Canal preparation and obturation: An updated view of the two pillars of nonsurgical endodontics

Deeper knowledge of metallurgical properties is desirable for clinicians who want to capitalize on these new alloys. Finally, more recent strategies such as minimally invasive endo-
dontics have emerged.

Basic nickel titanium metallurgy
What makes NiTi so special? It is highly resistant to corrosion and, more importantly, it is highly elastic and fracture resistant. NiTi exists

residually in two conformations, mar-
tensite and austenite, depending on external tension and ambient tem-
perature. While steel allows 5 per-
cent elastic deformation, NiTi in the austenitic form can withstand defor-
mation of up to 7 percent without permanent deformation or plastic deforma-
tion.

Knowing this is critical for rotary
endodontic instruments for two reasons. First, during preparation of curved canals, forces between the canal wall and abrading instru-
ments are smaller with more elastic instruments, hence less preparation
errors are likely to occur.

Second, rotation in curved canals will bend instruments once per rotation, which ultimately will lead to hardening and brittle fracture, also known as cyclic fatigue. Steel can withstand up to 20 complete bend-
ing cycles, while NiTi can endure up to 10,000 cycles.

Recently manufacturers have learned to produce NiTi instruments that are in the martensitic state and even more flexible than previous figures. File 2 shows how instrument conditions (austenite vs. martensite) are determined in the testing labora-
tory, using prescribed heating and cooling cycles. Heat-treated files with high martensite content typi-
cally do not have a silver metallic shade but are colored due to an ox-
ide layer, such as gold or blue.

It is important to note that CM files frequently deform; however, with a delicate touch, cutting is adequate and even more superior to conven-
tional NiTi instruments. It is imperative for clinicians to retrain themselves prior to using these new instruments to avoid excessive de-
formation and subsequent instru-
m ent fracture.

Preparation strategies
Clinical and experimental evidence suggests that the use of NiTi in-
struments combined with rotary movement results in improved preparation quality. Specifically, the incidence of gross preparation errors is greatly reduced. Canals with wide oval or ribbon-shaped cross sections present difficulties for rotary instru-
ments and strategies such as cir-
cumferential filing and ultrasonics should be used in those canals.

Studies found that oscillating instru-
ments recommended for these canal types did not perform as well par-
ticularly in curved canals. Specific instruments developed to address these challenges include the Self-
Adjusting File (SAF) System (ReDent-
NOVA, Raanana, Israel), TRUShape® (DentTec Surgical, San Diego, CA) and SP Endo® (Brasseler, Savannah, Ga.). However, there is no direct clinical evidence that these instruments lead to better outcomes.

Canal transportation with contem-
porary NiTi rotators, measured as un-
derdesirable changes of the canal center seen in cross-sections of natural teeth, is usually very small. This in-
dicates that canal walls are not exces-
sively thinned and apical canal paths are only minimally straightened (Fig. 1).

Almost all current rotaries are non-
landed, meaning they have sharp cutting edges. This can lead to lateral action toward a specific point on the perimeter. This “brushing” ac-
tion allows the clinician to actively change canal paths away from the foramina in the coronal and middle thirds of the root canal but can create apical canal straightening when taken beyond the apical constric-
tion.

Circumferential engagement of canal walls by active instruments may lead to a threading-in effect, but contemporary rotaries are designed with variable pitch and helical angle to counteract this tendency.

An important design element for all contemporary rotaries is a passive, non-cutting tip that guides the cut-
ing planes to allow for more evenly distributed dentin removal. Rotaries with cutting, active tips such as dedi-
cated retreatment files should be used with caution to avoid prepara-
tion errors.

NiTi instrument usage
As a general rule, NiTi instru-
ments are not very resistant to tor-
sional load but are resistant to cyclic
fatigue. Conversely, more rigid fil-
es can withstand more torque but are susceptible to fatigue. The greater the amount and the more peripheral the distribution of metal in the cross section, the stiffer the file. Therefore, a file with greater gauge and larger di-

ame-ter is more susceptible to fatigue failure moreover, a canal curvature that is more coronal is more vulner-
able to file fracture.

Instrument handling has been shown to be associated with file frac-
ture. For example, a lower rotational

speed (1-250 rpm) results in delayed build-up of fatigue† and reduced incidence of taper lock. Material im-
perfections such as microcracks and milling marks are believed to act as fractures initiation sites. Such sur-
face imperfections after manufac-
turing can be removed by electropo-
lishing but it is unclear if this process extends fatigue life.

Manufacturers’ recommendations stress that rotaries should be ad-
vanced with very light pressure; however, the recommendations differ with regard to the way NiTi instru-
ments are moved. A typical recom-
nendation is to move the instru-
ment into the canal gently in an in-and-out motion for three to four cycles, directed away from the furi-
cation, then withdraw to clean the flutes.

It is difficult to determine exactly the apically exerted force in the clinical setting; experiments have suggested that forces start at about 1 Newton (N) and range up to 5 N. More precise torque limits have been discussed as a means to reduce failure. Most clinicians use torque-controlled mo-
tors, which are based on presetting a maximum current for a DC electric motor.

To reduce friction, manufacturers often recommend the use of gel-
based lubricants in dentin, how-

Fig. 1: Root canal treatment of tooth #3 diagnosed with pulp necrosis and acute apical periodontitis. The mesiobuccal root has a significant curve and two canals with separate curvatures (Photos/Provided by American Association of Endodontists)

Fig. 2: Behavior of controlled memory nickel-titanium rotaries compared with standard instruments. Shown are data from Syrbu’s Differential Testing calorimetry, which document the transition between austenite and martensite at about 5 degrees C for standard NiTi and at about 25 degrees C for controlled memory (CM) alloys (A). At room temperature, this results in a drastically increased fatigue lifespan (B). Image A modified and reprinted with permission from Shen et al. Endod 2011; 37:1566-1571. (Photos/Provided by American Association of Endodontists)

By Dr. Ove A. Peters, USA

The ultimate goal of endodontic treatment is the long-term retention in function of teeth with pulpal or periapical pathosis. Depending on the diagnosis, this therapy typically involves the preparation and obtura-
tion of all root canals. Both steps are critical to an optimal long-term out-
come. This article is intended to up-
date clinicians on the current under-
standing of best practices in the two pillars of nonsurgical endodontics, canal preparation and obturation, and to highlight strategies for deci-

sion making in both uncomplicated and more difficult endodontic cases.

Prior to initiating therapy, a cli-
nician must establish a diagnosis, take a thorough patient history and conduct clinical tests. Recently, judi-
cious use of cone-beam computed tomography (CBCT) has augmented the clinically available diagnostic mo-
dalities. Verifying the mental image of canal anatomy goes a long way to promote success in canal prepa-
ration. For example, a missed canal frequency is associated with endo-
dontic failures.

As most maxillary molars have two canals in the mesiobuccal root, case referral to an endodontist for microsurgical support is imperative for clinicians to retrain themselves prior to using these new instruments. Endodontists are increasingly using CBCT and the operating microscope to diagnose and treat anatomically challenging teeth, such as those with unusual root anatomies, congenital variants or iatrogenic alteration. The endo-
dontic specialist, using appropriate strategies, can achieve good out-
comes even in cases with significant challenges (Fig. 1).

Preparation of the endodontic space
The goal of canal preparation is to provide adequate access for dis-
furting solutions without making major preparation errors such as perforations, canal transportations, instrument breaks or canal removal of tooth structure. The in-
troduction of nickel-titanium (NiTi) instru-
ments to endodontics almost a decade ago has resulted in dramatic improvements for success-
ful canal preparation for generalists and specialists. Today there are more than 50 canal preparation systems, however, not every instrument sys-
tem is suitable for every clinician and not all cases lend themselves to rotary preparation.

Several key factors have added versa-
tility in this regard, for example, the emergence of special designs such as orbit shapers and mechanized glide path files. Another recent de-
velopement is the application of heat

treatment to NiTi alloy, both before and after the file is manufactured.
ever, such lubricants have not been shown to be beneficial and actually did increase torque for radial-landed ProFile® instruments.17 Therefore, it is recommended to flood the canal system with sodium hypochlorite (NaOCl) during the use of rotaries. The best way to do this is to create an access cavity that can act as a reservoir.8

There are several concerns about reusing NiTi instruments. The effectiveness of disinfection procedures is not clear. It has been shown that protein particles cannot completely be removed from machined nickel-titanium surfaces.15 Moreover, it is clear that with additional usage, the chance for instrument fracture increases. Current recommendations advise that clinicians are judicious when using rotary instruments as there is no conclusive evidence of disease transmission occurring.13

Recently, the term minimally invasive endodontics has been used to describe smaller-than-usual apical scalers and, perhaps more important, an understanding that the long-term success of root canal-treated teeth will improve by retaining as much dentin structure as feasible.3 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19 The thought process for this was the finding that most root canal-treated teeth survive 10 years and longer.19

In consequence, a smaller coronal dimension of rotors is considered while maintaining apical sizes to support antimicrobial efficacy. There currently is no direct clinical evidence to support this strategy but it is clear that root fractures pose problems in the long-term outcomes of our patients. Another recent development is the emergence of certain specialized rotaries, such as dedicated-offilette shapers and so-called glide path files. The offilette shapers have larger tapers, such as ofl, which means that they are not flexible and can overprepare at the canal orifice level. Glide path files, for example, PatFiles® and ProGlider® (Dentsply Sirona), are delicate instruments and may fracture when used incorrectly. It is recommended to use a small K-file (size #4) before any rotary instrumentation and to use a delicate touch.

Clinical results

While results from in vitro studies on rotary systems are abundant, clinical studies on these instruments are sparse. Comparing NiTi and stainless-steel K-files, Pettiette et al.13 found less canal transportation and fewer gross preparation errors such as strip perforations. Subsequently, using radiographic evaluation of the same patient group, they demonstrated better healing in the NiTi group.20 An earlier outcome study with three rotary preparation paradigms did not show any difference between the three systems with an overall favorable outcome rate of about 87 percent.18

The most consistent clinical results are obtained when the manufacturer’s directions are followed. While these vary by instrument, a set of common rules applies to root canal preparation. Root canal systems are best prepared in the following sequence:

- Analysis of the specific anatomy of the case.
- Canal scouting.
- Coronal modifications.
- Negotiation to patency.
- Determination of working length.
- Glide path preparation.
- Root canal shaping to desired size.
- Sealing the foramen, apical ad- justment.

Obturation of the endodontic space
A well-shaped and cleaned canal system should create the conditions for optimum periradicular tissue. On the other hand, this root canal system is inaccessible to the body’s immune system and therefore it cannot combat coronal leakage. Accordingly, best practices dictate that 2–3 canals should be filled as completely as possible to prevent ingress of nutrients or oral microorganisms. None of the established techniques for root canal filling provides a definitive coronal, lateral, and apical seal.14

Basic strategies in root canal obturation ideally root canal fillings should seal all foramina leading to the periradicular tissue. Without voids, avoid to the instrumented canal walls and end at working length. There are various acceptable materials and techniques to obturate root canal systems, including:

- Sealer (cement/paste/mixed-only): Sealer and a single cone of a stiff or flexible cold cure
- Sealer coating combined with warm compaction of core materials.
- Sealer coating combined with carrier-based core materials.

Several of these techniques have shown comparable success rates regarding apical bone fill or healing of periradicular tissue. The clinician may choose from a variety of techniques and approaches that works best for him or her. The directs the clinicians toward preparation and disinfection of the root canal as the single most important factor in the treatment of endodontic pathosis, and no particular sealing technique can claim superior healing success.12

Current developments in root canal obturation materials
After the introduction of MTA (mineral trioxide aggregate) as a material for perforation repair and apical surgery more than two decades ago, materials with similar bioactive properties now are available as root canal sealers. Biocement root canal cement (Biocement®, Brasseler) has clinically acceptable radiopacity and flow.20 Moreover, it is well tolerated in cell culture experiments.21 However, there is no clinical evidence that using this cement leads to better outcomes. In fact, most research has...
The space created by the spreader is inserted by inserting a small, light-Gutta-percha cone down to the working length. Using auxiliary cones larger than the taper of the spreader will not advance the spreader into the filling and should be avoided. The procedure is repeated by inserting several Gutta-percha cones into the entire canal. For vertical compaction, electrically heated pluggers are used to heat the spreader to the working length. Tapered gutta-percha cones are packed into the canal until the spreader is forced out, which is a sign of completion of compacting, while the spreader is set to a specific temperature. When in contact with tissues and bone, Gutta-percha is not absorbed. Some by-products of resin-based materials typically are handled by the body and may be absorbed, while sealers are absorbable while in use. When in contact with tissues and bone, sealers should be used. Most sealers are available in pastes or liquids for about 60 seconds. Solution for about 60 seconds.

In general, canals should be filled using a technique and timing that ensure the obturation.

- Selecting master cones
- Canal drying, sealer application
- Filling the apical portion (lateral compaction, if necessary)
- Completing the fill
- Assessing the quality of the fill

The root canal system should be assessed before choosing an obturating technique. In the presence of open apices or procedural errors such as a blockage in the root canal, air should be used. When in contact with tissues and bone, Gutta-percha, a sealer or cement should be used. Most sealers are available in pastes or liquids for about 60 seconds. Solution for about 60 seconds.

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