

# Modern Molar Endodontic Access and Directed Dentin Conservation

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## KEYWORDS

• Molar • Endodontic • Access • Dentin

During patient treatment, the clinician needs to consider many factors that will affect the ultimate outcome. In simple terms, these factors can be grouped into 3 categories: the operator needs, the restoration needs, and the tooth needs. The operator needs are the conditions the clinician needs to treat the tooth. The restoration needs are the prep dimensions and tooth conditions for optimal strength and longevity. The tooth needs are the biologic and structural limitations for a treated tooth to remain predictably functional. This article discusses molar access and failures of endodontically treated teeth that occur not because of chronic or acute apical lesions but because of structural compromises to the teeth that ultimately renders them useless. What both authors have discovered in their respective practices through careful observations of failing cases and modes of failure, and observation of the truly long-term (decades) successful cases, is that the current models of endodontic treatment do not lead to long-term success. The authors want to coronally shift the focus to the cervical area of the tooth and create awareness for an endorestorative interface. This article introduces a set of criteria that will guide the clinician in treatment decisions to maintain optimal functionality of the tooth and help in deciding whether the treatment prognosis is poor and alternatives should be considered. This article is not an update on traditional endodontic access, as the authors believe the traditional approach to endodontic access is fundamentally flawed. Traditional endodontic access has been endodontic centric, primarily focused on operator needs, and has been decoupled from the restorative needs and tooth needs. Central to our philosophy is that balance needs to be restored to these 3 needs, which are almost always in conflict when performing complete cusp-tip to root-tip treatment.

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## SETTING THE STAGE FOR CONTEMPORARY MOLAR ENDODONTIC ACCESS

Modern clinicians must factor the unique and dramatically higher biting force of the molar tooth when designing the endodontic portion of the endo-endorestorative-prosthetic (EERP) continuum. The occlusal forces created by the attachment position of the elevator muscles to the mandible generate occlusal forces that vary dramatically throughout the dentition, with light biting force in the front of the mouth to increasingly heavier forces at the back of the mouth. In physics, the mandible with its hinged access (the temporomandibular joint) is classified as a moment arm. The closer to the hinge, the higher the moment, or force, applied. The ability of the incisor to splay forward when loaded occlusally also comes into play when evaluating tooth stresses during occlusal loading. However, the molar absorbs a more vertical force and, therefore, a significantly higher net compressive force. When these 2 factors are combined (moment arm and splay), the overall compressive forces on the molar create a situation that requires a different set of rules for the calculation of ferrule, post and core design, resistance to fracturing, and (of utmost importance) endodontic access and removal of radicular dentin during endodontic shaping.

There are also different forces. The incisor must withstand milder, but more oblique, shearing forces. Most of the *in vitro* and *in vivo* research of post and core design has been conducted on maxillary incisor teeth, and attempting to extrapolate these findings to the molar tooth is not feasible. Placing a post in a round, husky maxillary anterior root and subjecting it to mild shearing force has little relevance to placing a post in a delicate, ovoid root in a mandibular molar and subjecting it to heavy compressive force.

**Box 1** presents a compelling argument for change, or, perhaps, a return to the pre-Schilder era of directed dentin conservation. Many people were hopeful that the promise of point number 1, the endodontic monoblock of bonded endodontic obturants, posts, and cores, could revitalize a hollowed-out tooth. This has not reached fruition. Most restorative dentists are unaware of point number 2. Most have always assumed that coronal composite restorations, especially those that are bonded to enamel, strengthen the crown of the tooth and prevent coronal fracturing. This common notion has created a false hope, as no such intracoronal splinting benefit exists. Point number 4 eliminates posts as a reconstructive asset in molars. Point 5 presents the troubling fact that altering the thickness of radicular dentin, especially in the ovoid and fluted root, predisposes the root to fracture. Yet the dentin in the endodontically treated tooth has virtually the same strength and moisture content as a tooth with intact pulp. Root fractures in endodontically treated teeth should be considered as iatrogenically generated, not because of any fault of the tooth. The authors have exhausted the means to reinforce the endodontically treated molar stump, and now realize that dentin is the key.

### Box 1

#### Current research and restorative trends

- (1) The failure of the endodontic monoblock<sup>1</sup>
- (2) The failure of intracoronal splinting using adhesive dentistry<sup>2</sup>
- (3) The resurgence of partial coverage posterior restorations
- (4) The recognition that molars do not benefit from placement of posts<sup>3</sup>
- (5) Crack initiation in stress tests of endodontically treated roots<sup>4,5</sup>

Endodontic accesses are traditionally conservative to the occlusal/incisal tooth structure. However, with the changes that occur in restorative dentistry, this technique is unnecessarily restrictive for the operator and potentially damaging to the more critical cervical area of the tooth.

The following case is representative of a large percentage of endodontic accesses performed by general dentists and endodontists. This story is replayed each day in the United States and Canada. **Fig. 1** shows a lower first molar of a 20-year-old woman. These young teeth are dangerously hollow to begin with. By the time that both of these well-meaning dentists had finished with the tooth, the molar was nearly worthless. The most important structures were so badly compromised that the tooth was permanently crippled.

The general dentist created the first access using fissure burs and with the type of dentin removal that is the standard today (**Fig. 2A**). The tooth was then reaccessed by an internationally recognized endodontist (**Fig. 2B, C**). This model for generous removal of pericervical dentin is common in many specialty practices. Eighteen months later, the lesion on the mesial root continues to enlarge (**Fig. 3**). In the authors' practices, such a tooth does not warrant endodontic retreatment. The wholesale loss of PCD has reduced the value of this tooth to the point that, when the tooth becomes symptomatic, extraction and replacement with an implant is a better option. In fairness to their patients, dentists must change the process, or make implants a first option instead of the eventual option. The new model of endodontic access is superimposed over the tooth in **Fig. 4**.

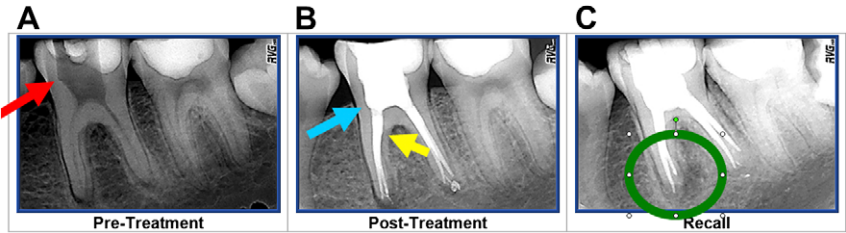
In summary, directed dentin and enamel conservation is the best and only proven method to buttress the endodontically treated molar. No man-made material or technique can compensate for tooth structure lost in key areas of the PCD. Molar access, key to endodontic success, should also be considered as the key to restorative success and to long-term retention of the molar tooth. The primary purpose of the redesigned access is to avoid the fracturing potential of the endodontically treated molar.<sup>7</sup> For expediency, molar fracturing can be described as retrograde vertical root fracture; midroot vertical root fracturing; oblique root/crown fracturing; and horizontal, oblique, and vertical coronal fracturing.

## A NEW MODEL FOR ENDODONTIC ACCESS

As endodontic access is deconstructed, it is crucial to understand the 5 catalyst forces that will change the future of endodontic access and coronal shaping. They are:



**Fig. 1.** Preoperative view of tooth #19 in a 20-year-old woman.



**Fig. 2.** (A) The deroofting problem. The likely bur used by the referring general dentist is a 56 carbide; one of the most popular burs in dentistry,<sup>6</sup> it is possibly the most iatrogenic instrument in modern medicine. Red arrow delineates the typical gouging. (B) Postoperative view provided by the endodontist. Blue arrow indicates the grossly excessive dentin removal of pericervical dentin (PCD). This serious gouging is typical of round bur access. Yellow arrow indicates the large canal flaring with unacceptable dentin removal (blind funneling). (C) Green circle highlights worsening lesion on mesial root ends.

1. Implant success rates
2. Operating microscopes and micro-endodontics
3. Biomimetic dentistry
4. Minimally invasive dentistry
5. Esthetic demands of patients.

In both of the authors' practices, the endodontic goals and armamentarium have been in a constant state of flux for nearly a decade as we have collaborated to bring the EERP continuum to maturity. The goal is to satisfy the demands of the big 5 forces for change mentioned earlier. In so doing, we have come to realize that, when cutting endodontic access, our previous needs as dentists were often in conflict with the needs of the tooth.

**Table 1** presents the hierarchy of needs to maintain optimal strength, fracture resistance, and several other characteristics needed for long-term full function of the endodontically treated tooth. Banking of tooth structure is key and is age- and case-sensitive. For example, in the case of the importance of pericervical enamel, the cemento-enamel junction (CEJ) is an invaluable asset in the physiologically young molar. Margins of direct and indirect restorations placed on enamel have been shown



**Fig. 3.** Eighteen-month follow-up. Despite generous access and aggressive canal enlargement, the lesion on the mesial root continues to enlarge.



**Fig. 4.** A more appropriate access shape is overlaid. Partial deroofing and maintenance of a robust amount of PCD is demonstrated. A soffit that includes pulp horns on mesial and distal is depicted.

to be more caries resistant than margins on dentin. The CEJ is also the most ideal vehicle to transition the stress from crown to apex.

### ***Three-dimensional Ferrule***

Three-dimensional ferrule is the backbone of prosthetic dentistry and has historically been described as axial wall dentin covered by the axial wall of the crown or bridge abutment. Ferrules are frequently used outside of dentistry. For example, in musical instruments, a ferrule is a metal band used to prevent the ends of wooden instruments from splitting. Compression fittings for attaching tubing (piping) commonly have ferrules in them. A swaged termination type for wire rope or the cap at the end of a cane or umbrella are ferrules. In pool and billiards, the portion of a cue that tops the shaft and to which the leather tip is bonded is a ferrule. In fishing, the male and female joints that join one section of a rod to the next are known as ferrules.

Research varies on the minimal vertical amount required, but the range of absolute minimums is from 1.5 mm to 2.5 mm.<sup>8-23</sup> The clinician must remember that buildup material, although necessary, does not count toward ferrules. A more comprehensive view of ferrules is needed, and is embodied in the term three-dimensional ferrule (3DF). There are 3 components of the new ferrule; first is the vertical component, which was

<b>Table 1</b> <b>The hierarchy of tooth needs for posterior teeth</b>	
<b>Value to the Tooth</b>	<b>Tissue Type</b>
High	PCD Undermined dentin The D <sup>2</sup> J Axial wall DEJ Cervical enamel in the physiologic young tooth
Medium	Coronal enamel
Low	2° dentin
No value or liability	3° Dentin Undermined enamel Inflamed pulp in mature teeth Cemento-enamel junction in physiologically aged tooth or in root caries-prone patient

described earlier, and is the traditional ferrule. The second component is dentin girth (thickness). The absolute minimum thickness is 1 mm; however, 2 mm is obviously a safer number. Girth becomes more important closer to the finish lines of the preparation. The thickness of the remaining dentin (the wall thickness) between the external surface of the tooth at the finish line and the endodontic access is more important apically. Further, progressing apically down onto the root surface in the endodontically treated tooth, the wall thickness can vary considerably and can become thin in places, especially if large coronal shaping or flaring was done during the endodontic treatment. Thus, axially deep finish lines on root structure can be extremely damaging to 3DF. Gutta percha is an exceptionally poor core material. The third component is total occlusal convergence (TOC) or net taper. TOC is the total draw of the 2 opposing axial walls of the prepared tooth to receive a fixed crown. A net taper or TOC of  $10^\circ$  requires 3 mm of vertical ferrule; a TOC of  $20^\circ$  requires 4 mm of vertical ferrule.<sup>24-37</sup> Deep chamfer marginal zones, common with modern porcelain crowns, typically have a net taper of  $50^\circ$  or more, and therefore many modern esthetic margins lose a millimeter or more of their original potential 3DF at the crown margin interface. In short, typical modern porcelain crown prep has less 3DF than the corresponding gold crown prep. Hence, the need for directed dentin conservation during endodontic access becomes even more crucial, and, at the same time, the volume of dentin removed in the axial direction should be questioned in the modern era of high-strength zirconia core crowns that actually allow minimal axiomarginal reduction. In certain case types and finish line designs, the degree of apical placement of the finish line can affect the ferrule quality, as mentioned earlier. Light axiomarginal reduction coupled with apically placed finish lines and a nonzero-degree emergence profile of the restoration can provide high 3DF. The concept of 3DF incorporates an interplay between these factors that, in sum, indicate the true ferrule quality.

### ***Undermined Enamel Versus Undermined Dentin***

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Because undermined enamel has not been shown to be strengthened by resin restorations, it becomes a liability because of fracture potential, poor C factor, and as a physical and visual obstruction to the endodontic operator. Conversely, because dentin acts as a trimodal composite, it can be of great value to the tooth whether the undermined dentin occurs naturally, such as the soffit, or from previous restorative/endodontic treatment. It is important to clarify that the act of purposely undermining dentin for mechanical retention of restorative materials or when using round burs in endodontic access is no longer indicated in contemporary restorative and endodontic dentistry. Enamel is essentially a crystalline structure and is therefore naturally supported 100% by dentin. Dentin, by contrast, is a multilevel composite that can stand alone and acts ideally as a semirigid pipe.

### ***PCD***

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PCD is the dentin near the alveolar crest. Although the apex of the root can be amputated, and the coronal third of the clinical crown removed and replaced prosthetically, the dentin near the alveolar crest is irreplaceable. This critical zone, roughly 4 mm above the crestal bone and extending 4 mm apical to the crestal bone, is important for 3 reasons: ferrule, fracturing, and dentin tubule orifice proximity from inside to out. The research is unequivocal; long-term retention of the tooth and resistance to fracturing are directly related to the amount of residual tooth structure.<sup>9,11</sup> The more dentin is kept, the longer the tooth is kept.

## SACRIFICE VERSUS COMPROMISE

In the featured case, significant dentin was sacrificed to facilitate expedient and safe (avoidance of rotary file separation) instrumentation. No compromise was made in creating a direct pathway to the apices allowing copious irrigation and full vertical compaction of heated gutta percha, and yet the endodontic treatment was failing. Contrast that case with the tooth in **Fig. 5**. There was a significant compromise when the dentist, 20 years ago, stopped removing dentin when he or she could not find the canal systems and filled less than half of the distal root. Yet the poor endodontic result is successful, the well-preserved PCD has buttressed the tooth, and the overall case is a still a success after 20 years. The authors have seen many cases of seemingly poor endodontic results that have defied current and conventional endodontic wisdom. Without detracting from the Schilder Objectives, the case types that seem to be lacking in the long-term are those with the appearance of high-quality endodontics, namely generous endodontic access, continuous taper, and large shape, facilitating the compaction of warm gutta percha.

## LOOK, GROOM, AND FOLLOW: SHAPING VERSUS MACHINING

- (1) Why are Gates Glidden (GG) burs so problematic? Since the introduction of rotary files, GG burs have been used more aggressively and with more reliance on larger sizes (4, 5 and 6) to reduce binding and fracture of rotary files. Gates burs have always been considered safe because they do not end cut and are self-centering. There is a significant problem here, which is cervical self centering. Because the shank of the GG is so thin, it is difficult to steer the GG away from high-risk anatomy. As the GG straightens the coronal or high curve, it can shortcut across a fluting or furcation and weaken or even create strip perforations (**Fig. 6**). Dr Clark has abandoned, and Dr Khademi has severely curtailed, the use of GG burs in their respective practices.
- (2) Why are round burs so destructive? The traditional method of initiating endodontic access is predicated on mental models that do not represent the day-to-day clinical reality presented to the clinician. Many texts shows the same round bur technique relying on tactile feedback as the round bur drops into the chamber (**Fig. 7**).



**Fig. 5.** Radiographically ugly but clinically successful (20 years) endodontic treatment. This case was likely done on a vital tooth. Residual PCD has buttressed this tooth to avoid fracture.

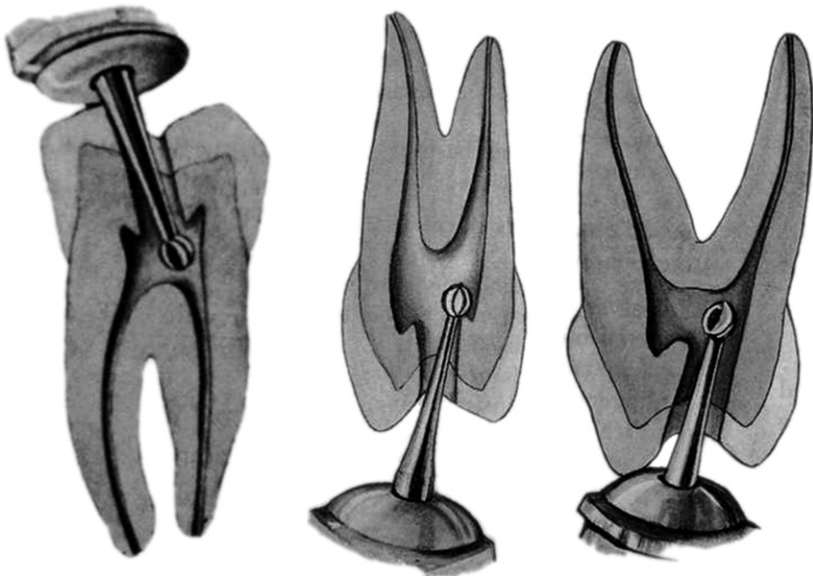




**Fig. 6.** Extensive coronal flaring results in extrusion of obturation material in the furcation. The furcal strip perforation is a perfect example of the dangers of blind funneling with GG burs.

These kinds of images, so frequently shown in dental school, textbooks, and lectures, are predicated on mental models based on occlusal decay in children. If the pulp chamber is sufficiently large, then a round bur can truly drop in to the pulp chamber, as shown in **Fig. 8**, with a #6 round bur superimposed on the lower molar of an 11-year-old child.

The reality of day-to-day clinical practice is far removed from this, and these deeply ingrained mental models are a setup for occult iatrogenic trauma. More realistically,



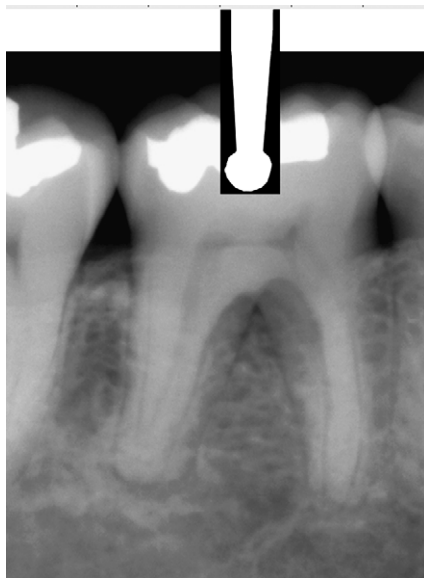
**Fig. 7.** Texts frequently show the same round bur technique relying on tactile feedback as the round bur drops into the chamber. (From Ingle JI, Beveridge EE. *Endodontics*. 2nd edition. Lea and Febiger; 1976. p. 132 (plate XII), 148 (plate XX), 157 (plate XXIV); with permission.)





**Fig. 8.** If the pulp chamber is sufficiently large, then a round bur can drop in to the pulp chamber, as shown here with a #6 round bur superimposed on the lower molar of this 11-year-old child.

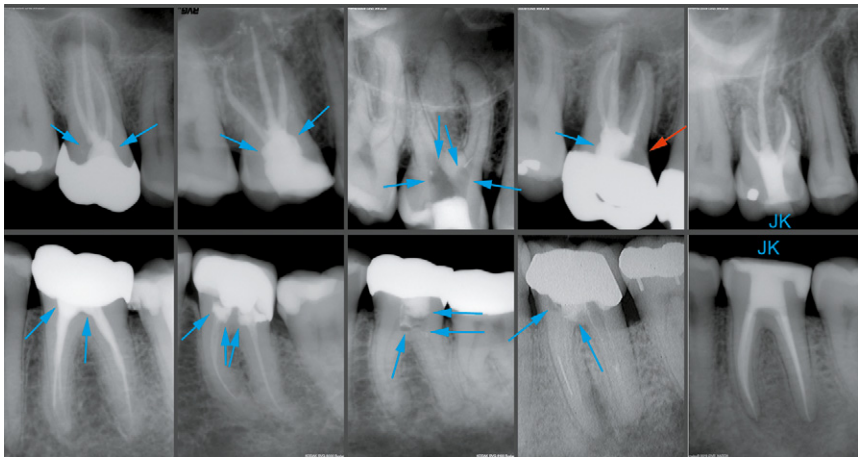
the case shown in **Fig. 9** is more representative of the spectrum of cases typically presenting for endodontic treatment. Clearly, trying to drop a round bur into the scant or nonexistent chamber is not going to lead to the desired outcome even for a skilled clinician. Instead, the size of the burs relative to the chambers, the omnidirectional cutting blades (which side cut aggressively), and chatter common with this bur design are much more likely to lead to the kinds of outcomes seen in **Figs. 2** and **3**.



**Fig. 9.** The case shown here is more representative of the spectrum of cases typically presenting for endodontic treatment. Trying to drop a round bur into the scant or nonexistent chamber is not going to lead to the desired outcome even for a skilled clinician.

So although round burs are destructive because they contribute to, or exacerbate, these problems, it is really the tactile-based mental models predicated on these kinds of drawings showing round burs dropping into the pulp that are the ultimate problem. Care and magnification can compensate, but only to a degree (**Fig. 10**).

(3) Why is complete deroofing so dangerous? When the authors first began to maintain a soffit, which is a small piece of roof around the entire coronal portion of the pulp chamber, it seemed sloppy and contradicted the compulsive nature of traditional dentistry that has made complete deroofing a mark of a thorough clinician. The pulp seemed difficult to remove under the tiny eve and the removal of sealer and gutta percha was equally difficult. It just seemed wrong. Today it makes perfect sense; cleanup is easier and the authors take pride in this important advance in minimally invasive access. It is a perfect example of banked tooth structure. However, it is the attempts at removing the soffit that are far more damaging to the surrounding PCD. The idea that a round bur can be dropped below this soffit and drawn coronally to unroof the chamber is predicated on large pulp chambers and exceptional hand skills. Clinically, it is impossible. Attempting to remove the pulp chamber roof does not accomplish any real endodontic objective, and invariably gouges the walls that are responsible for long-term survival of the tooth. The primary reason to maintain the soffit is to avoid the collateral damage that usually occurs, namely the gouging of the lateral walls. Research will certainly need to be done to validate the strength attributes of the roof strut or soffit. However, in the absence of a compelling



**Fig. 10.** Blue arrows indicate gouges. Red arrows indicate perforations. Essentially, all previously accessed molars were gouged to some degree. The first upper and lower molar cases show what many might consider acceptable access extension, and were obviously cut with round burs. Both are gouged. The third upper and lower cases have frighteningly thin pulpal floors with blushing dentin. The upper fourth case is deceptive in that it is perforated, whereas the worse-looking lower case is not, but the pulpal floor is thin. The last upper molar case (which has a class V resorption repair) shows what is possible with practice, microscope level magnification, an assistant, and the right instruments. The lower molar shows the type of access that should be routinely achievable with high-powered loupes and the right instruments. (JK indicates that the case was done by John Khademi with adherence to the modern model of directed dentin conservation.)

reason to remove dentin, our default position should always be conservative. This 360° soffit or roof-wall interface can also be compared with the metal ring that stabilizes a wooden barrel. Inference to the second moment of inertia in structural engineering deserves analysis. The second potential benefit, as described earlier, is embodied in the physics model of the second moment of inertia. An ideal example of second moment of inertia is the I beam. The second moment or furthest point of the I portion away from the center of the beam, or centroid, determines the resistance to bending. Maintaining dentin as it rounds a corner places it far from the cervical area, which is often where fracturing initiates in the endodontically accessed molar. More important than the soffit itself, however, is the preservation of axial wall dentin near the soffit.

Presuming one could drop into the pulp chamber in the way described earlier (see **Fig. 7**), the chamber roof is now to be removed by scooping it up and away with a round carbide. A two-dimensional drawing with the small size of the bur and chamber roof overhanging a large pulp chamber makes this seem like a reasonable proposition. The chamber walls are always drawn flat even though they are cut by a round bur.

In practice, it is impossible to cut flat walls in 3 dimensions with a round instrument. The chamber is not unroofed in some areas, leaving pulpal and necrotic debris with no specific subsequent step to address the debris, yet the walls are overextended and gouged in other areas. Further, the internal radius of curvature at many of the pulp chamber line angles is simply too small for all but the smallest of round burs.

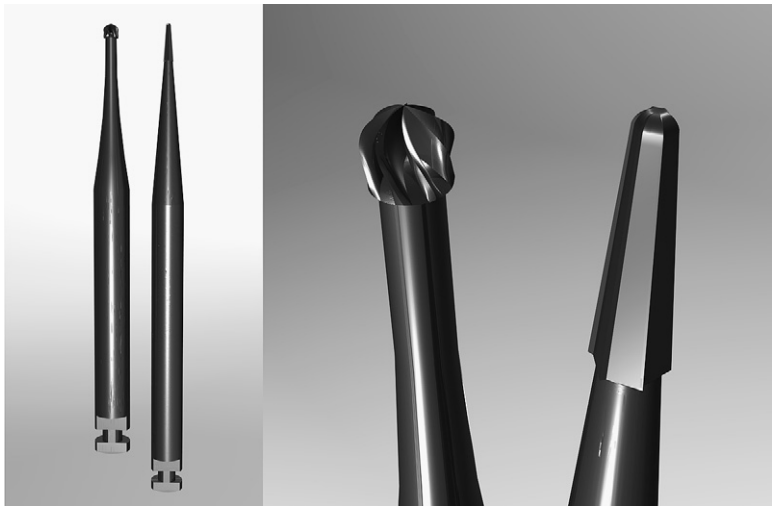
In the final analysis, round burs point cut in an endodontic access application, whereas what is needed is planing. What is needed is a new set of mental models based on vision, and a new set of instruments reflective of the task at hand and the desired shaping outcomes. The new vision-based mental model is *Look, Groom, Follow*. The new burs are all round-ended tapers (**Fig. 11**).

It is appropriate to provide updated cavosurface outlines and cross-sectional illustrations for initial access for the maxillary and mandibular molars (**Table 2**).

## **CAVOSURFACE AND CROSS-SECTIONAL ILLUSTRATIONS FOR MAXILLARY MOLAR ACCESS**

Traditional textbooks devote considerable length and effort on drawing access outline forms that are done on restoration-free, caries-free teeth. The authors hesitate to provide access outline drawings as there are so many variables that enter into the formula on real clinical cases. Within this context, the authors provide these drawings as a guideline for accessing full coverage gold or porcelain for cases in which the underlying restorative materials, the presence or absence of decay, and the locations of sound dentin cannot be ascertained. When in doubt, a larger outline form through the restorative should be cut, but only to the level at which dentin is encountered. Then, the access should be vision based, cuing from the color map and the presence of any PTRs that can be identified. This method is a stepped access, in which an intentionally over-enlarged access is made through the cavosurface of a restored tooth (typically a crowned tooth) to the level at which dentin is encountered, then the access steps in to the size of the pulp chamber outline.

The occlusal view drawing shows an inner outline form in black, requiring the most sophistication in skill and magnification. Suggested extensions for clinicians at different points along the experience/magnification curve in blue and green show extension and enlargement, primarily toward the mesial and buccal. These should be primarily interpreted as the direction to strategically extend the access based on



**Fig. 11.** Comparison of the CK endodontic access bur with the corresponding round bur. The tip size of these burs is less than half as wide as the corresponding round bur. One of the prototype CK endodontic access burs (*right*) is shown and contrasted with the corresponding surgical length round bur (*left*). These burs, designed by Drs Clark and Khademi, will be available from SS White Burs, Inc.

experience/magnification and case difficulty as opposed to absolute outline forms. The angles of entry into the canal system are unlikely to be perpendicular to the occlusal surface. The access rarely needs to be significantly extended to the distal or palatal, as the angle of entry to the palatal canal is out to the mesio-buccal (MB) (Fig. 12), and the distal is toward the mesio-palatal (MP) (Fig. 13). The MB and MB2 angles of entry are generally from the distal, and can also be from the palatal (Figs. 14 and 15).

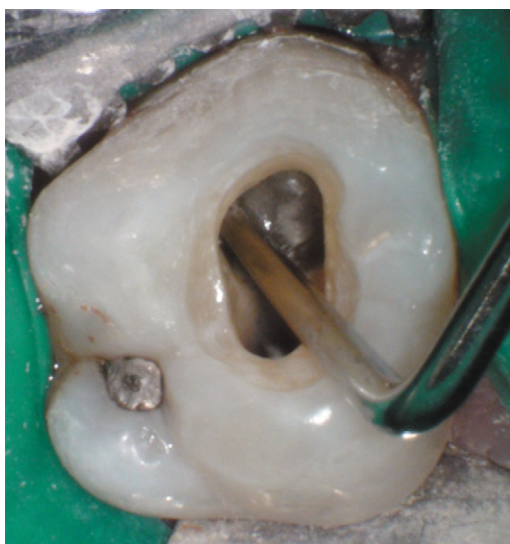
Table 2 The 6 types of molar cavosurface and chamber access	
Restorative Case Type	Cavosurface Angle (To Occlusal Table)
Nonmutilated molar to receive bonded indirect onlay or composite onlay	1 mm of anatomic flattening (2 mm cusp tip flattening); then 45° angle of penetration until reaching the dentinal map (Fig. 20)
Nonmutilated molar to receive full crown	1.5 mm of anatomic flattening (2.5 mm cusp tip flattening); then 45° angle of penetration until reaching the dentin map
Mutilated molar to receive full crown	2–3 mm of flattening
Gold crown to be retained	80° angle of penetration until reaching the dentin map
PFM crown to be retained	45° angle of penetration through the crown until reaching the dentin map
Zirconia based porcelain crown* to be maintained	70–90° angle of penetration until reaching the dentin map

\* As of date of publish, most zirconia based crowns including Lava tm and Procera tm have non etchable cores and non etchable stacked porcelains.

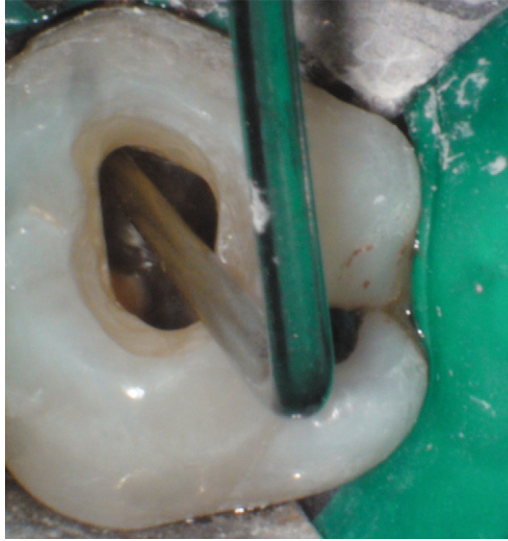


**Fig. 12.** The angle of entry to the palatal canal is out to the MB.

An access extension or modification that is frequently needed is the fluting or notching of the mesial wall in the area of the MB2. This requirement is due to the pattern of calcification that often places the angle of entry to the MB2 at an untenable distal angle. This notching can be performed in dentin with a BUC-1 ultrasonic tip, and, if need be, extended into restorative using an LAAXess nipple-tipped diamond. This case (**Fig. 16**) shows a preliminary access with a slight amount of fluting (**Fig. 17**). A closeup shows the finished fluting in the prepared case, and the overall sizes of the access through the porcelain fused to metal (PFM) (crown) and the dentin (**Figs. 18**

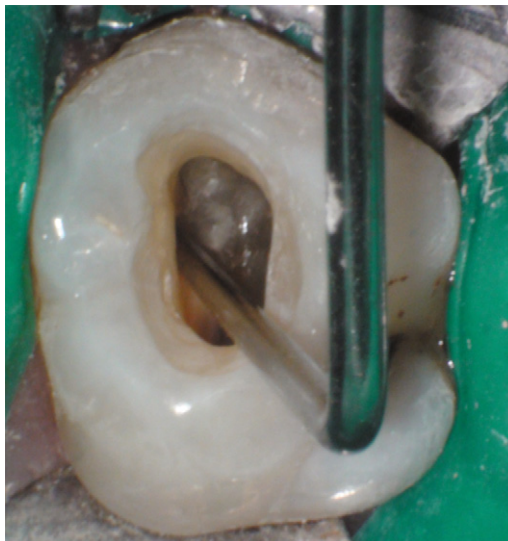


**Fig. 13.** The angle of entry to the distal canal is out to the MP.



**Fig. 14.** The MB angles of entry are generally from the distal side.

and 19). A frequent criticism of the techniques demonstrated here is that these more precise shapes preclude the discovery of coronal points of negotiation (PONs), and deep anatomy, and preclude the development of condensation hydraulics. The authors have not found this to be the case. In this case with an apparent confluent MB/MB2, precurved files were introduced with intent on the palatal aspect of the MB2, which often contains a deep split. The wire radiograph shows the 2 larger files, 1 in the MB orifice and 1 in the MB2 orifice joining, and a smaller file, also in the MB2



**Fig. 15.** The MB2 angles of entry can also be from the palatal side.





**Fig. 16.** Preoperative condition.

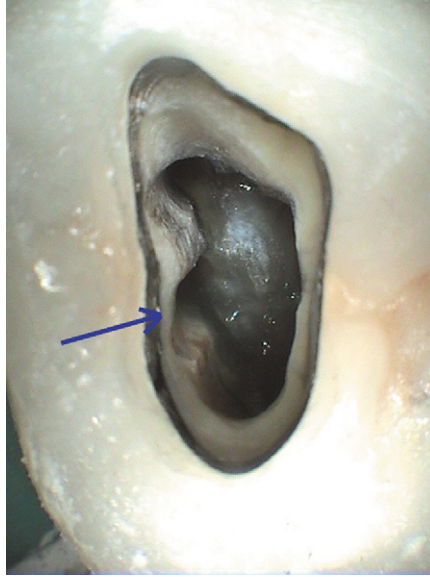
orifice branching deep to a separate portal of exit (**Fig. 20**). The completed case is shown in **Fig. 21**.

As discussed earlier, these should be interpreted more as guides on how and where to extend, rather than as absolute extension guidelines. The first 2 buccal views show a large pulp chamber (**Fig. 22**), and a raw Clark/Khademi (CK)-style access with small



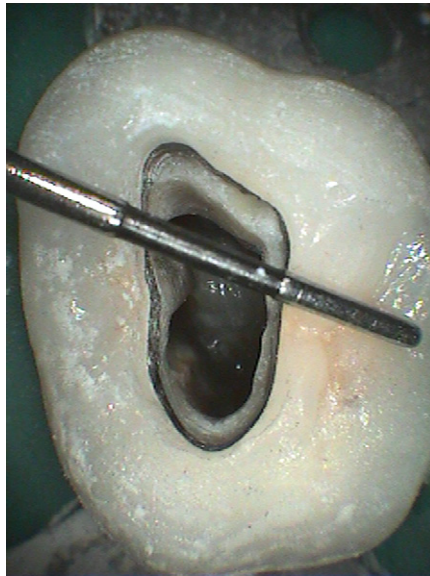
**Fig. 17.** Initial access, slight fluting.





**Fig. 18.** Closeup fluting (*arrow*).

soffits of chamber roof left to be debrided later (**Fig. 23**). The next buccal view is an overlay of the CK-style access, a more traditional occlusally divergent access, and an access taken from a recent text showing fairly parallel walls, but grossly overextended cervically (**Fig. 24**). The second set of overlays shows the CK-style access with blue and green extensions, with cavosurface finish lines appropriate for a bonded



**Fig. 19.** Access with probe.

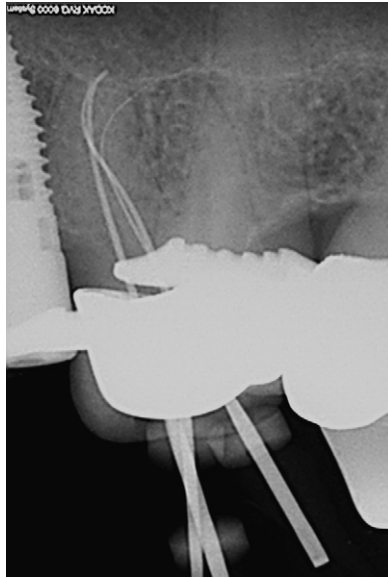


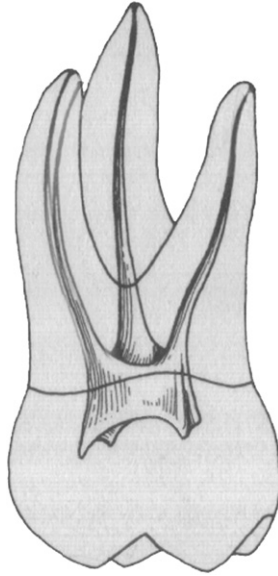
Fig. 20. Working radiograph.

substrate with a bonded restorative, which are described later (Fig. 25). The mesial view shows the various extensions, again emphasizing the directions to extend as opposed to exact amounts and locations (Fig. 26). The extension is not balanced equally between buccal and palatal, but favors the buccal.

The guiding principles and strategy on access and access extension should recognize the hierarchy of tooth needs listed in Table 1. Restorative materials should almost



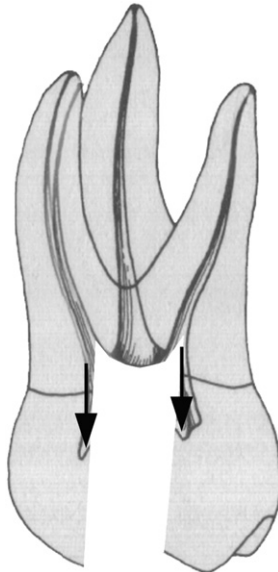
Fig. 21. Final radiograph.



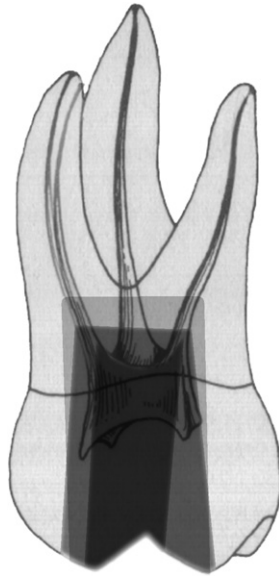
**Fig. 22.** Buccal view with normal pulp.

always be sacrificed before tooth structure. More occlusal tooth structure should be sacrificed for more cervical tooth structure. The key pericervical tooth structure should remain as untouched as possible.

Final cavosurface outline extension at the finish appointment (which may be the start appointment on a 1-step case) hinges on the existing restorative, and the restorative plan. If abundant highly bondable substrate such as etchable porcelain or

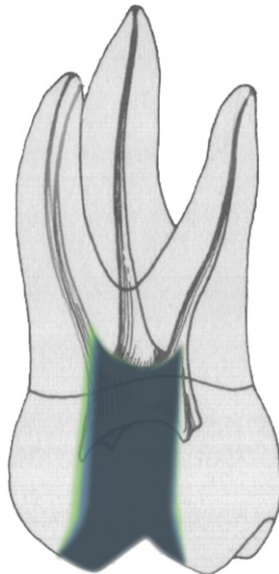


**Fig. 23.** Buccal view with CK access and soffit (arrows).

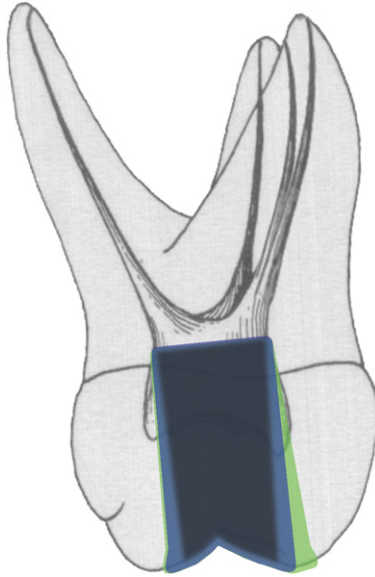


**Fig. 24.** Buccal view with access overlays.

enamel is available, and a bondable restorative material such as a heavily filled composite resin is planned, the cavosurface should be Cala Lillied (**Fig. 27**), or generously beveled on those areas. If the bondability of the substrate is of low, or a bond cannot be established between the substrate and restorative material, a butt joint or 70 to 90° interface at the cavosurface should be the objective. On multiple visit cases in which an unbonded temporary restoration is placed, the cavosurface should be maintained at 70 to 90° until the completion visit.



**Fig. 25.** Buccal view with various extensions.



**Fig. 26.** Mesial view with various extensions.

#### **CAVOSURFACE AND CROSS-SECTIONAL ILLUSTRATIONS FOR MANDIBULAR MOLAR ACCESS**

These illustrations are consistent with the style of access demonstrated in the maxillary molar section earlier (generously flared and flattened when appropriate in the coronal third of the tooth, then conservative in the middle and apical portion of the coronal portion of the tooth).

The first step in contemporary molar access in the noncrowned tooth is flattening. It is a step that is ignored or overdone in most practices.

#### **GUIDELINES FOR TREATMENT DECISIONS**

There have been some consistent patterns in what the authors have observed in their practices with the long-term successful cases. These observations are important for



**Fig. 27.** Traditional parallel-sided access (*left*), compared with the Cala Lilly enamel preparation (*right*). (*Left*) Unfavorable C factor and poor enamel rod engagement are typically present when removing old amalgam or composite restorations or with traditional endodontic access of 90° to the occlusal table. (*Right*) The enamel is cut back at 45° with the Cala Lilly shape. This modified preparation will now allow engagement of nearly the entire occlusal surface.

2 reasons: (1) they can serve to direct how virgin endo/restorative cases planned for treatment are managed; (2) they can help the endodontist quickly decide whether retreatment failing prior treatment is even worth investigating. Although it would be advantageous for the treating clinician to have objective randomized clinical trials (RCTs) on the factors related to long-term endodontic success, there is a dearth of RCTs of longer than 20 years to guide the clinician with the real variables related to long-term success. The authors are, however, able to observe the cases presenting to their practices. These observations contradict contemporary endodontic thinking, yet, when put to the test, remain essentially unchallenged. They are certain to cause controversy in the endodontic community:

- (1) Long-term, that is, 20- to 40-year, success of the endodontically treated tooth has little to do with what would be traditionally characterized as the quality of the endodontic result.
- (2) Preservation of dentin trumps quality endodontics when evaluated over a time frame of 20 to 40 years.

### ***The Three Strikes Rule***

In endodontically treated cases from 20 to 40 years ago, the authors have observed consistently that these teeth are violated in less than 3 ways. The cases that truly go the distance have damage in 2 or less of the following clinically controllable variables:

- (1) Excessive axial reduction (consistent with PFM or all-porcelain restorations)
- (2) Gouged endodontic access
- (3) Large and arbitrarily round endodontic shape.

The authors would contend that teeth that are violated in 3 or more ways simply do not go the distance. All 3 of these violations are insults to the PCD, and if all 3 are present, the loss of PCD is irreparable and the tooth is permanently compromised or destroyed. When the clinician is evaluating a case for possible treatment, it is far more advantageous and expedient to evaluate the restorative aspects of the case first. One should ask: "Presuming successful endodontic treatment, what is left to work with?" For instance, if the distal half of the tooth is severely decayed, but the patient has adequate opening, the access can be distalized, directing dentin conservation to the mesial half of the tooth, leaving the opportunity for enough 3DF.

With retreatment cases, the rationale is the same, and the question to ask, before even considering the endodontic issues, is: "How many ways has this tooth been violated?" If the tooth has been violated 2 or more ways (ie, 3 strikes), it is exceptionally unlikely that a long-term result can be delivered to the patient with even the most exceptional endodontic care.

### **GLOSSARY OF TERMS FOR CONTEMPORARY MOLAR ENDODONTIC ACCESS**

- The endodontic-endorestorative-prosthetic (EERP) continuum

The EERP is a restoratively driven view of the endodontics as simply a servant to the restoration and preservation of the tooth, concurrent with a complete integration of endodontic design as part of an interlocking series of components. From crown to apex an outside fortress of fracture resistance, and from inside to outside a set of firewalls for leakage prevention. Biomimetics and minimally invasive dentistry are guiding

principles. Each component must compliment, not compromise, the other components. If at any point in the diagnosis, access, endodontic shaping, or obturation a critical compromise is discovered, the ethical directive demands that extraction and implant placement must be considered in lieu of continuation of the attempt to retain the tooth.

- Three-dimensional ferrule (3DF)

3DF is an evaluation of the available dentin that will buttress the crown. The 3 components are dentin height, dentin girth (dentin thickness), and TOC (total draw of the opposing axial walls; buccal-lingual and mesial-distal).

- Pericervical dentin (PCD)

PCD is defined as the dentin near the alveolar crest. This critical zone, roughly 4 mm coronal to the crestal bone and extending 4 mm apical to crestal bone, is crucial to transferring load from the occlusal table to the root, and much of the PCD is irreplaceable.

- Banked tooth structure

The approach of banking of tooth structure in restorative dentistry dictates that whenever possible, more tooth structure should be left in place than is needed for the procedure at hand. It may involve a less expedient, but more conservative, approach. This banked tooth structure may serve as a valuable future asset in the advent of unforeseen future trauma or disease, coupled with the reality that a tooth will need to last for decades and potentially be restored and then rerestored in the patient's lifetime.

- *The inverse funnel*

An undesirable endodontic access shape in which the size of the access becomes wider as it progresses deeper into the tooth. It is a common occurrence when constricted cavosurface access opening size is paired with round bur use. It is exacerbated when advanced magnification is not used during tooth cutting.

- *Blind tunneling*

Blind tunneling is another undesirable endodontic access approach and shape that creates a parallel sided access when performed without advanced magnification, relying on tactile feedback rather than on microscopic visualization and following the dentinal maps of primary, secondary, and tertiary dentin and microscopic traces of residual pulp tissue. Typically performed with round burs.

- *Blind funneling*

Blind funneling is another undesirable access shape, common in generalist and endodontic specialist practices. This popular practice obliterates significant tooth structure to facilitate rapid and safe (avoidance of file separation) machining of the roots with rotary files.

- Filling and caries leveraged access
- Partial deroofing
- Soffit
- Stepped access
- Secondary dentin (2° dentin)



- Tertiary dentin (3° dentin)
- Biomimetic endodontic shaping (BES)
- *Arbitrary round shaping (ARS)*
- The dentinal map
- The dentinoenamel junction (DEJ)
- The junction of primary and secondary dentin (D<sup>2</sup>J)
- The junction of primary and tertiary dentin (D<sup>3</sup>J)
- Pulp tissue remnants (PTRs)
- The Cala Lilly

**Fig. 27** highlights the creation of the Cala Lilly cavity shape. The Cala Lilly is a flower and is the new model for composite preparations.

- Points of negotiation (PONs)

PONs are statistically predictable anatomic areas that may serve as starting points during the access portion of endodontic therapy.

*Italicized points indicate an undesirable outcome or technique.*

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