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Untying the Gordian Knot; Part II
Kenneth Serota continues his look at the Endodontic Implant Algorithm

Microstructural replication – obturation

Stephen 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 statu ary 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 (39). Until recently, in vitro testing (dye leakage, fluid transport, bacte rial penetration, glucose leakage) was used to evaluate the sealing efficacy of endodontic filling materials and techniques by assessing the degree of penetration/absorbance of these tracers (34, 35, 36). Unfortunately, leakage studies are limited static models that do not simulate the conditions found in the oral cavity (temperature changes, dietary influences, salivary flow). Given the historic dominance of in vitro testing, the clinician must be cautious when extrapolating study findings to the clinical situation, regardless of manufacturer’s claims (39). This reliance on invalid testing protocols diminishes the “monoblock” assertions applied to the new generation of adhesive obturating materials proposed as the “replacement material” for gutta-percha (39).

Gutta-percha was introduced to dentistry by Edwin Truman in 1847 (39). The concept of ther momalleable vertical condensation of gutta-percha was originally described by Dr J R Blaney in 1927 (39). The defining article on obturation remains Dr. Schilder’s classic on filling the root canal space in three dimensions published some 40 years later (39). 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 criti que Dr Schilder’s exposition, but it does demonstrate that words can easily be miscon strued 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 In gle indicated that 38 per cent of treatment failures were due to incomplete obturation (39). The corollary is obvious; teeth that are poorly obturated are invariably poorly debrided and disinf ected. 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 (39). The Toronto study evaluating success and failure of endodontic treat ment at four to six years after completion of treatment showed that teeth treated with a flared canal preparation and vertical condensation of thermomalleable gutta-percha had a higher success rate when compared with step-back canal preparation and lateral compaction. Highlight ing 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 hall marked by proprietary modifications and each is heralded as the most significant iteration in obturation since the previous one; today, we practice with a sad tru-
is - marketing is inexorably directing science. However, gutta-percha in combination with a myriad of sealers and solvents remains the primary endodontic obturating material. The dominant systems remain carrier-based obturation (Thermofil - Tulsa Dental Specialties, Tulsa OK), Continuous Wave Compaction Technique (Elements Obturation - Sybron Endo, Orange CA and Thermoplastic Injection (Obtura III Max - Obtura Spartan, Earth City MO).

Resilon (RealSeal - SybronEndo Corp, Orange, CA), a high-performance industrial polyurethane was developed as an alternative to gutta-percha. There are scattered studies that show Resilon exhibits less microbial leakage and higher bond strength to root canal dentin and ability to maintain patency at the minor apical diameter - will cause loss of the apical reference point as a result of blockage, or ellipticization of the foramen.

Fig 14a - The working length has two reference points, cervical and apical. Failure to maintain patency at the minor apical diameter will cause loss of the apical reference point as a result of blockage, or ellipticization of the foramen.

Fig 14b - The volume of irrigant necessary to prevent apical blockage is indeterminant. While NiTi rotary instrumentation has minimized this procedural problem to a significant degree, nonetheless, a slurry of dentin mud is always a risk factor to be monitored.

Fig 15 - Rheology is a science that addresses the deformation and flow of matter. The biochemistry of filling material, its viscosity gradient, the lubricating effect of sealer and the manner of its delivery is essential, but to date, remains elusive.

Instrumentation

The steps required for debris removal 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 56 per cent of the time 46. Denial 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 patency 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 47. 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 moved through the apical terminus without widening it is most effective; it will refresh the NaOCl upon the others, leading to interdependence 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.

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plug. Therefore, establishing apical patency is recommended even during treatment of canals with vital pulps. Historically, numerous techniques have been advocated for canal preparation (balanced force, anti-curvature, double-flare, modified 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 (Figs 15) (5a, 5b). 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.

A second “wave” with the NiTi rotaries is then used to effect deep shape approximating the working length and depending 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 sones demonstrates an exaggerated taper from the spatial position determined by an electronic foramen locator to the minor apical diameter. Whether this is linear or a point determination is a function of histology. 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 thermostable vertical compaction.

All NiTi systems are modeled upon a single or multiple taper 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 corresponds to the length of the apical third of the root canal space. As shown, the 0.07 taper of the F1 (.20 tip), the .08 taper of the F2 (.25 tip) and the .09 taper of the F3 (.30 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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Fig 16b—Modulation of taper in last mm of the apical terminus, exaggerates the “resection” or “minor” apical diameter. Thermal-tolerant coronal condensation has been shown to enhance survival rates. The small incision of the apical foramen as small as practically possible. Whatever file shape approximates the minor apical diameter, in conjunction with hand filing, the apical control complex can be achieved in the apical 1 mm to 2 mm. Clariﬁcation of vectors of compaction and condensation will have a greater lateral volume of displacement at the terminus.

FASHIONING A RISK ASSESSMENT ALGORITHM

If the biologic parameters that mandate endodontic success are adhered to, in almost all circumstances, treatment outcomes will be ideal. The practitioner’s endodontic implant algorithm processes to the array of contributory factors leading to endodontic failure, in order to determine whether to implement a re-engineered 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 extent of root canal involvement, adjacent teeth, the quality and quantity of the bone support and tissue condition, the endodontic therapy to be borne by the tooth or teeth in question and assesses the occlusal scheme and the patient’s aesthetic and functional expectancies of treatment.

Thereasons for tooth extraction may include, but are not limited to, crown to root ratio, remaining root length, periapical attachment levels, variations in the periapical health of teeth adjacent to the proposed fixture site and non-restantorable adjacent teeth. In addition, the clinician must consider questionable teeth in need of endodontic treatment, teeth requiring root amputation, semi-sections or advanced periodontal procedures with a questionable prognosis and pulpal tissue condition at the gingival margin with roots smaller than 15 mm. These teeth will require endodontic therapy or extraction. The options are extraction, root post/cores and crowns; however, their longevity is much in doubt with these parameters.

Practitioners are ethically obligated to inform patients of the different treatment options. It is the patient’s attitude, values and expectations that are integral to the risk assessment algorithm. Poor motivation to retain a tooth mandates extraction, not clinical intervention whereas high motivation can be an osseointegrated intervention or surgery. The process of planning, presentation and acceptance of dental treatment is always dominated by the dental attractiveness of the endodontists and macro-biologic replacement of a debilitated tooth.

Far too often the comparison of purported treatment outcome percentages are based upon corporate afﬁliations and status, usually are simply too narrow a parameter to suggest comparable alternatives. With the treatment of teeth by an experienced endodontist, only a very few structurally sound teeth need be removed.