Clinical Update

Naval Postgraduate Dental School
National Naval Dental Center
8901 Wisconsin Ave
Bethesda, Maryland 20889-5602
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Endodontic rotary nickel-titanium instrument systems

Lieutenant Brent J. Crumpton, DC, USN and Captain Scott McClanahan, DC, USN

The purpose of this clinical update is to bring clinicians up to date with three current and popular endodontic rotary nickel-titanium instrument systems.

Background

Since the end of the nineteenth century, automated root canal instrumentation has been available, but systems had many problems. The challenges of increased canal blockage, instrument breakage, and insufficient canal debridement were related to the use of stainless steel instruments and have been dramatically improved with the introduction of nickel-titanium (NiTi) files. The first useable NiTi alloy was developed by William Buehler in 1960 at the U. S. Navy Ordinance Lab in Silver Spring, Maryland. Walia et al. investigated the feasibility of using this alloy in the fabrication of endodontic files, and showed that NiTi files had two to three times the elastic flexibility in bending and torsion, as well as superior resistance to torsional fracture when compared with stainless steel files of the same size. These features led to better centering of the instruments within the canal (1), less straightening of the canal, fewer elbows and ledges, and less transportation (2).

NiTi rotary instrumentation should always be performed with slow-speed, low-torque or "right-torque" electric motors (3). A variety of motors exist from varying manufacturers including the Tecnika ATR and Aseptico ITR both of which were designed specifically for endodontics and are supplied by Tulsa Densply. These types of electronic motors have preprogrammed speed and torque values preset by the manufacturer for their recommended instruments. The units also allow the operator to adjust the manufacturers' settings to the specific needs of the user. An additional benefit to the electric motors is the auto-reverse feature which is activated prior to reaching the elastic torque limit of the file, potentially reducing the possibility of instrument separation. Also available are air driven motors that connect to a slow-speed attachment on the dental unit. The air driven motors are less expensive than the electric motors. However, they are unable to control torque and do not have an auto-reverse feature.

The past few years have seen a dramatic increase in the number of manufacturers producing NiTi rotary files. The most popular systems are marketed by Tulsa Dental and Sybron Endo (formally Analytic Technologies). Tulsa markets both the ProSystem GT and ProTaper lines of rotary instruments, where Sybron Endo markets K3 (the successor of the Quantec line of files).

ProSystem GT™

ProSystem GT is the next evolution of the Greater Taper series (GT) Profile instruments. The file has traditional U-shaped flutes to lift debris coronally, safe-ended tips that reduce the risk of apical transportation, ledging, or perforation, and varied pitch and sharpness along flutes to reduce the potential for threading into the canal (4). Files are available in three different ISO tip sizes #20, #30, and #40 corresponding to small, medium, and large canals respectively with varying tapers from 0.10 to 0.04 in 0.02 increments. The manufacturer recommends crowning down beginning with the 0.10 taper instrument and continuing with the 0.08, 0.06, and 0.04. Once the working length has been reached with the 0.04 taper instrument, the operator can either choose to increase the taper by using the previous instrument to the full working length (i.e. the 0.06 taper instrument), increase the apical preparation size by selecting the next larger apical tip size with the same taper as the last instrument to reach the working length, or terminate the preparation.

ProTaper™

ProTaper files are marketed to instrument difficult, highly calcified, and severely curved root canals. The progressive taper and advanced flute design reportedly provide the flexibility and efficiency to achieve consistent, successful cleaning and shaping when faced with these challenges. A unique feature of the ProTaper instrument is the convex triangular cross-section which reduces the contact area between the file and dentin (Figure 1). The greater cutting efficiency has been purportedly safely incorporated through balancing the pitch and helical angles. These instruments also have a partially active tip which cuts as it moves apically (5).
The system consists of six files beginning with the SX, or Shaping X file, which is used to optimally shape canals in shorter roots, relocate canals away from external root concavities, and to produce more shape, as desired, in the coronal aspects of canals in longer roots.
The shaping 1 (S-1), and shaping 2 (S-2) files have increasingly larger tapers over the length of their cutting blades allowing each instrument to engage, cut and prepare a specific area of the canal. S-1 is designed to prepare the coronal one-third of a canal, whereas, S-2 enlarges and prepares the middle one-third. Although both instruments optimally prepare the coronal two-thirds of a canal, they do progressively enlarge its apical one-third.

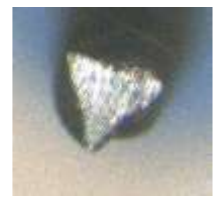

Figure 1
Photograph of ProTaper's triangular cross section

The finishing files, or F1, F2 and F3 instruments, reportedly optimally finish the apical one-third, while progressively and subtly expanding the shape in the middle one-third of the canal. The manufacturer states that generally only one finishing instrument is required to prepare the apical one-third of a canal and the one selected is based on the canal's curvature and cross-sectional diameter.

K$^{3(TM)}$

K3 is a third generation, triple fluted, asymmetric endodontic file system, and is marketed to cut quickly, efficiently and safely, with good debris removal. The manufacturer claims the advantages of this file over other systems are: 1. Positive rake angle, 2. Variable helical flute angle, 3. Wide radial land, 4. Surface reduction, 5. Access handle, 6. Third radial land, 7. Variable core diameter, 8. Simplified color coding, and 9. Safe-ended tip (6). See Figure 2.
The K3 technique: Begin filing with K3 0.06 tapered instruments. Speed 200-250 rpm using light even pressure with a slow in and out movement. Use each instrument for no more than 6 seconds. Files are used in sequence from the largest to the smallest. Silicone stops are placed on the instruments at the working length. Start with size 35, then 30, 25, 20, in a run down to size 15. Repeat the step-down from size 35 until size 20 reaches the working length. For those difficult canals that are long, very fine and curved, alternate 0.04 tapers and 0.06 tapered files.

Figure 2
Photograph of K^3's complex cross section

Advantages and Disadvantages

Nickel titanium instruments stay centered within the canal space; however, the increase in flexibility and elasticity are a trade off for decreased cutting efficiency (7). The newer ProTaper instruments reportedly make up for this deficiency with an increase in cutting efficiency, but also an increase in deformation rate (8). Due to the fact that both the ProTaper and K3 instruments are relatively new to the market, only limited research has been published to date. A recent study using resin blocks showed that K3 instruments prepared curved canals rapidly, with few canal aberrations, and minimal transportation (9). A subsequent study in extracted teeth showed that use of K3 instruments resulted in significantly more remaining debris when compared with stainless steel hand files (10). Both studies demonstrated a significant separation rate of K3 instruments (9,10). One potential disadvantage of the ProTaper instruments is the partially active tip. Previous studies have shown that cutting tips produce a greater amount of canal transportation, and created other aberrations such as zips, elbows, and ledges (11,12,13).

A significant risk during NiTi rotary instrumentation is instrument separation. When the instruments are stressed over time, the crystalline structure can change or deform making the files weaker and more prone to reaching their elastic limit. When this occurs, the instrument undergoes plastic deformation and if the stress is not relieved, instrument failure will result. Current studies show that these instruments can be used safely in up to a maximum of 10 canals (14,15); however, a single use in a very difficult canal should warrant disposal of the file. The use of a labeling system to keep track of file usage is highly recommended.

A major advantage to NiTi rotary systems is the use of the crown down technique. Crowning down has been shown to effectively pull debris and pulpal remnants out of the canal rather than pushing them into the periradicular tissues (16). In addition, early coronal flaring makes instrumentation easier (17) and increases the efficiency of electronic apex locators (18).

Use of Rotary NiTi Files

A significant learning curve exists with rotary instrumentation. An in depth understanding of the file system and of the tooth or canal morphology to be instrumented is paramount prior to use. Case selection is of utmost importance. Teeth with sharp, severe curves or S-shaped curves should not be instrumented to the full working length with rotary files. Remember that radiographs only give a two dimensional view of a three dimensional object, and the most severe curve may exist in the proximal aspect.

Manufacturers recommend that these files be used at varying speeds. Studies have shown that files used at higher speeds (333.33 RPM) are four times more likely to separate than those used at lower speeds (166.67 RPM) (19). Another study has shown that the radius of curvature, or degree of sharpness, is the most significant factor in predicting cyclic failure, and that the larger, more tapered files are more susceptible to the effects of cyclic fatigue (20).

Conclusions

The initial startup cost for rotary instrumentation can be expensive, and the overhead cost is also high in maintaining a supply of files. The potential benefits are the crown down technique and increased efficiency which are an important part of a modern endodontic practice. All of the systems have advantages and disadvantages. It is incumbent upon the practitioner to determine which system best fits their individual needs and their level of experience to provide the best possible endodontic care for our patients.

References

1. Esposito PT, Cunningham CJ. A comparison of canal preparation with nickel-titanium and stainless steel instruments. J Endod 1995 Apr;21(4):173-6.
2. Zmener O, Balbachan L. Effectiveness of nickel-titanium files for preparing curved root canals. Endod Dent Traumatol 1995 Jun;11(3):121-3.
3. Gambarini G. Rationale for the use of low-torque endodontic motors in root canal instrumentation. Endod Dent Traumatol 2000 Jun;16(3):95-1000.
4. http://www.tulsadental.com/PDFs/ProSystem_GT_brochure_BR108_3-03C.pdf
5. http://store.tulsadental.com/catalog/protaper_main.htm
6. http://www.k3endo.com/index.htm
7. Schafer E, Lau R. Comparison of cutting efficiency and instrumentation of curved canals with nickel-titanium and stainless-steel instruments. J Endod 1999 Jun;25(6):427-30.
8. Yun HH, Kim SK. A comparison of the shaping abilities of 4 nickel-titanium rotary instruments in simulated root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003 Feb;95(2):228-33.
9. Schafer E, Florek H. Efficiency of rotary nickel-titanium K3 instruments compared with stainless steel hand K-Flexofile. Part 1. Shaping ability in simulated curved canals. Int Endod J 2003 Mar;36(3):199-207.
10. Schafer E, Schlingemann R. Efficiency of rotary nickel-titanium K3 instruments compared with stainless steel hand K-Flexofile. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J 2003 Mar;36(3):208-17.
11. Thompson SA, Dummer PM. Shaping ability of Quantec Series 2000 rotary nickel-titanium instruments in simulated root canals: Part 2. Int Endod J 1998 Jul;31(4):268-74.
12. Thompson SA, Dummer PM. Shaping ability of Quantec Series 2000 rotary nickel-titanium instruments in simulated root canals: Part 1. Int Endod J 1998 Jul;31(4):259-67.
13. Kosa D, Marshall G, Baumgartner J. An analysis of canal centering using mechanical instrumentation techniques. J Endod 1999 Jun;25(6):441-45.
14. Yared GM, Bou Dagher FE, Machtou P. Cyclic fatigue of Profile rotary instruments after simulated clinical use. Int Endod J 1999 Mar;32(2):115-9.
15. Peters OA, Barbakow F. Dynamic torque and apical forces of ProFile.04 rotary instruments during preparation of curved canals. Int Endod J 2002 Apr;35(4):379-89.
16. Morgan LF, Montgomery S. An evaluation of the crown-down pressureless technique. J Endod 1984 Oct;10(10):491-8.
17. Swindle RB, Neaverth EJ, Pantera EA Jr, Ringle RD. Effect of coronal-radicular flaring on apical transportation. J Endod 1991 Apr;17(4):147-9.
18. Ibarrola JL, Chapman BL, Howard JH, Knowles KI, Ludlow MO. Effect of preflaring on Root ZX apex locators. J Endod 1999 Sep;25(9):625-6.
19. Gabel WP, Hoen M, Steiman HR, Pink FE, Dietz R. Effect of rotational speed on nickel-titanium file distortion. J Endod 1999 Nov;25(11):752-4.
20. Haikel Y, Serfaty R, Bateman G, Senger B, Allemann C. Dynamic and cyclic fatigue of engine driven rotary nickel-titanium endodontic instruments. J Endod 1999 Jun;25(6):434-40.

Dr. Crumpton is a second year resident in the Endodontics Department. Dr. McClanahan is the Chairman of the Endodontics Department at the Naval Postgraduate Dental School.