Preparation of the Root Canal System 2
Rotary Instrumentation

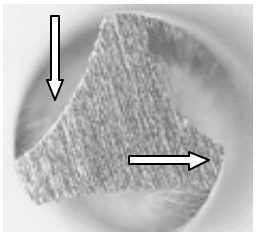
This is intended to be an adjunct to Preparation of the Root Canal System, not a replacement

INTRODUCTION

Gambarini G. Rationale for the use of low-torque endodontic motors in root canal instrumentation. Endod Dent Traumatol 2000;16:95-100.
A good review of the physical characteristics of nickel titanium, including explanations of the stronger, high temperature form (austentite), and the weaker, low temperature form (martensite). The use of slow-speed high-torque NiTi rotary instrumentation had been accepted in the last decade by manufacturers, clinicians, and researchers, leading to many iatrogenic errors. Ideally it should now be changed to slow-speed low-torque or, preferably, *right-torque motors*, since each instrument has a specific ideal right torque. The values are usually low for the smaller and less tapered instruments, and high for the bigger and more tapered ones. A new endodontic motor (step-motor) with computer-controlled electronics allows fine adjustments for different brands in order not to exceed their elastic limit.

- Bottom Line: NiTi rotary instrumentation should be performed with slow-speed, low-torque or right-torque motors to allow for ideal torque settings for each instrument. Low torque motors set below the instrument specific limit-torque will reduce the risk of fracture and will increase tactile sensation. *(Do not use a traditional air-driven slow speed handpiece)*

Nickel Titanium
The first useable nickel-titanium alloy was developed by William Buehler in 1960 at the U.S. Navy Ordinance Lab, Silver Springs, MD, (a.k.a. *NITINOL*). With its introduction, the use and popularity of rotary instruments increased. Currently, there are several systems available including: Profile, ProTaper, GT, Quantec, Lightspeed, K^3, and RaCe. The majority of the rotary files have a radial land. The radial land (→) prevents uncontrolled cutting into the canal walls, thus minimizing transportation and contributes to the strength of the instrument by adding mass peripherally. The flutes (↓) create the active portion of the file; they aid in transporting debris coronally and increase flexibility due to a decrease in cross-sectional diameter.



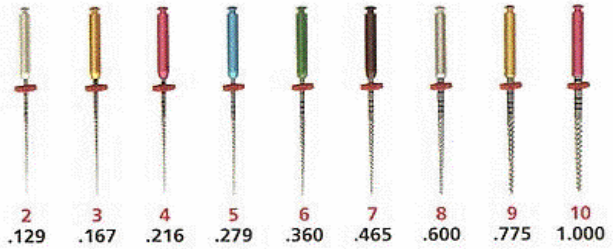
Introduction of first NiTi file
Walia H, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. J Endodon 1988;14:346-51.
The purpose of this study was to investigate the feasibility of manufacturing root canal files from Nitonol and evaluate their bending and torsional properties. Used machined K-type files to manufacture both the Nitinol and stainless steel #15 files.

- Bottom Line: Nitinol files were found to have two or three times more elastic flexibility in bending and torsion, as well as superior resistance to torsional fracture, compared with size #15 stainless steel files.

1. PROFILE

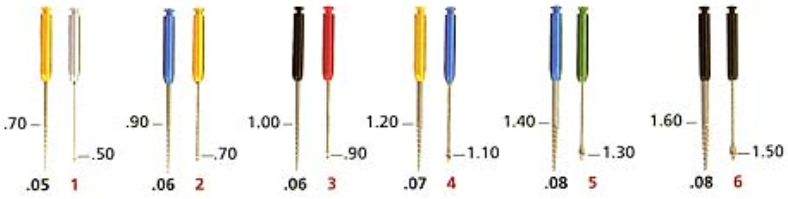
The ProFile NiTi rotary instrument line includes orfice shapers, ProFile .02, .04 and .06 tapers, Greater Taper (GT) files, Series 29, and Pro Taper instruments. The ProFile .02, .04 and .06 tapers, GTfiles, and Series 29 files all share the same cross sectional geometries have three radial lands that each contain bi-directional cutting edges. The radial lands keep the instrument centered in the canal while their cutting edges are intended to scrape rather than actively engage and screw into dentin. The radial lands are separated by three U-shaped flutes that provide space for the accumulation of debris. The U-shaped configuration effectively augurs debris coronally and out of the canal during clinical use. These files have a parallel core that enhances flexibility; non-cutting tips are designed to follow a pilot hole and 'guide' the instrument through the canal during preparation procedures. The recommended rotational speed for these instruments, regardless of the product line, is 150-300 RPM.

ProFile Series 29 The original nickel titanium rotary instruments from Tulsa Dental. These instruments are manufactured under the Series 29 standard, meaning they feature a constant 29 percent increase in tip diameter between file sizes. The constant percentage increase offers a smooth, progressive enlargement of the canal.



ProFile 0.02(#15-50), 0.04(#20-50) and 0.06(#20-50) ISO instrument lines are the benchmark against which all other rotary shaping files are measured. These rotary shaping instruments are machined with safe-ended non-cutting tips, increasing D_0 diameters, and 16 mm of cutting blades. The Profile 0.02 taper series is designed for extremely curved canals. The ProFile 0.04 series was initially designed for subsequent carrier based obturation techniques while the 0.06 taper instruments provide a fuller shape over the length of the canal.

Orifice openers 0.05, 0.06, 0.07, and 0.08 tapers (D_0 : #20, #30, #40, #50, #60, #80)- extend 19mm below the head of the handpiece and have 10 mm of cutting blades. The series, comprised of six instruments that are safe-ended, have increaseing D_0 diameters and are generally used to prepare the coronal two-thirds of the root canal system.



ProSystem GT or Greater Taper (GT) rotary files (Small series #20 ISO, Medium #30 series, Large #40 series) are made up of a series of four safe-ended instruments with variably pitched flutes and fixed minimal and fixed maximal flute diameters. Each instrument set has a different linear length of cutting blades, a fixed D_0 diameter of 0.20, 0.30, or 0.40 mm, and a maximal flute diameter of 1.0 mm. File taper changes as D_0 diameters and maximal flute diameter remain fixed. Tapers vary from 0.10, 0.08 0.06, and 0.04.

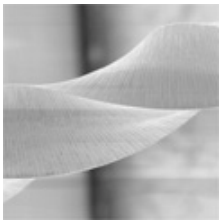
Accessory GT files are designed to pre-enlarge the coronal portion of a canal or to prepare the apical one-third of a large root canal system. The set consists of three NiTi instruments with tapers that are 0.12 mm/mm. Maximal file diameters are 1.5 mm and D_0 diameters are either 0.35mm, 0.50mm, 0.70mm, or 0.90mm.

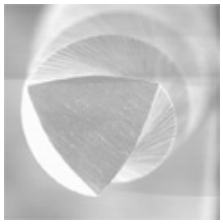
ProTaper nickel titanium rotary files are specially designed to instrument difficult, highly calcified, and severely curved root canals. The patented progressive taper and advanced flute design provides the flexibility and efficiency to achieve consistent, successful cleaning and shaping when faced with these challenges.

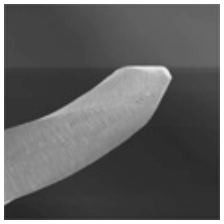
The SX or Shaping X file is used to optimally shape canals in shorter roots, relocate canals away from external root concavities, and to produce more shape, as desired, in the coronal aspects of canals in longer roots.

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, or 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.

The finishing files, or F-1, F-2 and F-3 instruments, have been designed to optimally finish the apical one-third, as well as subtly and progressively expanding the shape in the middle one-third of the canal. 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.







Additional features of the ProTaper series are: decreased zones of dentin engagement, triangular cross section, and a tapered core. ProTapers may be used in electric torque controlled motors at 300 RPM. The Tecnika/ATR handpiece provides the ability to choose the desired RPM and the recommended torque control for each specific instrument.

2. QUANTEC (Analytic):

The Quantec system is the product of two previous Ni-Ti rotary systems (the NT system and the McXim system) developed by McSpadden. Quantec files were introduced in 1996, and are now available from Sybron Endo. These instruments are available in tapers of 0.12, 0.10, 0.08, 0.06, 0.05, 0.04, 0.03, and 0.02 mm/mm. All have a D_0 diameter of 0.25mm. Quantec files have a reduced radial land that minimizes surface tension, contact area, and stress on the instrument. Two flutes allow for a greater depth of flute, as compared with three fluted instruments of the same tip, size, and diameter. Increasing the flute depth provides greater space for debris accumulation and subsequent travel out of the canal; it also potentially reduces file breakage. A variable helical angle reduces the tendenacy of the file to screw into the canal.

Quantec files vary in taper and rate taper along their blanks and are available in non-cutting (LX) or safe-cutting (SC) tip. The recommended rotational speed for all instruments is 340RPM. Quantec files are also available with Axxess handles that are 30% shorter than those of other files. When placed into a minihead contra-angle, 7 mm of interocclusal clearance is gained.

LX Non-Cutting **(Gold handles)**- The LX pilot tip maintains a central axis and deflects around severe curvatures.

SC Safe-Cutting **(Silver handles)**- The Quantec SC features a negotiating tip that cuts as it moves apically, following canal pathways and minimizing stress.

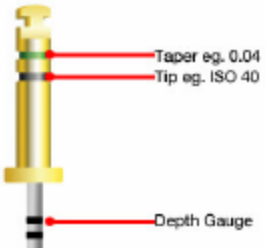
The Axxess Line

A 1998 study by *Thompson and Dummer* regarding the shaping ability and morphologic characteristics of canals prepared by Quantec Series 2000 rotary NiTi instruments showed that the instruments prepared simulated canals rapidly, with good taper and flow and without creating blockages. Generally, canals with large, acute curves had less desirable characteristics. The major problem with these instruments were the “safe cutting tips” that created canal aberrations such as: zips, elbows, perforations, and ledges. The aberrations were created by the larger instruments, so these should be used with caution at the full working distance. SEMs of these instruments revealed sharp instrument tips which would predispose to transportation and create defects along the outer aspect of severely curved canals. The results of this study led Quantec to develop the LX non-cutting tip.

3. K³ FILE SYSTEM

K^3 is a third generation, triple fluted, asymmetric endodontic file system. Designed to cut quickly, efficiently and safely, with unparalleled debris removal, the K^3 addresses technical and procedural issues that no other endodontic instrument does. K^3's advantages over other NiTi rotary systems are significant and plentiful, with the key points as follows:

1) Positive Rake Angle	**6) Third Radial Land**
2) Variable Helical Flute Angle	**7) Variable Core Diameter**
3) Wide Radial Land	**8) Simplified Color Coding**
4) Surface Reduction	**9) Safe-Ended Tip**
5) Access Handle	



COMARISON STUDIES

Esposito PT, Cunningham CJ. A comparison of canal preparation with nickel-titanium and stainless steel instruments. J Endodon 1995;21:173-6.
This study compared the maintenance of the original canal path of curved root canals during instrumentation with NiTi hand files, NiTi rotary files, and SS K-Flex files.

- Bottom Line: NiTi hand and engine driven files were more effective in maintaining the original canal path of curved root canals when the apical preparation was enlarged to size 35, 40, & 45.

Zmener O, Balbachan L. Effectiveness of nickel-titanium files for preparing curved root canals. Endod Dent Traumatol 1995;11:121-3.
In curved canals, NiTi hand file preparations maintained the apical constriction, were well centered and no ledges were formed. K-files showed straightening, elbows and transportation.

Kosa DA, Marshall G, Baumgartner JC. An analysis of canal centering using mechanical instrumentation techniques. J Endodon 1999;25:441-5.
Compared ProFile Series 29, Quantec 2000, M4 with Shaping Hedstroms, and Endo-Gripper with Flex-R hand files. All mechanical instrumentation systems resulted in some degree of canal transportation with NSD between the groups. Quantec 2000 system, with cutting tips, produced greater transportation than ProFile Series 29 at the apical level. *(Cutting Tip = Transportation)*

Siqueira JF, Lima KC, Magalhaes FAC, Lopes HP, de Uzeda M. Mechanical reduction of the bacterial population in the root canal by three instrumentation techniques. J Endodon 1999;25:332-5.
The purpose of this study was to compare the intraanal bacterial reduction provided by instrumentation using hand NiTi K-type files, GT files, and Profile 0.06 taper Series 29 rotary files.

The most reduction occurred with hand instrumentation to a #40 (99.57%) *(i.e. A #25-30 as your MAF doesn't get the job done!!)*

Bramante CM, Betti LV. Comparative analysis of curved root canal preparation using nickel-titanium instruments with or without EDTA. J Endodon 2000;26;278-80.

NiTi instruments used with EDTA were less effective in maintaining the original path of curved canals. EDTA (RC Prep) should be used only after preparation because it may increase canal transportation.

Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. J Endodon 1998;24:180-3.

Step-back produced significantly more debris than any other method. Balanced forces was similar to rotary because the technique uses a rotary motion.

Bottom Line: Hand or engine-driven instrumentation that uses rotation seems to reduce the amount of debris extruded apically when compared with a push-pull (filing) technique. Step-back technique produced significantly more debris than balanced-force, ProFile or Lightspeed instrumentation.

FILE USAGE AND OPERATION

Yared GM, Bou Daghe r FE, Machtou P. Cyclic fatigue of ProFile rotary instruments after clinical use. Int Endod J 2000;33:204-307.

Dry heat sterilization and simulated clinical use in the presence of NaOCl did not lead to a decrease in the number of rotations to breakage of the files. According to these results, ProFiles could be safely used in the instrumentation of the mesial canals of human mandibular molars in up to 10 canals (**not** 10 teeth).

Gabel WP, Hoen M, Steiman, HR, Pink FE, Dietz R. Effect of rotational speed on nickel-titanium file distortion. J Endodon 1999;25:752-4.

Profiles .04 files used at 333.33 rpm showed separation/distortion 4X as often as files used at 166.67 rpm. The smallest orifice opener (#3) and the smallest file (#8) were observed to have separated/ distorted most frequently.

Yared GM, Bou Dagher FE, Machtou P, Kulkarni GK. Influence of rotational speed, torque and operator proficiency on failure of Greater Taper files. Int Endod J 2002;35:7-12.

Instrument failure with GT files can be avoided when trained operators utilize the crown-down technique at 150 rpm.

CONCLUSIONS

Ruddle CJ. "Cleaning and Shaping the Root Canal System" in Cohen S, Burns RC (eds). Pathways of the Pulp. 8th ed. St. Louis: Mosby pg. 242-258

NiTi rotary instruments have an unpredictable, increased incidence of file breakage. Deviations from methods of use protocols increase the potential for breakage. Multiple use of what should be considered a disposable file is a major cause of separation. These instruments should be

discarded after a single use because of metal fatigue, loss of cutting efficiency, and the great variation in the length, diameter, and curvature of any given canal.

General Guidelines for Using Rotary NiTi Instruments

- Apply light apical pressure, the equivalent of writing with a lead pencil.
- Never force the instrument apically.
- Use copious irrigation.
- The file should be continuously engaging and disengaging the canal walls.
- Use a passive motion; do not leave the file stationary in canal.
- The instrument should be rotating when introduced into the canal.
- No more than 1mm per second of advancement down the canal.
- Use each instrument for a duration of about 3-5 seconds.
- Use an electric hand piece for accurate speed and application of torque.
- Use a constant, recommended, rotational speed, never 'feather' the rheostat.

Regardless of manufacturers instructions and sales representative claims, a glide path should be established to a minimum of a #20 using standard 0.02 taper hand instruments prior to entering the apical third with any rotary instruments.