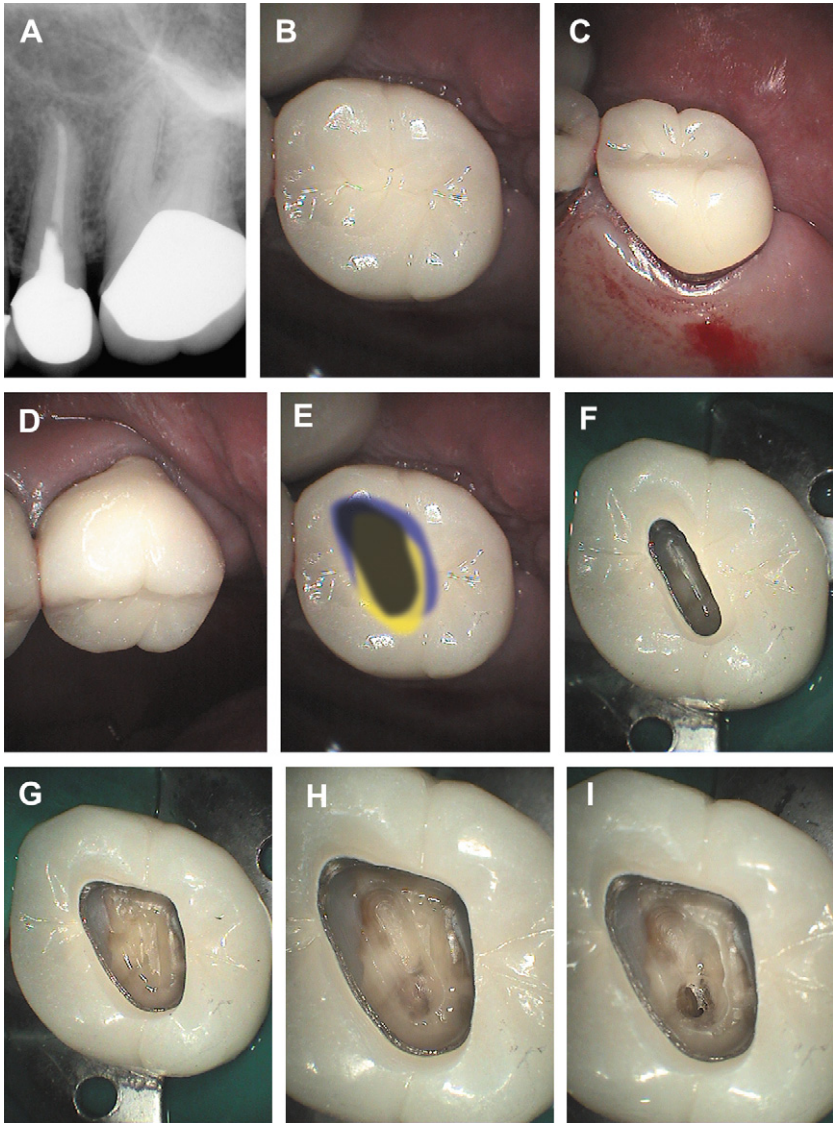


Fig. 3. (A–P) Case 3, the upper first molar with a PFM crown.

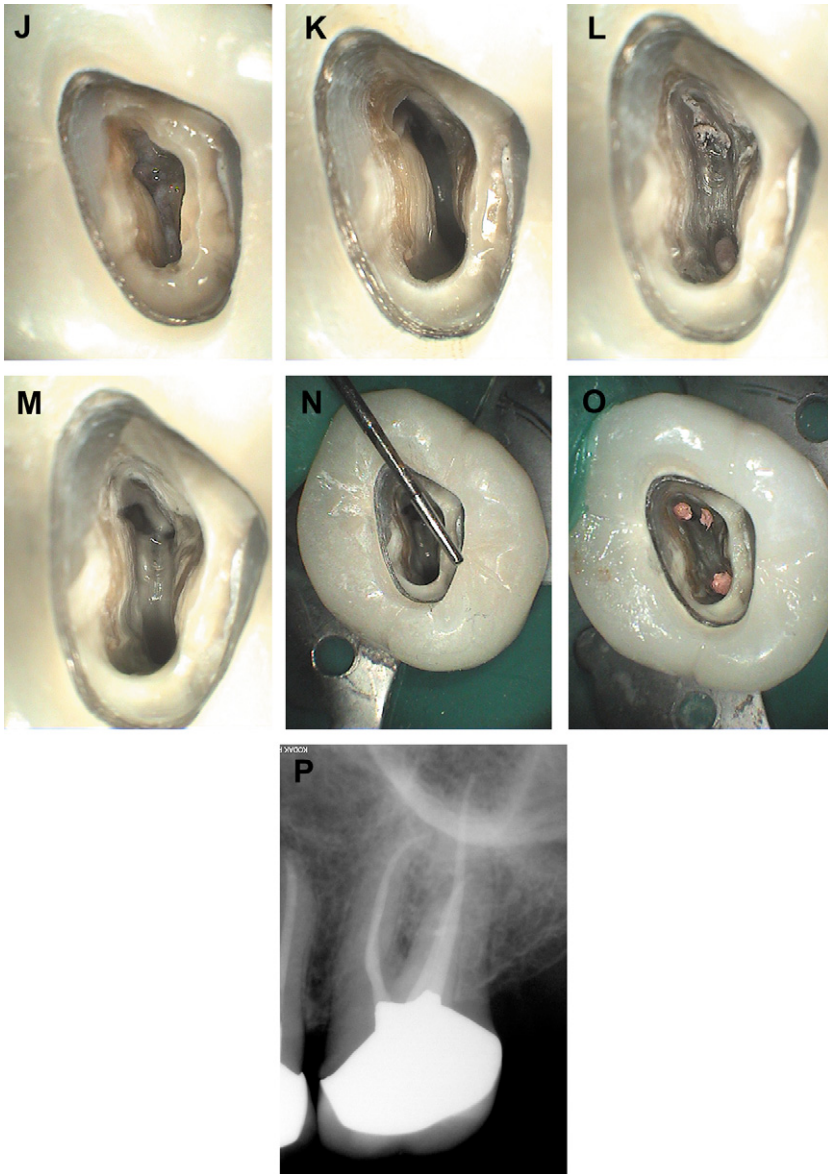


Fig. 3. (continued)

that obscures many of the normal anatomic landmarks, and has moderate calcification. The MB root has a cervical bend and a concurrent distal angle of entry to the MB system.

The preoperative occlusal view gives almost no indication of the underlying rotation or the multiplanar inclination of the underlying tooth (Fig. 3B). It is only through examination of the cervical outline that the clinician can gain some hints to the true orientation and inclination of the tooth and the modifications to the access that will be required. By observing the palatal view (Fig. 3C), the bulge of the palatal root can

be prominently seen, and a hint as to the mesial inclination can be gained by observing the contour of the mesial contact reaching for the distal part of tooth No. 13. The preoperative buccal view (Fig. 3D) shows a reversal of the root prominences, with no evidence of the normally more prominent MB, yet a marked prominence of the DB, which is reflected both in the alveolar housing and the cervical contour of the PFM. This evidence suggests that the mesial of the tooth has rotated inward as it has drifted mesially. In the preoperative occlusal view, the translucency of the porcelain can often allow the clinician to look through to the opaque layer and better ascertain where at least the occlusal portion of the tooth mass is. The yellow outline form (Fig. 3E) shows a normal orientation on a maxillary first molar, with the mesial roughly paralleling the mesial of the crown, but authors are not accessing the crown; authors are accessing the root structure through the crown. The blue outline shows an appropriate rotation of the outline form along with a mesial and buccal translation in an attempt to compensate for the rotation and tipping of the underlying tooth structure. It is also increased in size to reflect the lower confidence in the true locations of the underlying tooth mass. The smaller black outline represents the expected outline form that is obtained once the clinician gains access to the underlying dentin map, and it is reflective of the more oval shape of the maxillary second molar pulp chamber. There is no green outline for this difficult type of case. The initial cut through porcelain and metal and slightly into dentin is oriented along the anticipated line connecting the MB and palatal (P) horns, generally the largest of the pulp horns (Fig. 3F). The access is liberally extended in the crown without progressing apically (Fig. 3G). A close-up shows a color change, whereby it would be reasonable to expect a P pulp horn (Fig. 3H). Careful apical progression through dentin exposes the chamber through the P horn, and the color map gives a visual cue as to the location of the MB horn as well (Fig. 3I). The tip of a CK bur is barely placed through the exposed P horn, dropping through the chamber roof, and is drawn around using the visual cues filtered through the expected chamber outline (black outline form mentioned earlier, Fig. 3J). Fig. 3K shows a considerable soffit over the P horn, less over the MB, and almost none over the DB. The buccal-most extent of the MB is carefully partially unroofed and troughed out to ensure that an additional MB canal is not present to the buccal, and a small amount of troughing and fluting slightly buccal of the palatal canal is done, because maxillary second molars occasionally harbors the MB2 canals in or near the P orifice (Fig. 3L). Fig. 3M shows the completed outline form ready for instrumentation. If the angle of entry to the DB is too constricted, a CK bur can be used to remove the small lip of dentin. The old residual DB horn can be seen when observed carefully. Fig. 3N shows the absolute sizes of the outline form through the PFM and the step in once the dentin is reached. Fig. 3O shows a slightly different view with a fairly dramatic step at the distal and palatal and a little-to-no step toward the MB. Thus, even with a fairly dramatic rotation and translation of the outline form, the access through the PFM was barely buccal and mesial enough. The final radiograph is shown in Fig. 3P.

CASE 4: MAXILLARY FIRST MOLAR WITH TYPICAL COMPLEXITY OF THE MB ROOT

A common criticism of these more-precise endodontic accesses is that they preclude PON location and discovery of deep anatomy. Yet there is no real evidence that generous outline forms actually facilitate discovery of coronal or deep anatomy. This can be confirmed by reviewing endodontic texts that continue to present clinical cases such as this fairly routine upper molar as anatomic oddities.

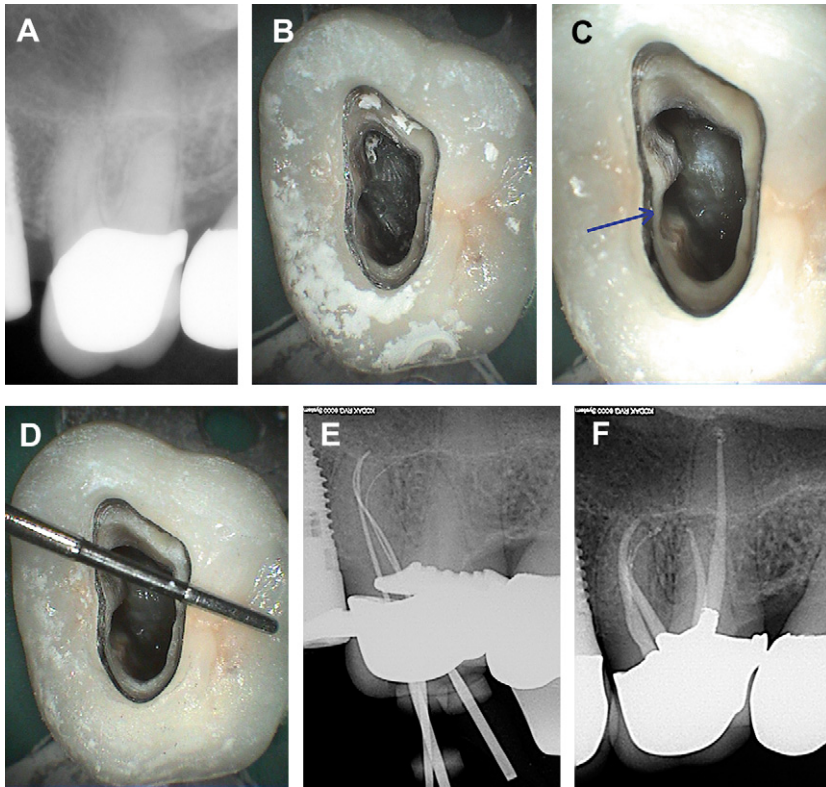


Fig. 4. (A–F) Maxillary first molar with a typical complexity of the MB root.

This case presents a stepped access on a somewhat calcific maxillary molar through a PFM (**Fig. 4A**). The initial outline form is on the larger side until the dentin is reached (**Fig. 4B**). Once the dentin is reached, the visual cues are followed as shown in case 6, slowly dissecting away just enough dentin to gain access. In this case, a cervical bulge shrouds the MB2 orifice, which is a fairly common finding in a maxillary molar. Instead of extending the entire mesial wall and unnecessarily removing irreplaceable PCD to gain access to the MB2 orifice, the mesial wall is slightly fluted as the MB2 is chased mesially before finally diving down the root (**Fig. 4C**). **Fig. 4D** shows the dimensions of the finished outline form using a 3-mm Marquis probe.

The canals are prepared, and a confluent MB/MB2 is noted. With this canal configuration, a deep split off the MB2 reaching the palatal is not an infrequent finding. This deep split is picked up by using a precurved file with a marked stopper, with the tip of the file directed along the palatal aspect of the MB2-prepared MB2 wall. **Fig. 4E** shows 3 instruments in the MB root: a No. 20 hand file in the MB orifice and 2 files (Nos. 20 and 10) in the MB2 orifice. The 2 No. 20 files can be seen to join, while the smaller No. 10 file curves off to a separate portal of exit. The final radiograph demonstrates the confluent prepared canals and the deep split likely filled with sealer (**Fig. 4F**).

Endodontic treatment is a balancing act. In the final analysis, the endodontic anatomy needs to be adequately addressed, requiring removal of dentin, which cannot possibly result in a stronger tooth. The authors believe that the endodontic

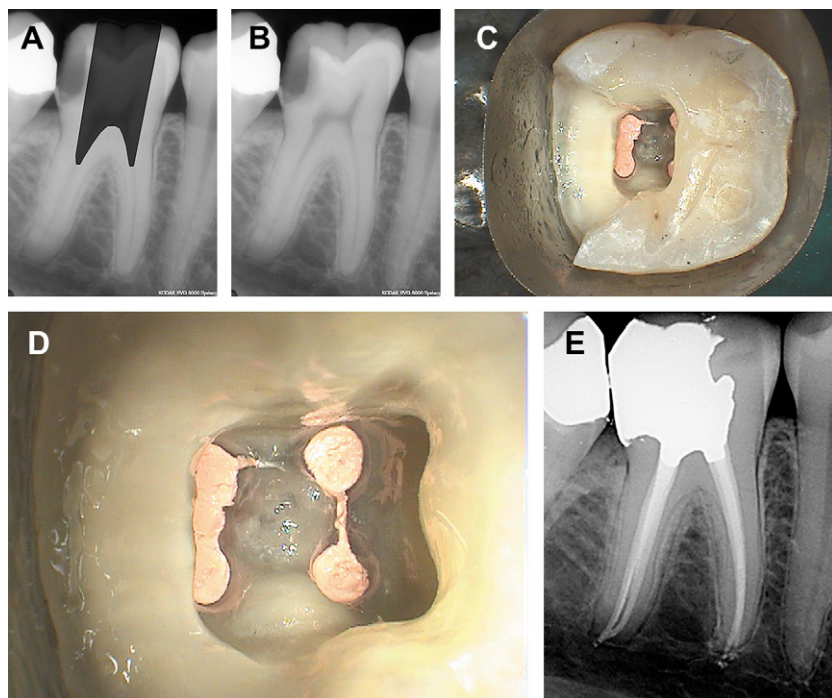


Fig. 5. (A–E) Caries-leveraged access in a lower first molar.

access has probed too far and that teeth are being needlessly weakened because of these larger outline forms, shapes, and the occult gouging that accompanies the traditional access technique and instrumentation. The clinician needs to be acutely aware of the biologic price of dentin removal and should always ask the question “*Do I really need to cut here?*”

CASE 5: CARIES-LEVERAGED ACCESS IN A LOWER FIRST MOLAR

Traditional endodontic access has paid little importance to the concept of directed dentin conservation, placing the operator’s needs for facile access to the canal systems above the restoration needs and the tooth needs, when it is really a balance between these needs that is the objective. Traditionally, a case like this lower molar would have an endodontic access cut paying no importance to the decay on the distal, but instead, removing a substantial amount of the remaining healthy tooth structure (in the mesial region) to aid in accomplishing the endodontic objectives (Fig. 5A, B).

To avoid such a situation, the authors introduce the concept of caries- and filling-leveraged access, whereby existing restorative materials, decay, and less-strategic tooth structure are preferentially removed in favor of keeping tooth structure farther up on the hierarchy of tooth needs. Creativity and resourcefulness are the new directives. This concept leverages the availability of low- or zero-value tooth or restorative materials to skew the access and direct the conservation of dentin to where it is most important. In this case, there is distal decay, which is of zero value. The access is skewed distally, being almost entirely in the distal half of the tooth (Fig. 5C). A close-up of the chamber shows that the mesial wall, the mesial portion of the chamber

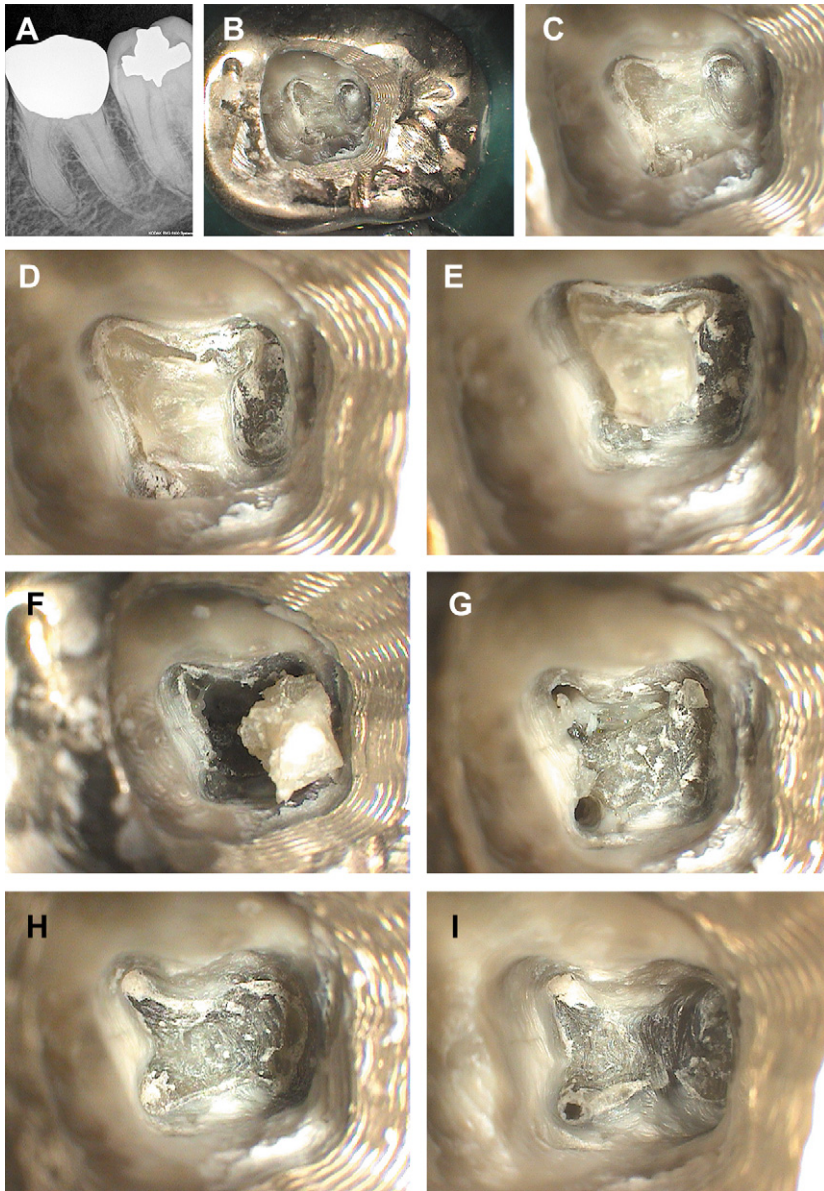


Fig. 6. (A–O) Case 6, the calcific lower first molar with a gold crown.

roof or soffit, as well as the mesial pulp horns are untouched and are left in their natural anatomic state (Fig. 5D). The undercut areas are cleaned out with prebent Maillefer micro-openers and Shepherd hook explorers. The final radiograph shows the completed case with an amalgam core that has been driven up into the mesial pulp horns (Fig. 5E). If traditional access had been cut in this tooth, the 3-dimensional ferrule in the most important walls, buccal and lingual, would have been insufficient to retain the tooth long term.

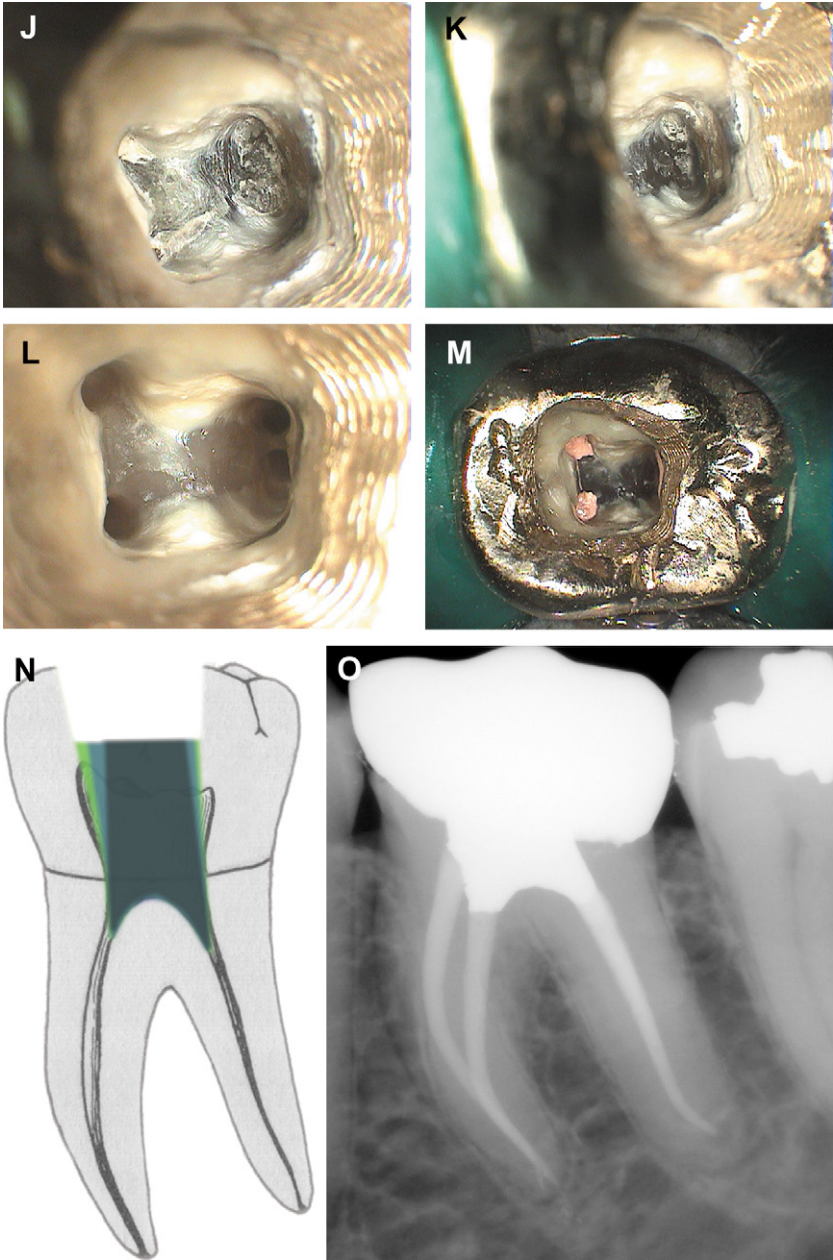


Fig. 6. (continued)

CASE 6: THE CALCIFIC LOWER FIRST MOLAR WITH A GOLD CROWN

The idea of using a round bur to drop in to a pulp chamber was put to test on a case such as a fairly routine lower molar (Fig. 6A). After a wide access was cut through the gold crown to the level at which dentin is encountered, the access was stepped in, and

the color map was followed, leading to the first pulp tissue remnant (PTR) (**Fig. 6B**). The framework through which the color map and PTRs were interpreted was the outline of the pulp chamber when the patient was young (**Fig. 6C**). In this case, a pulp stone had been growing for decades and had obliterated the bulk of the lumen of the pulp chamber, leaving a periphery of PTRs that could be traced out with ultrasonics or CK burs.

Exploration is worthless with this case type because the bulk of the periphery sticks, leading to innumerable false positives, wasted time, and unnecessary digging that results in occult damage to the PCD. Instead, a moat is cut around the pulp stone. **Fig. 6D** shows the moat troughing around 3 of the 4 sides of this roughly trapezoidal chamber. The partial trough starts at the ML line angle and moves buccal to the MB line angle, turns about 90° distal toward the DB, turns another 90° at the DB line angle proceeding lingually, and terminates at the DL line angle. **Fig. 6E** shows the last leg of the moat connecting the DL to the ML.

A spoon excavator can usually pop the stone free (**Fig. 6F**). The chamber floor is inspected, revealing a small piece of necrotic pulp emanating from the MB and some residual stone stuck to the pulpal floor flowing down the distal system occluding access to that system (**Fig. 6G**). A mild amount of troughing reveals a fairly tenacious stone stuck partway down the distal system (**Fig. 6H**). Continued troughing begins to eliminate PTRs around several parts of the chamber periphery (**Fig. 6I**).

Troughing the distal system reveals a PTR surrounding the stone lodged in the distal system similar to the way in which the initial pulp stone occluded the pulp chamber (**Fig. 6J**). Again, the mental model is to identify the periphery of the stone by looking for color changes and PTRs that match the expected shape of lumen of the distal canal (**Fig. 6K**).

The cleaned-up and prepared chamber is shown in **Fig. 6L**. The obturated case was planned for a bonded amalgam repair of the access. As gold is not an etchable substrate, the cavosurface was left as a butt joint (**Fig. 6M, N**). The final radiograph is presented in **Fig. 6O**.

The strategy is to cut a larger-than-needed access through the dispensable restorative material only to the depth at which dentin is encountered. First cues in the color map should then be used to find the first PTRs, and slowly and carefully the dentin, pulp stones, and restoratives are dissected away to find the extent of the pulp chamber floor. By carefully tracing around the chamber floor, the PONs, which are almost invariably located at the periphery of the chamber floor, can be identified. Endodontic explorers are relics from the tactile-based world and have little value in the vision-based world in a case such as this.

FINAL NOTES: LOGISTICS OF THE CK APPROACH TO MOLAR ACCESS

1. You will notice that your measurement reference points may change; for example, in the past, the reference for the mesial canals was often the corresponding MB cusp. You may now find the reference more to the distal as you have preserved PCD and soffit dentin.
2. The simultaneous placement of 4 or 5 gutta-percha points for a cone fit radiograph in this more constricted access may require that some of the cones be cut back into the chamber to eliminate binding.
3. We recommend not removing the pulp tissue under the soffit until the obturation is finished; that way you only have to clean it up once.