

## **Endodontic Access Preparations: Dentin Conservation and the Anatomical Danger Zones**

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*The author and his practice partner, Dr. Paul Brown, have spent the last 30 years in clinical endodontic practice. As established specialists, they have handled their share of difficult cases and in that time they became aware that most of the iatrogenic treatment errors in endodontic therapy were the result of an **incomplete understanding of dental anatomy**. Their frustration with how to address this lack of understanding and how to teach the principles of anatomy were answered with a serendipitous visit by Dr. Brown to a computer laboratory at Stanford University, California. The Stanford/NASA Biocomputational Laboratory was developing interactive viewing software for three-dimensional computer models and applying it to medical computerized tomography (CT) images. Dr. Brown realized that this technology could be applied to dental anatomy education. With funding from the National Institutes of Health, the authors have spent the last 10 years developing a unique educational product using this software and the power of the modern computer to teach dental anatomy. Called the “3D Interactive Tooth Atlas,” the current version, 5.1, contains more than 450 high-resolution interactive computer models of real human teeth derived from research-grade micro CTs (mCTs).<sup>1</sup> The authors are pleased that this unique product is starting to impact the anatomy education of dental students in the United States. While the author has always been a student of dental anatomy,<sup>2</sup> this work has dramatically increased his awareness of the nuances and clinical ramifications of the teeth that we treat. As his understanding has increased, the awareness of the complexity of our treatment task became more obvious.*

At the same time, endodontics has seen significant changes. For example, the wide adoption of the surgical operating microscope has allowed dentists to visualize more complex anatomy.<sup>3,4</sup> When the author started practice in the 1970s, the assumption was that the upper first molar had a second canal in the mesiobuccal (MB) root about 50% of the time.<sup>5</sup> Currently, endodontists are reporting fourth canals in the MB anywhere from 70% to 95% of the time in clinical practice, and teeth with five and six canals are seen with some frequency.<sup>6</sup> The author’s practice partner, Dr. John Jaber, recently treated an upper first molar with seven canals (Figure 1 [View Figure](#)). All of this variation and complexity that dentists are seeing is the result of the increased understanding of the potential for complexity and the ability to visualize details with the microscope. This has created better treatment outcomes because if a clinician understands and can see the anatomy, they can treat optimally.

Endodontics also saw the introduction and adoption of engine-driven nickel-titanium (NiTi) rotary instruments for shaping the canals. They have increased the efficiency of treating endodontics cases, especially difficult ones with curved canals. As one might expect, there is no universal answer to dental problems and there occasionally exist incompatibilities between the file system being used and the anatomy being addressed. This can be a subtle problem, and this article will point out some of the anatomical danger zones and the shaping strategies needed to address them. The author does not attempt to provide a comprehensive review of all the file systems on the market, but seeks to identify the features of which the clinician needs to be aware when selecting instruments for a specific situation.

### **The Problem: There Is Less Dentine than We Think**

This situation is illustrated by Figure 2 ([View Figure](#)), showing the mesial root of a lower first molar that was extracted because of a distal root fracture. The mesial root, along with some attached bone was mCT scanned to evaluate the clinical fill requirements. This tooth was shaped with a popular file system that produces a final, predefined shape with one instrument. The clinician found and treated a middle mesial canal. The interesting feature of this tooth is the presence of deep concavities on both the mesial and distal sides of the root, which produced a narrow isthmus in the middle of the root. While there is some minimal transportation of the canals toward the furcation in the MB and distobuccal (DB) canals, the file used is appropriate to the amount of dentine in these canals. This is not the case with the middle mesial. The minimal amount of dentine, combined with some transportation of the canal, resulted in a possible lateral strip perforation. A more appropriate shaping strategy would have been to use a file with a smaller diameter at this level. Interestingly, this did not result in destruction of the bone and was not the cause of the extraction. Middle mesial canals are reported to occur in approximately 13% of lower first molars<sup>7</sup> and they may be common with another canal. The clinician should assume that the middle mesial canal does not join another canal until proven otherwise. The clinician should also assume that the root has a furcation-side concavity, resulting in a thin layer of dentine over that canal. A more conservative shaping preparation should be routine to prevent a lateral strip perforation.

**Concavities in the roots of lower molars are more common** than is appreciated and are not obvious in radiographs. These concavities tend to be on the furcation side of the root but can occur in the outside root surface also ([Figure 3 View Figure](#)).

The upper molar MB root can also be problematic. They usually have concavities on the furcation side and the dentine over the MB2 canal can be quite thin. (Figure 4 [View Figure](#)). Many of these canals have high curves, which exacerbates the canal transportation tendencies of the shaping procedures. Straightening out the upper part of the canal will reduce the curve and thus reduce the transportation potential (Figure 5 [View Figure](#)). Figure 6 ([View Figure](#)) illustrates a typical access preparation that applies these principles. The MB2 and MB3 canals were both left smaller in diameter to conserve dentine but moved laterally to the outside of the tooth to straighten the canal. In some upper molars there is a shelf of dentine that appears to cover the canal orifice, as in Figure 7 ([View Figure](#)). Preparation in this case required removal of the shelf; presentations like this will often need a significantly greater amount of lateral movement of the drill in the MB2 canal orifice during the access preparation. This must be done judiciously to avoid perforation into the furcation.

### Features of the NiTi File

There are many different files on the market at this time. Traditional hand files have a specific geometry: they have a 16-mm cutting flute length and a constant .02 taper (ie, the file increases in diameter .02 mm for each mm from the tip), so the file is .32 mm ( $.02 \times 16 = .32$ ) larger in diameter from the tip (D1) to the end of the flutes (D16). The current constant-taper NiTi rotary files presently on the market come in tapers from .02 up to .12, and the most common tapers used are .04 or .06. The thickness of the shaft varies with the file size and taper. Because file flexibility varies with the diameter, a more tapered instrument is considerably stiffer at D16 than a less tapered one, even though the tips are the same diameter and stiffness,<sup>8</sup> and this has significance when dealing with canals with high curves. The initial clinical conclusion might be to just use a less-tapered instrument for all canals but larger tapers do have advantages—providing more room for instrument and irrigation access and steeper tapers provide better control of the apical extension of the filling material. However, a steep, straight-tapered instrument used in a long canal can remove too much dentine coronally. The ProFile® (DENTSPLY Tulsa, Tulsa, OK), K3™ (SybronEndo Corporation, Orange, CA), Quantec™ (SybronEndo), and Endo Sequence (Brasseler USA, Savannah, GA) instruments are all straight tapers that vary in flute design.

A number of strategies have been developed to resolve the problem of removing too much dentine coronally. The GT® and GT Series X™ systems (DENTSPLY Tulsa) limit the shaft diameter to 1 mm, regardless of the taper or tip diameter of the file, though the flute length necessarily changes with this

strategy. The use of newer alloys in the GT Series X system creates a relatively flexible shaft above the flutes. The ProTaper® (DENTSPLY Tulsa) system has three shaping burs and three finishing burs, which have a multi-taper design. The system has steeper tapers at the apex, with the tapering decreasing up the flutes, which allows good access for irrigation and good control of the obturation material. Both systems have a 1.2-mm shaft diameter. The V-Taper system (Guidance Endodontics, Albuquerque, NM) uses a multi-taper design with a unique reduced-diameter shaft to provide a consistent flexibility between the flutes and the shaft. This smaller shaft and the use of new alloys creates a file with good flexibility higher in the file shaft. The Lightspeed LSX system (Smart Endodontics by Discus Dental, Culver City, CA) has a small, spade-shaped cutting tip on a long, flexible shaft. This is probably **the most flexible** instrument on the market, but it requires the use of a step-back technique with multiple-sized instruments to create a tapered apical shape. There are also many other systems available and the clinician should evaluate and select from them based on their strengths and weaknesses. Many clinicians have multiple systems in their offices to meet the demands of different clinical situations.

A crown-down shaping approach, where the coronal third of the canal is enlarged first, opens up access to the mid and apical thirds of the canal and makes shaping easier.<sup>9</sup> Many instruments can be used for this (Figure 8 [View Figure](#)), though, historically, the Gates-Glidden bur was the instrument of choice and is still popular. It can be used with lateral pressure to help straighten the coronal part of the canal; however, care must be taken with Gates-Glidden burs to ensure that appropriate sizes are used.<sup>10</sup> The larger sizes are too large for most canals and should only be used in the pulp chamber or not at all (Figure 9 [View Figure](#)).

### **Other Danger Zones**

The upper premolar creates some special challenges because of the narrow mesial-distal width. The root is only about half the width of the crown, creating the illusion of a tooth that is larger than it really is. Accuracy in accessing the canal is important, as is using the appropriate size of burs and files to shape the canal(s). **Some file systems are too large in diameter for a small premolar.** The post must be matched in diameter to the narrow ovoid shape of the canal (Figure 10 [View Figure](#)). Note that any excess dentine removed for a post space will **only weaken the tooth** and increase the potential for root fracture later.

The lower lateral and central teeth have the same problem as the upper premolar—having a very narrow mesial-distal dimension. They present unique challenges in access and in minimizing the amount of dentine removed during shaping. It is very easy to over-prepare these teeth and compromise their

structural integrity (Figure 11 [View Figure](#)). Very thin posts are necessary to conserve structural dentine.<sup>11</sup>

### Clinical Decisions

The clinical decisions made during access and shaping involve a variety of judgments. Once access is created, the canal is explored with small hand instruments and possibly radiographs to determine the amount and location of any canal curvature and judgment is used to assess the potential amount of dentine. A strategy is then created to deal with the specific situation that each canal presents, keeping in mind the dimensions and shape of the file system being used. For example, using a ProTaper finishing file in the MB and DB canals of a typical lower molar may be very appropriate, while the same file in the middle mesial of the same tooth would be too large in diameter. In the upper molars, each canal typically presents its own set of challenges, as Figure 12 ([View Figure](#)) illustrates. Here, the lingual canal was straightforward and large enough not to require special consideration. The DB had a curve near the apex that most NiTi systems would negotiate gracefully, though the MB root was another story: it had three canals and a high, sharp curve that created a very difficult situation. Careful negotiation with hand instruments and selection of instruments with good shaft flexibility was necessary to avoid instrument breakage and each canal had to be approached with a different strategy to create success.

### CONCLUSION

In summary, having a sound understanding of the anatomy and the instrument systems being used will help the clinician avoid frustrating procedural errors in complex teeth. Such understanding will help the clinician to make the various judgments required in **typical and atypical** endodontic cases.

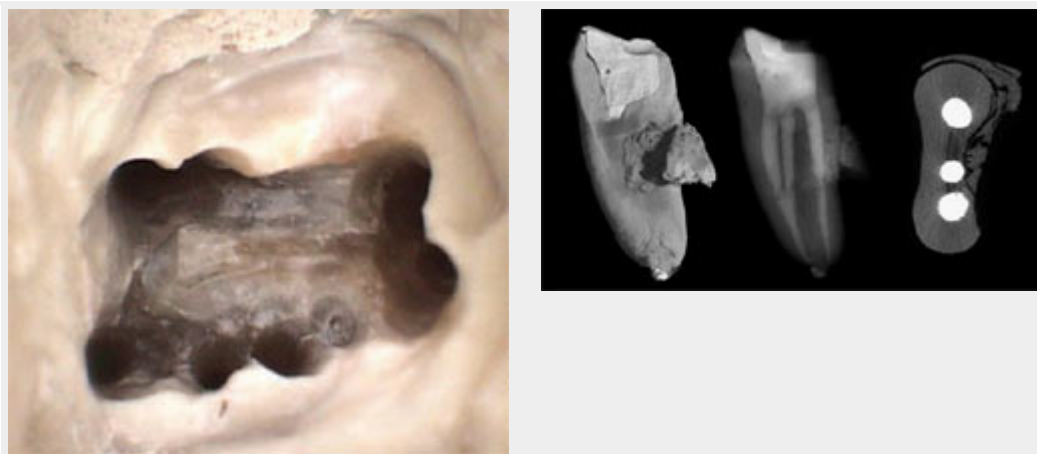
### DISCLOSURE

Dr. Herbranson is an owner/employee and stock shareholder at Brown and Herbranson Imaging.

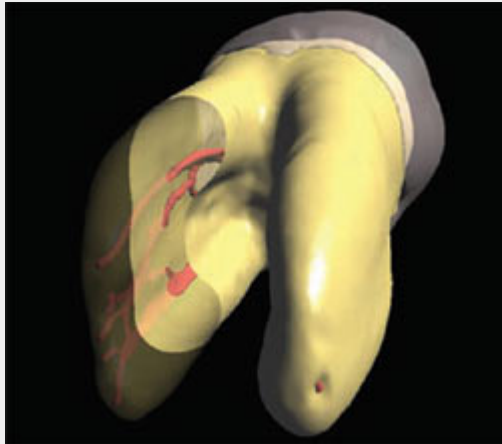
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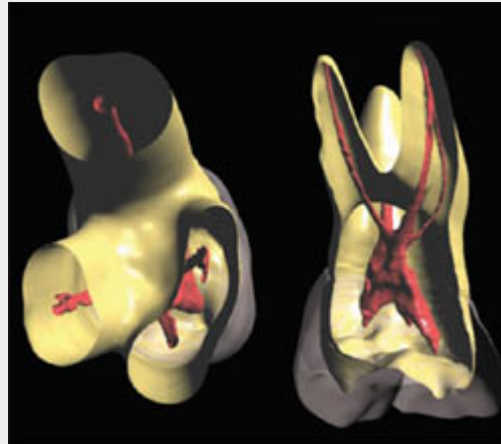
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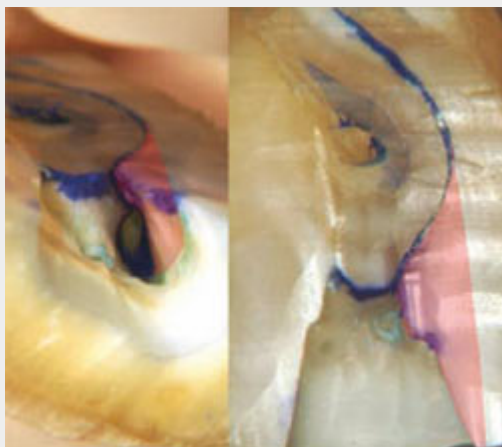
**Figure 1** An upper first molar with seven canals. Image was taken with an intraoral video camera.



**Figure 2** A lower first molar mesial root. The left image is a voxel model from the mCT scan, the middle image is a radiographic derived from the mCT scan, and the right image is a slice from the mCT data, at a level just below the furcation.



**Figure 3** A polygon model of a five-canal lower first molar with the mesial root apex transparent. Note the complex anatomy with three canals and five portals of exit.



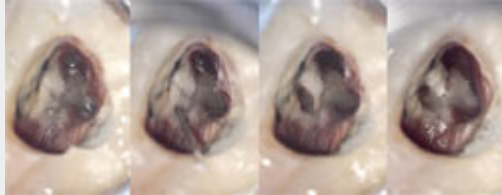
**Figure 4** An upper first molar with two canals in the MB root. Note the narrow amount of dentine in the area of the MB2 canal. Also note the high curve and steep angle of entry to the pulp chamber of the MB2 canal.



**Figure 5** An upper first molar

**Figure 6** An upper first molar

sectioned and stained to show the high curve in the MB canal and the dentine to be removed during the access to reduce it. Sample prepared by Dr. David Clark.



**Figure 7** An upper first molar access showing considerable lateral transportation of the MB2 orifice.

showing conservative shaping in the MB2 and MB3 canals.



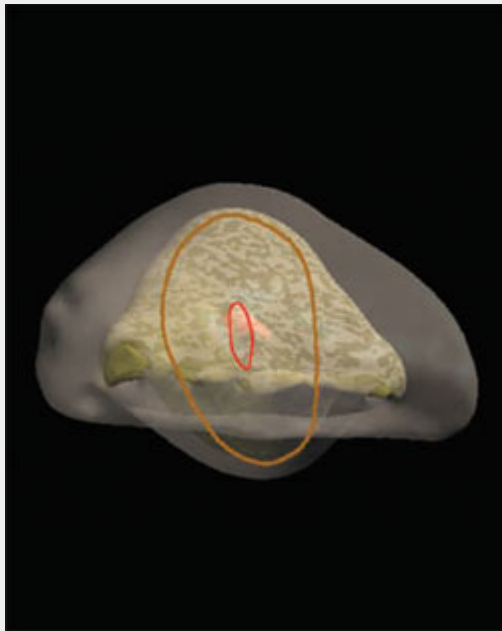
**Figure 8** Shows the use of the ProTaper SX bur to create the initial crown-down access. This bur can be used with lateral pressure, but since the maximum diameter of the bur is 1.2 mm, care must be taken to not over-prepare the coronal part of the canal by carrying it too deep in the canal.



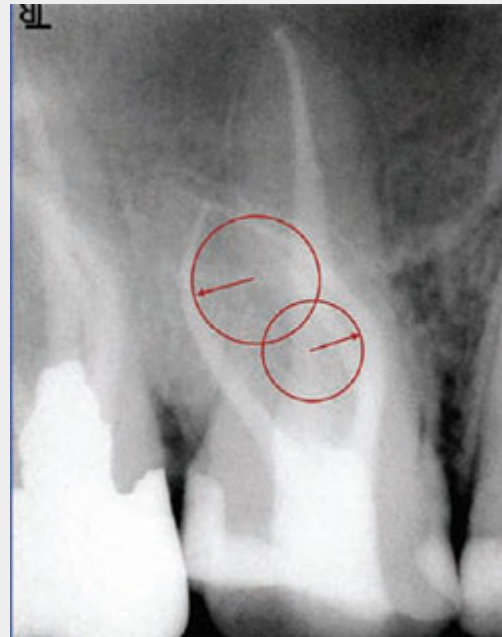
**Figure 9** Large Gates-Glidden burs are too large for most canals and should only be used in the pulp chamber to re-contour the access preparation.



**Figure 10** An upper premolar with the root form projected onto the clinical crown. Note the ovoid nature of the canal system and the narrow mesial-distal dimension of the root.



**Figure 11** A lower lateral incisor. Note the narrow mesial-distal



**Figure 12** An upper first molar with a difficult high, sharp curve

dimension of the root compared with the crown form. in the MB root.

### **About the Author**