Minimally invasive and biomimetic endodontics: The final evolution?

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Traditional endodontics is 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. With radiographs and electronic apex locators, this blind approach has produced the surprising result that, in the words of Dr Eric Herbransen, “the endodontics succeeds often in spite of us.”

There is, however, a significant failure rate, especially long-term failure, that is driving mainstream dentistry to extract natural teeth aggressively in favour of implants. The sting of clinical failure is a powerful motivator for change. In this article, I describe the rationale and techniques involved in minimally traumatic endodontic access and shaping. Also, I discuss obturation techniques for smaller and non-round endodontic shapes in a follow-up article in this publication.

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. Dr Angelo Sargenti later introduced a more rapid approach that involved machine-driven instruments (rotary files) creating larger shapes with significantly more dentine removal.

As of late, a crown-down approach has become popular. The roots are rapidly and blindly machined. This can result in better obturation of the apical half because of improved penetration of 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 per cent, 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 anastomosing canal systems (Figs. 4–6).

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

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.

Fig. 3. This radiograph demonstrates a 31-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).

Ribbons, sheets and banners

One of the most distressing hangovers of the era of blind endodontics and endo-restorative are the beliefs that canal systems are straight, exit at the apical third 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 per cent, 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 anastomosing canal systems (Figs. 4–6).
irrigation during instrumentation and improved hydraulics during obturation. But at what cost (Fig. 2)?

_Is crown-down endodontics actually better than lateral condensation?

The outcome studies are inconclusive, 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 dentine 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 fibre post is proving to be inconsistent. Another startling revelation is that the dentine in an endodontically treated tooth is not more brittle than in a vital tooth. In short, preservation of peri-cervical dentine and ferrule girth trump all other factors.

_Ovoid canal systems and 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 aims 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 centre 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 dentine 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 dentine can allow instruments to engage potentially significant complex anatomy.
Two potential shapes that are anatomic and address the complex anatomy yet do not weaken the tooth. The obturated anatomic shapes in the second axis.

A CK endodontic access bur (right) is shown and contrasted with the corresponding surgical-length round bur (left). The tip size of the CK bur is less than half as wide as the corresponding round bur. Designed by Drs Clark and Khademi, the CK endodontic access burs will be available from SS White Burs Inc.

A new model for lower incisor access is depicted, 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 for both visual (dentists using microscopes) and tactile (little or no magnification) endodontics.

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

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

(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 dentine of the delicate, narrow portion of the root is the common approach today. While this can allow access to the complex branching of systems that 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 centre of the root.

How: By 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. 7–8a & b).

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 3-D compaction of gutta-percha. Endodontics is, in reality, a restoratively driven procedure; thus, minimally invasive and biomimetic principles will require different skills and materials to shape, pack and restore these non-round canal systems.
Table 1
New microscope–enhanced protocol

• Initial access with round-ended carbide or diamond burs. For incisors and canines, the new CK endodontic access burs provide optimum safety and dentine preservation (Figs. 9a & b).
• Gross de-roofing with tapered diamond burs, retaining a small ‘soffit.’
• Provide straight-line access sweeping away from high-risk anatomy using the CPR-2D.

Table 2
For ovoid systems

• Sweep the coronal ¼ of the ovoid system with the CPR-2D.
• Sweep the next ¼ or ½ with the CPR-4D or 5D (Fig. 10b).
• Irrigate, dry with the Stropko syringe and then evaluate at 16 to 24x for multiple systems that branch in the apical half.
• Begin filing.

Editorial note: A complete list of references is available from the publisher.

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