Kenneth Serota continues his look at the Endodontic Implant Algorithm

Microstructural replication – obturation

Steve Covey is known for his book The Seven Habits of Highly Effective People. The habit most applicable to endodontics is the second one; begin with the End in Mind. The implication of this vision in regard to idealising the final shape of the root canal system to ensure that the obturation represents a totality is profound. The root canal is negative space and as such recovery of its original unaffected form is the sine qua non of obturation or more descriptively – microstructural replication.

Perhaps the most significant example of negative space recovery is Michelangelo’s statuary for the funerary of Pope Julius II. Four unfinished sculptures speak eloquently to this process: the figure was outlined on the front of the marble block and then Michelangelo worked steadily inwards from this side, in his own words ‘liberating the figure imprisoned in the marble’. This is an exacting description of debridement and instrumentation of the root canal space prior to root filling after a myriad of pathologic vectors have destroyed the dental pulp, and altered the morphology/topography of the system (Fig 12).

Incomplete filling of the debrided and sculpted root canal space is one of the major causes of endodontic failure (38). Until recently, in vitro testing (dye leakage, fluid transport, bacterial penetration, glucose leakage) was used to evaluate the sealing efficacy of endodontic filling materials and techniques by assessing the degree of debridement and instrumentation of the root canal space prior to root filling after a myriad of pathologic vectors have destroyed the dental pulp, and altered the morphology/topography of the system (Fig 12).

Gutta-percha was introduced to dentistry by Edwin Truman in 1847 (39). The concept of thermoplastic vertical condensation of gutta-percha was originally described by Dr J R Bilany in 1927 (40). The defining article on obturation remains Dr. Schilder’s classic on filling the root canal space in three dimensions published some 40 years later (41). Logically, one cannot physically fill the root canal in two dimensions; however, one can fill the root canal space badly in three dimensions. This does not critique Dr Schilder’s exposition, but it does demonstrate that words can easily be misconstrued and alter perspective once they become, as Kipling said, ‘the most powerful drug of mankind’.

Ironically, Schilder’s article came seven years prior to his treatise on cleaning and shaping the root canal system, which even to this day remains the iconic standard for the technical imperatives associated with instrumentation.

The Washington Study by Ingle indicated that 38 per cent of treatment failures were due to incomplete obturation (42). The corollary is obvious; teeth that are poorly obturated are invariably poorly debrided and disinfected. Procedural errors such as loss of working length, canal/apical transportation, perforations, loss of coronal seal and vertical root fractures have been shown to adversely affect the integrity of the apical seal (43, 44). The Toronto study evaluating success and failure of endodontic treatment at four to six years after completion of treatment showed that teeth treated with a flared canal preparation and vertical condensation of thermomelable gutta-percha had a higher success rate when compared with step-back canal preparation and lateral compaction. Highlighting the vertical condensation of warm gutta-percha obturation technique as a factor influencing success and failure simply confirmed a perspective evident to most endodontists from years of clinical empiricism.

There is a never-ending array of obturation materials, delivery systems and sealers appearing in the marketplace. Each is hallmarked by proprietary modifications and each is heralded as the most significant iteration in obturation since the previous one; today, we practice with a sad truth: the artist/clinician recognizes that negative space surrounding an object is equally important as the object itself. In the case of root canal therapy, the positive space is alterable, but must be treated in balance with the encompassing negative space to ensure morphologic integrity.
There are scattered studies that show Resilon exhibits less microleakage (44) and higher bond strength (45) compared with gutta-percha (46). Other studies have reported undesirable properties associated with Resilon including low push-out bond strength (47) and low cohesive strength plus stiffness (48). In addition, Resilon could not achieve a complete hermetic apical seal (49). These results indicate that a more appropriate material for root canal obturation still needs to be developed. There is still no obturation method or material that produces a leakproof seal.

A material that is bio-inductive and promotes regeneration, a "smart" nano-material, can adapt to the ever-changing microenvironment of the canal system is essential, but to date, remains elusive.

All polymers demonstrate melt temperature and flow rate. Both gutta-percha and Resilon demonstrate a viscoelastic gradient that manifests as a dynamic rheological birefringence in the molded state. Dependent upon the molecular weight of the source material (without the opacifiers, waxes and modifiers), gravimetric measurements of the time-temperature-transformation diagram of any molding compound can be constructed. In the thermoplastic world of today, this has engendered an increase in the weight of the mass of obturating material and an improvement in the bacterial seal. This applies to carrier based obturation techniques, Continuous Wave Compaction Technique and Obtura III obturation without cone placement.

**Instrumentation**

The steps required for debridement and disinfection of the root canal space are sequential and interdependent. Aberration of any node in the process impacts upon the others, leading to iatrogenic damage and potentially treatment outcome failure. The most common distortion of native anatomy is ledging; canal curvature exceeding 20° was shown to produce ledging of mandibular molars in a cohort of undergraduate students 50 per cent of the time (50). Denin chips pushed apically by instrumentation incorporated with fragments of pulp tissue will compact into the apical third and the foramen area causing blockage, altering the working length due to the loss of patency (Figs 14a, 14b).

Apical patience is a technique in which the minor apical diameter of the canal is maintained free of debris by recapitulation with a small file through the apical foramen (51). The most predictable method is to regularly use a designated patency file throughout the cleaning and shaping procedure in conjunction with copious irrigation. A .08 K-file passively instrumentation enables recapitulation with the apical terminus without widening it is most effective; it will refresh the NaOCl upon the others, leading to interdependence of all the others, leading to interdependence of all the others, leading to interdependence of all.

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Historically, numerous techniques have been advocated for canal preparation (balanced force, anti-curvature, double-flare; however, step-back \(^*\) and crown-down \(^*\) are the most universally accepted. Experience has shown that a crown-down preparation will cause fewer procedural errors (apical transportation, elbow formation, ledging, strip perforation, instrument fracture). The preliminary removal of coronal dentin (pre-enlargement - treating the apex last) minimizes blockage and enables an increasing volume of irrigant penetration thereby sustaining working length throughout the procedure \(^*\).

The balanced force shaping philosophy is integral to the crown-down approach. Its premise is that instruments are guided by the canal structure when rotational/anti-rotation motion (watch-winding) is used. Changing the direction of rotation controls the probability that instruments will become overstressed and thus ensures that the cutting of structure occurs most efficiently \(^*\). Endodontists have long appreciated what the science reported, that the balanced-force hand instrumentation technique produced a cleaner apical portion of the canal than other techniques (Fig 15) \(^{15,16}\). As will be discussed shortly, this author remains committed to hand filing in order to refine apical third shaping and creating an enhanced apical control zone taper.

Two distinct phases are required for the preparation of canals with nickel titanium (NiTi) rotary files. It is essential, that no matter the protocol used, a reservoir of NaOCl must be maintained and replenished repeatedly in the strategically extended access preparation. The coronal portion of the canal space is explored with small sized K-files to establish a glide path for the rotaries to follow. The taper of NiTi files, regardless of manufacturer, induces a crown-down effect in the straight portion of the canal. After the coronal and middle third segments are opened and repeatedly irrigated with NaOCl, a sequence of small K-files can progress apically, ultimately defining patency, confirming the topography of the accessible canal space and its degree of curvature.

As a second “wave” with the NiTi rotaries is then used to effect deep shape approximating the working length and depend upon the configuration of the apical third, to enlarge the terminus to the gauged apical size and initiate the taper of the apical control zone \(^*\). This is a basic concept. It is inherent in all templated protocols that each tooth is different and modifications to the process are always necessary as a function of the tooth morphology and type being treated.

The apical control zone is defined as a matrix like region created at the terminus of the apical third of the root canal space. The zone demonstrates an exaggerated taper from the spatial position determined by an electronic foramenal locator to be the minor apical diameter. Whether this is linear or a point determination is a function of histopathology. The enhanced taper at the terminus creates a resistance form against the condensation pressures of obturation and acts to prevent excessive extrusion of filling material during thermobalve vertical compaction.

All NiTi systems are modeled upon a single or multiple taper ratio per millimeter of file length. Fig 16a demonstrates the metrics of the F1, F2, F3 finishing files of the ProTaper Universal system (author’s preference). These files demonstrate a common taper in the last four mm of the file, which in the vast majority of situations correspond to the length of the apical third of the root canal space. As shown, the .07 taper of the F1 (.20 tip), the .08 taper of the F2 (.30 tip) and the .09 taper of the F3 (.50 tip) produce the corresponding diametral dimension indicated each millimeter back from the apical terminus if the crown down protocol built into this multiple taper file system is adhered to. If the shape of the
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internal micro-morphology of the root canal system were cavi- ty formation - the three "imprinting" of the canal preparation would be logical. Unfortunately, such is not the case 186.

Figure 16b shows how the use of hand files in the apical third of the root canal system: the apical terminus. 

If the biomechanical parameters that are adhered to, in almost all cases, treatment outcomes will be favored. Additionally, the endodontic implant algorithm processes to the array of contributing factors leading to endodontic failure, in order to determine whether to implement a re-engi- nered endodontic approach or to extract and replace the natural tooth with an osseointegrated implant. It finds the greatest common divisor among the degree of coronal breakdown, the length of the root canal, the number of adjacent teeth, the quality and quantity of the bone support and tissue condition, the engi- nered endodontic treatment to be born by the tooth or teeth in ques- tion and assesses the occlusal scheme and the patient’s aes- thetic and functional expecta- tions of treatment.

ThereforATIONS for tooth extrac- tion may include, but are not limited to, crowned to root ratio, remaining root length, peri- odontal attachment levels, evaluation of periodontal health of teeth adjacent to the proposed fixture site and non-restor- able cervical lesions. In addition, the clinician must consider questionable teeth in need of endodontic treatment, teeth requiring extensive restora- tion, semi-sections or ad- vanced periodontal procedures with a questionable prognosis and pulo-perio-odontal health at the gingival margin with roots smaller than 15 mm. These teeth will require endodontic treatment; the outcomes of root canals and post/corons and crowns; however, their longevity is very high in doubt with these param- eters 187.

Practitioners are ethically obligated to inform patients of all the possible treatment options. It is the patient’s atti- tudinal density of the required hermetic seal as well as enabling more material to flow into the region of occlusal files, cal-davus, delus and lateralarborization.

References


About the author

Sorenson B, N Ste- rova, DSHA, MFL: Endodontics and Periodontology. Directors of the Department of Endodontics at the University of Toronto School of Dentistry in 1973 and 1985, where he was appointed the George W. Brat- ing Chair in Endodontics in order for excellence in Preodontistry. He is the Director of a Center of Excellence in Endodontics and Master of Medical Sciences De- gree from the Harvard Forsyth Dental Center in Boston, MA. The founder of ROOTS – an online educational forum for dentists from around the world who wish to learn cutting edge endo-dontics, he recently launched IMPLANTS (www.rximplants.com) in order to provide a clear understanding of the endodontic/implantologic algorithm in endo-odontology.