Knot: Part II
Kenneth Serota continues his look at the Endodontic Implant Algorithm

Microstructural replication – obturation

Steven 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 debride- ment and instrumentation of the root canal space prior to root filling after a myriad of patho- logic 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 (90). 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 pen- etration/absorbance of these tracers (91, 92). Unfortunately, leakage studies are limited stat- ic models that do not simulate the conditions found in the oral cavity (temperature changes, di- etary 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 (93). This reliance on invalid testing pro- tocols diminishes the “monoblock” assertions applied to the new generation of adhesive obturating materials proposed as the “replacement material” for gutta-percha (94).

Gutta-percha was introduced to dentistry by Edwin Truman in 1847 (95). The concept of thermo- labile vertical condensation of gutta-percha was originally de- scribed by Dr J R Bilany in 1927 (96). The defining article on ob- turation remains Dr. Schilder’s classic on filling the root canal space in three dimensions pub- lished some 40 years later (97). Logically, one cannot physically fill the root canal in two dimen- sions; however, one can fill the root canal space badly in three dimensions. This does not cri- tique 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 as- sociated with instrumentation.

The Washington Study by In- gle indicated that 58 per cent of treatment failures were due to incomplete obturation (98). The corollary is obvious; teeth that are poorly obturated are invari- ably poorly debrided and disin- fected. Procedural errors such as loss of working length, canal/ apical transportation, perfora- tions, loss of coronal seal and vertical root fractures have been shown to adversely affect the in- tegrity of the apical seal (99). 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 thermolabile gutta-percha had a higher suc- cess 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 con- firmed 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 modifica- tions and each is heralded as the most significant iteration in ob- turation since the previous one; today, we practice with a sad tru-
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.

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. 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 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.40 Dentin 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 (Fig 14a, 14b).

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plug. Therefore, establishing apical patency is recommended even during treatment of canals with vital pulps \[\text{[15]}\].

Historically, numerous techniques have been advocated for canal preparation (balanced force, anti-curvature, double-flare; however, step-back [16] and crown-down [17]) 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 [18].

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 \[\text{[19]}\]. 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 \[\text{[15]} \text{, [20]}\]. As will be discussed shortly, this author remains 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 \[\text{[21]}\]. 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 K-nb demonstrates an exaggerated taper from the spatial position determined by an electronic foramen 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 thermolabile vertical compaction.

All NiTi systems are modeled upon a single or multiple taper ratio per millimeter of file length. \text{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 .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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internal micro morphology of the root canal system were epi - dermis thickness in the form of the “intruding” of the canal preparation would be logical. Unfortunately, such is not the case.  

Figure 16b shows how the use of hand files in the apical third of the canal will produce the “constriction” or minor apical diameter. Careful positioning of a series of files within the last mm can produce a 2 mm or 20 per cent taper with no undue disruption of the native anatomy. Schilder’s precept for hand filing was to keep the apical foramen as small as prac - tically possible. Whatever file shape approximates the minor apical diameter, in conjunction with hand filing, the apical control will enhance the apical seal. Machined NiTi vectors of compaction and condensation have a greater lateral volume of displacement at the terminus.

Focusing a risk assessment algorithm  

If the biologic parameters that mandate endodontic success are adhered to, in almost all cases, treatment outcomes will be diametrically opposed to the monolithic implant algorithm process to the array of contributing fac - tors leading to endodontic failure, in order to determine whether to implement a re-en - gineered endodontic approach or to extract and replace the natural tooth with an osteo - genically integrated implant. It finds the greatest common divisor among the degree of coronal breakdown, periradicular infections involving adjacent teeth, the quality and quantity of the bone support and tissue condition, the en - gineering and materials to be used by the tooth or teeth in ques - tion and assesses the occlusal scheme and the patient’s aes - thetical and functional expecta - tions of treatment.

Theorems for tooth extrac - tion may include, but are not limited to, crown to root ratio, remaining root length, peri - odontal attachment lev - els, size and location of peri - odontal health of teeth adjacent to the proposed fixture site and non-restor - able canals. In addition, the clinician must consider questionable teeth in need of endodontic treatment, teeth requiring root ampu - tations, semi-sections or ad - vanced periodontal procedures with a questionable prognosis and possible tooth loss or 20 per cent taper with no undue disruption of the native anatomy. Schilder’s precept for hand filing was to keep the apical foramen as small as prac - tically possible. Whatever file shape approximates the minor apical diameter, in conjunction with hand filing, the apical control will enhance the apical seal. Machined NiTi vectors of compaction and condensation have a greater lateral volume of displacement at the terminus.

Practitioners are ethically obliged to inform patients of all available treatment options. It is the patient’s atti - tude, values and expectations that are integral to the risk assessment algorithm. Poor motivation to retain a tooth mandates extraction, not clini - cal intervention whereas high motivation allows for an osteo - genically integrated intervention or surgery. The process of planning, pres - entation and acceptance of dental treatment is very often dom - inated by the dynamic of emotion and pragmatism associated with cost. Where it becomes economically viable, the by-side dollar comparison of restoring a natural tooth or placement of a fixed bridge at a cost that represents the biologic re - placement of a debilitated tooth.

Far too often the compari - son of purported treatment outcomes percentage are based upon corporate affilia - tions, fee structure, status or are simply too narrow a pa - rameter to suggest comparable alternatives. With the treat - ment algorithms of an experienced endodontist, only a very few structurally sound teeth need be removed.