The ultimate goal of endodontic treatment is the long-term retention in function of teeth with pulpal or periradicular disease. Depending on the diagnosis, this therapy typically involves the preparation and obturation of all root canals. Both steps are critical to an optimal long-term outcome. This article is intended to update clinicians on the current understanding of best practices in the two pillars of nonsurgical endodontics, canal preparation and obturation, and to highlight strategies for decision making in both uncomplicated and more difficult endodontic cases.

Prior to initiating therapy, a clinician must establish a diagnosis, take a thorough patient history and conduct clinical tests. Recently, judicious use of cone-beam computed tomography has augmented the clinically available imaging modalities. Verifying the mental image of canal anatomy goes a long way to promote success in canal preparation. For example, a raised canal frequency is associated with endodontic failures. As many maxillary molars have two canals in the mesiobuccal root, case referral to an endodontist for management and root canal treatment should be considered. Endodontists are increasingly using C Kit and the operating microscope to diagnose and treat anatomically challenging teeth, such as those with unusual root anatomy, congenital variants or iatrogenic alterations. The endodontist, using appropriate strategies, can achieve good outcomes even in cases with significant challenges.

Preparation of the endodontic space

The goal of canal preparation is to provide adequate access for dissecting solutions without making major preparation errors such as perforations, canal transportation, instrument fractures or unnecessary removal of tooth structure. The introduction of nickel-titanium (NiTi) instruments to endodontics almost two decades ago has resulted in dramatic improvements for successful canal preparation for generalists and specialists. Today there are more than 50 canal preparation systems; however, not every instrument system is suitable for every clinician and not all cases lend themselves to rotary preparation.

Several key factors have added versatility in this regard, for example, the emergence of special designs such as orifice shapers and mechanized glide path files. Another recent development is the application of heat treatment to NiTi alloy, both before and after the file is manufactured. 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 endodontics have emerged.

Basic nickel-titanium metallurgy

What can NiTi alloy do? It is highly resistant to corrosion and, more importantly, it is highly elastic and fracture resistant. NiTi exists reversibly in two conformations, martensite and austenite, dependent on external tension and ambient temperature. While steel allows 3 percent elastic deformation, NiTi in the martensitic form can withstand deformations of up to 7 percent without permanent damage or plastic deformation. Knowing this is critical for rotary endodontic instruments for two reasons. First, controlled variable preparation of curved canals, forces between the canal wall and aligning instruments 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 work hardening and brittle fracture, also known as cyclic fatigue. Steel can withstand up to 20 complete bending cycles, while NiTi can endure up to 1000 cycles.

Recently manufactured files have learned to produce NiTi instruments that are in the martensitic state and even more flexible than previous files. Figure 2 shows how instrument conditions (austenite vs. martensite) are determined in the testing laboratory, using prescribed heating and cooling cycles. The a-ti-x state is the metastable state and more resistant to torsional load at room temperature than the martensite state. Shown are current NiTi instruments, comparing reciprocating files, can enlarge the canal path safely while minimizing procedural errors. Almost all current NiTi files are non-rounded, meaning they have sharp cutting edges, and they can be used in lateral action toward a specific point on the perimeter. This “brushing” action allows the clinician to actively change canal direction, where possible, but may create apical canal straightening when taken beyond the apex. Figure 3 shows the controlled memory nickel-titanium rotary file compared with standard instruments, shown from data by Synho Diagnostic Scanning caloctomy, which document the transition between martensite and austenite at about 5 degrees C for standard NiTi and at about 25 degrees C for controlled-memory (CM) alloy (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 2012; 37:566-572.

Preparation strategies

Clinical and experimental evidence suggests that the use of NiTi instruments 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 instruments and strategies such as circumferential filing and ultrasonics should be used in those canals. Studies found that oscillating instruments recommended for these canal types did not perform as well as particularly in curved canals. Specific instruments developed to address these challenges includes the Self-Adjusting File (SAF) System (ReDent-NYSA; Dentsply Tulsa, Okla.) and XP ENDO® (Brasseler, Savannah, Ga.). However, there is no direct clinical evidence that these instruments lead to better outcomes.

Canal transportation with contemporary NiTi rotary files, as measured in uninstrumented, canals, is seen in cross-sections of natural teeth, is usually very slight, and well tolerated. However, previous studies have shown that canal walls are not excessively thinned and apical canal paths are only minimally straightened, even when preparing curved root canals. While preparation usually reduces dentin, some dentin may be preferentially toward the outside of the curvature. Current NiTi instruments, including reciprocating files, can enlarge the canal path safely without minimizing procedural errors.

By Ove A. Peters, USA

mCME SELF INSTRUCTION PROGRAM

Membership

To join, complete the online registration form at www.cappmea.com. mCME offers you the flexibility to receive your membership number and allowing you to start the program.

Completion of mCME

• mCME participants are required to read the continuing medical education (CME) units published in the current issue of Dental Tribune Middle East & Africa Edition and complete the online post-test assessment (a minimum passing score of 80% must be achieved in order to claim credit).

• All post-test assessments will be available online at www.cappmea.com/mCME/questions.html. The answers and critiques published herein have been checked carefully and represent authoritative opinions about the questions concerned.

The ultimate goal of endodontic treatment is the long-term retention in function of teeth with pulpal or periradicular disease. Depending on the diagnosis, this therapy typically involves the preparation and obturation of all root canals. Both steps are critical to an optimal long-term outcome. This article is intended to update clinicians on the current understanding of best practices in the two pillars of nonsurgical endodontics, canal preparation and obturation, and to highlight strategies for decision making in both uncomplicated and more difficult endodontic cases.

Prior to initiating therapy, a clinician must establish a diagnosis, take a thorough patient history and conduct clinical tests. Recently, judicious use of cone-beam computed tomography has augmented the clinically available imaging modalities. Verifying the mental image of canal anatomy goes a long way to promote success in canal preparation. For example, a raised canal frequency is associated with endodontic failures. As many maxillary molars have two canals in the mesiobuccal root, case referral to an endodontist for management and root canal treatment should be considered. Endodontists are increasingly using C Kit and the operating microscope to diagnose and treat anatomically challenging teeth, such as those with unusual root anatomy, congenital variants or iatrogenic alterations. The endodontist, using appropriate strategies, can achieve good outcomes even in cases with significant challenges.

Preparation of the endodontic space

The goal of canal preparation is to provide adequate access for dissecting solutions without making major preparation errors such as perforations, canal transportation, instrument fractures or unnecessary removal of tooth structure. The introduction of nickel-titanium (NiTi) instruments to endodontics almost two decades ago has resulted in dramatic improvements for successful canal preparation for generalists and specialists. Today there are more than 50 canal preparation systems; however, not every instrument system is suitable for every clinician and not all cases lend themselves to rotary preparation.

Several key factors have added versatility in this regard, for example, the emergence of special designs such as orifice shapers and mechanized glide path files. Another recent development is the application of heat treatment to NiTi alloy, both before and after the file is manufactured. 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 endodontics have emerged. The ultimate goal of endodontic treatment is the long-term retention in function of teeth with pulpal or periradicular disease. Depending on the diagnosis, this therapy typically involves the preparation and obturation of all root canals. Both steps are critical to an optimal long-term outcome. This article is intended to update clinicians on the current understanding of best practices in the two pillars of nonsurgical endodontics, canal preparation and obturation, and to highlight strategies for decision making in both uncomplicated and more difficult endodontic cases. Prior to initiating therapy, a clinician must establish a diagnosis, take a thorough patient history and conduct clinical tests. Recently, judicious use of cone-beam computed tomography has augmented the clinically available imaging modalities. Verifying the mental image of canal anatomy goes a long way to promote success in canal preparation. For example, a raised canal frequency is associated with endodontic failures. As many maxillary molars have two canals in the mesiobuccal root, case referral to an endodontist for management and root canal treatment should be considered. Endodontists are increasingly using C Kit and the operating microscope to diagnose and treat anatomically challenging teeth, such as those with unusual root anatomy, congenital variants or iatrogenic alterations. The endodontist, using appropriate strategies, can achieve good outcomes even in cases with significant challenges. (Fig. 1)

Preparation of the endodontic space

The goal of canal preparation is to provide adequate access for dissecting solutions without making major preparation errors such as perforations, canal transportation, instrument fractures or unnecessary removal of tooth structure. The introduction of nickel-titanium (NiTi) instruments to endodontics almost two decades ago has resulted in dramatic improvements for successful canal preparation for generalists and specialists. Today there are more than 50 canal preparation systems; however, not every instrument system is suitable for every clinician and not all cases lend themselves to rotary preparation.

Several key factors have added versatility in this regard, for example, the emergence of special designs such as orifice shapers and mechanized glide path files. Another recent development is the application of heat treatment to NiTi alloy, both before and after the file is manufactured. 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 endodontics have emerged.

Basic nickel-titanium metallurgy

What can NiTi alloy do? It is highly resistant to corrosion and, more importantly, it is highly elastic and fracture resistant. NiTi exists reversibly in two conformations, martensite and austenite, dependent on external tension and ambient temperature. While steel allows 3 percent elastic deformation, NiTi in the martensitic form can withstand deformations of up to 7 percent without permanent damage or plastic deformation. Knowledge of this is critical for rotary endodontic instruments for two reasons. First, controlled variable preparation of curved canals, forces between the canal wall and aligning instruments 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 work hardening and brittle fracture, also known as cyclic fatigue. Steel can withstand up to 20 complete bending cycles, while NiTi can endure up to 1000 cycles. Recently manufactured files have learned to produce NiTi instruments that are in the martensitic state and even more flexible than previous files. Figure 2 shows how instrument conditions (austenite vs. martensite) are determined in the testing laboratory, using prescribed heating and cooling cycles. The α-Ti-X state is the metastable state and more resistant to torsional load at room temperature than the martensite state. Shown are current NiTi instruments, comparing reciprocating files, can enlarge the canal path safely without minimizing procedural errors. Almost all current NiTi files are non-rounded, meaning they have sharp cutting edges, and they can be used in lateral action toward a specific point on the perimeter. This “brushing” action allows the clinician to actively change canal direction, where possible, but may create apical canal straightening when taken beyond the apex. Figure 3 shows the controlled memory nickel-titanium rotary file compared with standard instruments, shown from data by Synho Diagnostic Scanning caloctomy, which document the transition between martensite and austenite at about 5 degrees C for standard NiTi and at about 25 degrees C for controlled-memory (CM) alloy (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 2012; 37:566-572.
more coronal is more vulnerable to marginal leakage, or oral microorganism. It has been shown comparable success rates regardless of the type of cement used has come into question. Bioceramic root canal filling materials into the periapical tissues, specifically in the mandibular canal to be referred to an endodontist. While these vary by instrument, a set of common rules applies to root canal preparation. Root canal systems appear in the following sequence: • Analysis of the specific anatomy of the case. • Canal scouting • Coronal modifications • Negotiation to patency. • Determination of working length • Gliding gutta-percha • Root canal shaping to desired size. • Gauging the foramen, apical guidance.

Obturation of the apical space
A well-shaped and cleaned canal system should create the conditions for optimal obturation. On the other hand, this root canal system is incapable of the body’s immune system of an infected root canal. Therefore, it is recommended to flush the canal system with sodium hypochlorite (NaOCl) during the use of rotaries. This decision is based on the assumption that saliva can act as a retainer (Fig. 3).

There are several concerns about using NiTi instruments. The effectiveness of the ultrasonic procedure as such is not clear. It has been shown that protein particles cannot completely be removed from machined nickel-titanium surfaces. Moreover, it is recommended that lubricants be used during these procedures as a means to reduce failure. Most clinicians use torque-controlled motors to reduce the risk of canal irritation. Reducing friction, manufacturers recommend the use of gel-based lubricants. However, in clinical practice, gel-based lubricants are not considered to be any rotary instrumentation and should be used with a delicate touch.

Clinical results
While results from in vitro studies on rotary systems are far from abundant, clinical studies on these instruments are sparse. Comparing NiTi and stainless steel instruments, recent prospective studies have suggested that NiTi files are better at removing debris and achieving a clean cross-section of root canals. Importantly, these studies are conducted in a dry setting; experiments have suggested that wet settings reduce friction, manufacturers an impediment to healing but in the mandibular canal to be referred to an endodontist. Br Dent Res 2016, 45:52–58. Henry WA, Gerstein H. An initial investigation of the bending and torsional properties of minored root canal files. J Endod 1988, 14:346–51. Giuskan AD, Peters CL, Peters OA. Sealer retention in root fillings: a micromorphological study. Int Endod J 2004, 37:541–50.

Summary and conclusions
Root canal preparation with conventional rotary systems has been a predictable procedure in most cases for endodontists following established guidelines. Cases with a recognized high degree of difficulty are best referred to an endodontist. While many cases can be treated successfully in routine practice, the ad- ditional time and expense associated with the use of the aforementioned devices may be justified in cases that are challenging or difficult to treat.

References
4. This article originally appeared in ENDODONTICS: Colleagues’ Corner, with permission from the American Association of Endodontists, 2021. The AAE official newsletter is available at www.aae.org/collegians.