Minimally invasive and biomimetic endodontics: The final evolution?

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Traditional endodontics has been based on feel, not sight. Tactile proprioreception was the only guide as burs and files were blindly inserted into pulp chambers and root canal systems. Together with radiographs and electronic apex locators, this blind approach has produced surprising success that, in the words of Dr. Eric Herbransen, "the endodontics succeeds often in spite of us."

Fig. 1: An immature maxillary molar is sectioned and viewed from the apical aspect.

Fig 2: This lower bicuspid was treated with a generous crown-down endodontic shape and suffered a retrograde root fracture within three years of the endodontic treatment.

Figure 3: This radiograph demonstrates a thirty-one year success with delicate shaping and crude obturation with silver points (#14), and a four-year failure with a large crown-down shape and heated gutta-percha (note the lesion on #13).

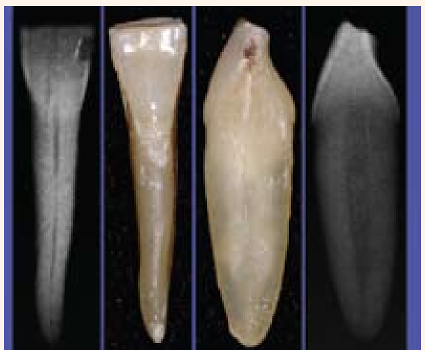

Fig. 4: This mandibular incisor appears so frail with a lingual view or radiographic image. It appears husky with a mesial view. It is at least twice as broad buccal lingually.

There is, however, a significant failure rate, especially long-term failure, that is driving mainstream dentistry to aggressively extract natural teeth in favor of implants. The sting of clinical failure is a powerful motivator for change. In this article, I will describe the rationale and techniques involved in minimally traumatic endodontic access and shaping (Part I). In my upcoming Webinar I will discuss obturation techniques for smaller and non-round endodontic shapes, which will also appear as a follow up article in this publication (Part II).

Ribbons, sheets & banners

One of the most distressing "hangovers" of the era of blind endodontics and endo-restorative is the belief that canal systems are straight, exit at the radiographic apex and are round in cross section. In reality, most canal systems curve and exit short of the radiographic terminus. A very large number, at least 50 percent, are ovoid or super-ovoid in cross section. Figure 1 demonstrates that of the three roots and canal systems shown, only one is round. As these canal systems mature, they narrow into a variety of unpredictable ovoid shapes often with smaller anastamosing canal systems (Figs. 4–6).

The evolution of endodontic shaping

The original endodontic shape was established based on mostly hand filing and filled with either silver points or cold lateral condensation of gutta-percha. Sargenti later introduced a more rapid approach that involved machine-driven instruments (rotary files) creating larger shapes with significantly more dentin removal. As of late, a "crown down" approach is now popular. The roots are rapidly and blindly machined. This can result in better obturation of the apical half because of improved penetration of irrigation during instrumentation and improved hydraulics during obturation. But at what cost (Fig. 2)?

Is crown down endo actually better than lateral condensation?

The outcome studies are inclusive, but what we do know is that the success rate today is no better than it was 40 years ago (Fig. 3). The advantages of crown down are often offset by the weakening caused by Gates-Glidden burs and orifice shapers. The short-term thrill of the radiographic "puff of sealer" at the apex is lost when the tooth implodes a few years down the line. Residual dentin is directly related to long-term strength and has indisputably been shown as the key to long-term tooth retention.

In contrast, the supposed strengthening of the root from a "monoblock" of bonded resin obturation, bonded core and fiber post is proving to be inconsistent.[1] Another startling revelation is that the dentin in an endodontically treated tooth is *not* more brittle than in a vital tooth.[2–4] In short, preservation of peri-cervical dentin and ferrule girth trump all other factors.

Ovoid canal systems & roots are non-round for a reason

Rotary instruments and obturating points of gutta-percha are round because of the limitations of their mechanical nature. They create anatomically appropriate shapes in round roots, but fail in ovoid roots. Over the ages, the dynamics of occlusion and arch form have guided the development of human tooth roots such that at least half have ovoid roots.

Smaller and/or ovoid shaping: Why and how?

Why Biomimetics is a treatment approach that has, as its ultimate goal, to retain as much of the natural tissue as practical, and to mimic the physics and structures of the human body. There is nothing biomimetic about a stiff, round rod (prefabricated post) running through the center of an ovoid root.

The natural ovoid root is essentially a semi-rigid pipe deriving its strength from without, not within. The endodontic and endo-restorative goal should be to mimic the pulp space that was present when the tooth was young. From that point, it can be argued that any secondary dentin that is deposited adds little additional strength because of the amorphous and irregular deposition pattern. This point is supported by the robust strength of young teeth with large pulp chambers and large radicular pulp spaces.

If a small round access that does not disturb primary dentin can allow instruments to engage potentially significant complex anatomy (e.g., a second or third major system and corresponding portals of exit), then the round access is acceptable. The reality of ovoid roots would seem to disagree with this approach.

Creating a large round access that results in removal of primary dentin of the delicate, narrow portion of the root is the common approach today. While this can allow access to complex branching of systems that

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occurs further apically, it does not satisfy the more appropriate goals of anatomic, biomimetic dentistry. Additionally, the single large round endodontic shaping pattern often encroaches upon a fluting in the center of the root.

How: visually shaping ovoid systems The three components of ovoid shaping are:

1) the operating microscope with powerful coaxial shadowless lighting,

2) ultrasonic instruments, and

3) an understanding of the anatomy of ovoid roots.

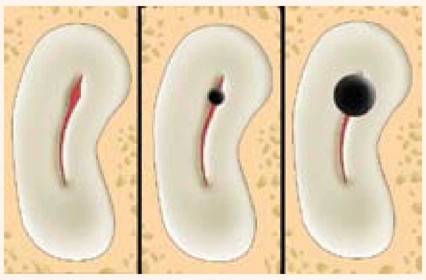
Anatomic, biomimetic shaping cannot occur safely "by feel" (Figs. 7, 8).

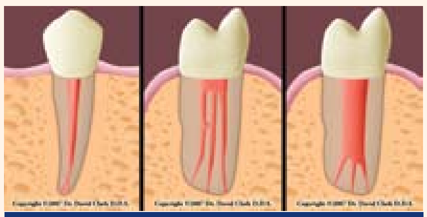
Summary

Although no two roots are the same, general anatomic patterns allow the microscope-equipped clinician to search for major pulpal regions that will yield a high probability of cleaning and shaping the clinically available pulpal zones. The shapes that were introduced during the Schilder era have served as a transitional technique to allow the first real three-dimensional compaction of gutta-percha. Endodontics is, in reality, a *restoratively* driven procedure; and minimally invasive and biomimetic principles will require different skills and materials to shape, pack and restore these non-round canal systems.

Figs 5: One variation of potential anatomy in an ovoid root; system branches in apical third of a C-shaped second molar.

Fig. 6: Another variation of ovoid roots, non-round systems branch into five systems in the coronal third. (Image courtesy Dr. John Khademi)





Figs. 7, 8: Several renderings contrast current endodontic shapes versus new biomimetic microscope enhanced shapes. Figure 7 shows the preoperative pulpal space of the root, sectioned at the orifice, then shows lateral condensation shape that does not weaken the root but also does not address the potential complex anatomy. Next image shows the new aggressive crown-down shape that weakens non-round roots. Figure 8 shows two potential shapes that are anatomic, address the complex anatomy and yet do not weaken the tooth. Figure 8a shows the obturated anatomic shapes in the second axis.

Fig 9: A new model for lower incisor access is depicted, along with the new CK endodontic access bur. Note that the access has been moved away from the cingulum and towards the incisal edge. The delicate tip size of the bur and its conical shape are helpful to both visual (dentists using microscopes) and tactile (little or no magnification) endodontics.

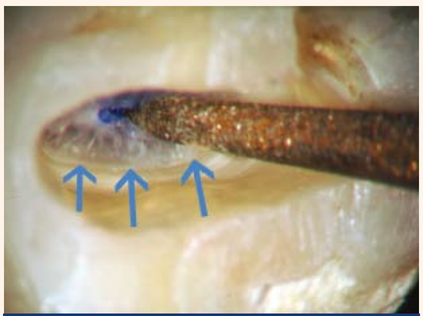


Fig. 10a. Extracted bicuspid is shaped to follow the pattern of secondary dentin that has been described by Carr as resembling "glacial ice" in appearance under the microscope. One border of secondary dentin and primary dentin is outlined with arrows. Glacial ice is one of the many terms used to describe the many color and translucency features of secondary and tertiary dentin. CPR 2D (Obtura-Spartan) ultrasonic tip is pictured at 16X.

Fig. 10b: Depicts the much finer CPR 5D as the ovoid system is explored further apically with constant microscopic visualization. Note the ideal visual environment that is the hallmark of the microscope-ultrasonic combination. It allows for identification of dentin maps for the ultimate in dentin preservation.

Table 1: New Microscope-Enhanced Protocol
1. Initial access with round-ended carbide or diamond burs. For incisors and canines, the new CK endo access burs provide optimum safety and dentin preservation (Fig. 9).
2. Gross de-roofing with tapered diamond burs, retaining a small "soffit."
3. Provide straight-line access sweeping away from high-risk anatomy with the CPR-2D.
For ovoid systems ...
4. Sweep the coronal ¼ of the ovoid system with the CPR-2.
5. Sweep the next ¼ or ½ with the CPR-4D or 5D (Fig. 10b).
6. Irrigate, dry with the Stropko syringe and then evaluate at 16–24x for multiple systems that branch in the apical half.
7. Begin filing.

References

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About the author

Dr. David Clark founded the Academy of Microscope Enhanced Dentistry and is a course director at the Newport Coast Oral Facial Institute. He lectured for Clinical Research Associates in the "Update Series." In addition, Clark authored the first comprehensive guide to enamel and dentinal cracks based on 16 power magnification, and numerous articles relating to minimally invasive dentistry, biomimetic endodontic shaping, diastema closure and advanced magnification. Clark helped pioneer the concept of "biomimetic micro-endodontics." He serves as an opinion leader for restorative dentistry and endodontics, introduced the "Clark Class II" for posterior composites and developed the Bioclear Matrix System.

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