New possibilities for managing severe curvature: The Twisted File

By Richard E. Mounce, DDS

I received this letter from a good friend and colleague asking about management of a severe apical curvature. My friend practices in a remote location without access to specialists.

"The patient came in last week with slight discomfort in this tooth. I was hoping it was sensitivity from a recent filling, but he came in yesterday with severe pain and I had to start a root canal. The canals are 25 mm long and the distal canal has almost a right angle curve. I've opened the first 18 mm to a #30 and have eased a #6 file to the apex of the mesial canals. On the distal canal, I have rounded the corner with a #6, but I do not think I am at the apex. Any tips for a happy outcome on this one?" (Fig. 1.)

Definitive competent management of apical third anatomy, especially severe curvature, is the net result of performing all the previous steps (beginning with access) in treatment correctly. In essence, the final desired result is an accumulation of many small steps that were optimally performed. The converse is true. Many of the strategies described in this paper can be used with any rotary nickel titanium (RNT) file system. The purpose of this paper is to describe, in a sequential manner, what I believe to be the optimal strategy going forward to manage this case and do so using the new Twisted File (TF) (SybronEndo, Orange, CA, USA). *(Fig. 2.)*

The primary challenge to be overcome in this root is to:

1. Negotiate the curvature and do so without ledging and blockage or other iatrogenic event.
2. Enlarge the canal space and yet keep the canal in its original position as well as keep the minor constriction (MC) of the apical foramen at its original position and size.
3. Create a final prepared taper that optimizes both irrigation and the hydraulic forces of obturation.

TF can be used universally across all manner of canal anatomies. TF would be ideal for this case. The proprietary process of heating, cooling and twisting rotary nickel titanium (RNT) used to manufacture TF creates vastly superior resistance to torsional and cyclic fatigue and improved cutting efficiency over present systems. Existing RNT file systems, those before TF, have all been ground from a blank of nickel titanium, with one exception in which the file is stamped and not ground (Lightspeed, Discus Dental, Culver City, CA). The grinding of nickel titanium is done against the grain structure of the metal and results in microcracks that can become the focus of fracture if the file is exposed to excess torsion and cyclic fatigue. At no time in the manufacture of TF is the file ever cut against the grain structure of the metal. Not cutting against the grain structure, in addition to the heat treatment and surface conditioning provided to TF, all contribute to its exceptional performance characteristics.

Research on TF has shown that:

1. Files from the new manufacturing method that makes TF results in a significantly higher average hardness than nickel titanium files from other manufacturing processes.
2. TF provides significantly reduced torsional failure relative to the alternatives.
3. TF provides significantly reduced cyclic fatigue failure. TF can withstand dramatically more bending energy and increases in the number of cycles to failure in comparison with files manufactured using traditional methods.

The heating and cooling mentioned above leaves nickel titanium temporarily in a molecular state known as the R phase. While in R phase, the material can be twisted. Nickel titanium cannot be twisted without being in this molecular phase state.

R phase technology used in the manufacture of TF:

1. Overcomes many of the limitations of ground file technology and opens up new opportunities for improved file design such as twisting.
2. Optimizes molecular phase structure and optimizes the resulting properties of nickel titanium.
3. Employs a crystalline structural modification that maximizes flexibility and resistance to breakage.

TF is available in five tapers — 0.12, 0.10, 0.08, 0.06 and 0.04 — with a fixed 25-tip size and in 23 mm and 27 mm lengths. Pack configurations at this time include 0.10, 0.08 and 0.06 taper in the "Large pack" configuration, and 0.04, 0.06 and 0.08 in the "Small pack" configuration. Both of these large and small pack configurations are also available in 23 mm and 27 mm lengths. TF is color coded for easy identification *(Figs 3-4)*.

With regard to file design, a brief summary of the design features and benefits are included below. TF has:

A. A triangular cross-section that:
1) Enhances flexibility.
2) Generates less friction inside the canal walls due to a lack of peripheral lands.

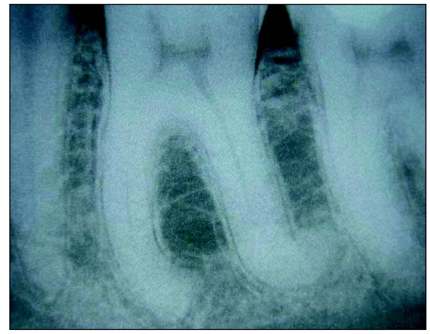

Fig. 1: Severe curvature of the distal root. Management of this clinical case is described.

B. A variable pitch that:
1) Minimizes the "screw-in" effect.
2) Allows debris to be effectively channeled out of the canal due to flute widths and flute depths that become accentuated toward the handpiece.

C. A one-piece design. The file is made from one piece of nickel titanium.
1) The one-piece design gives TF more structural integrity than those that require the handle to be crimped onto the ground nickel titanium blank.
2) The one-piece design minimizes "wobble" during rotation.

D. A proprietary surface conditioning that:
1) Helps maintain the surface hardness of the material and sharpness of the edges.

TF tactile control

The recommended tactile control for TF is:

1. TF is inserted passively and gently.
2. TF is always in motion either being inserted or withdrawn but never held stationary in the canal.
3. The engagement of the flutes of the file against the canal walls is minimized to 1-3 mm of the canal walls at a time.
4. The clinician irrigates and recapitulates after every TF insertion.
5. The flutes of the TF file are wiped after every insertion.
6. The motion of insertion is continuous, controlled and is a single insertion and withdrawal. TF is never pumped into the canal like a toilet plunger. Such use can lock the tip of any RNT file

Fig. 2: The Twisted File, SybronEndo, Orange, CA, USA.

Figs. 3-4: The "small" and "large" pack configurations of TF. The "small pack" has 0.04, 0.06 and 0.08 TF files, and the "large pack" has 0.10, 0.08 and 0.06 files.

(TF or otherwise) and accentuate possibilities for breakage. A single TF file is not taken repeatedly to the same depth in the canal. There is no benefit to the canal preparation to do this, and such motion only risks possibly locking the tip.

7. SybronEndo recommends 500 rpm for TF. With experience, some clinicians may wish to rotate TF faster than 500 rpm; caution and clinical judgment are required. TF can be used with any electric motor. This said, the Elements Motor (SybronEndo, Orange, CA, USA) is a simple, efficient, cost-effective and corded option for TF utilization. Alternatively, TF can be used in cordless handpiece if the clinician desires.

8. TF can be used with the torque control on or off. Using torque control is a matter of personal preference. I use TF with the torque control off.

9. TF can be used Crown Down (CD) or as a Single File (SF) technique. Insertion of TF should take about 2-3 seconds per insertion before the file is withdrawn. In a multiple file CD TF technique, once TF is taken to the desired level of the canal, it is withdrawn, and a new TF taper is inserted as needed. In a SF technique, the TF is wiped, the canal irrigated and recapitulated and the TF reinserted further apically, ultimately in such a sequence to the EWL.

10. After every TF insertion, the file should be inspected for unwinding and stretching. SybronEndo recommends TF as a single use instrument. This said, I have used TF in multiple cases, i.e. at least 3-5 canals. If deformation is present on the file, it should be discarded.

With this background, the management for the coronal third of the tooth in Fig. 1 will be described as it would be performed with TF *(description of middle and apical third management will follow later)*:

1. Ideally, all instruments, equipment and TF files needed for instrumentation are laid out in their respective positions on the operatory countertop in the expected order that they will be used. Such excellent preparation and organization stands in distinction to a procedure in which supplies are gathered one by one from all over the office "on the fly" as needed. Efficiency, timesaving and profitability can be gained by such preparation without a loss in quality. The final result can only be enhanced with this preparation and when the procedure is well rehearsed among staff.

2. Access must be straight line once the procedure is ready to commence. The LA Axxess kit (SybronEndo, Orange, CA, USA) contains all the burs needed to make access through all manner of restoratives, gold, porcelain, amalgam, enamel and dentin, etc. The orifices of the canals should not be touched until the access above is ideal. All caries, unsupported enamel, unset restoratives, should ideally be removed during access. Enlargement of the canal into the coronal third or to the point of the first root curvature must allow a hand file to be inserted without deflection against the access walls. The cervical dentinal triangle must always be removed in shaping the orifice.

Once the access is complete, the clinician should pause shortly and verify that the tooth is still restorable. It is possible, in some clinical cases that the tooth, once cleared, may be found to be non-restorable. Vertical root fracture, unfavorable crown root ratio, lack of tooth structure, etc., individually or collectively, may become evident once proper access is made.

Removal of the cervical dentinal triangle can be performed with either RNT orifice openers such as the TF 0.12 and 0.10 files or possibly the line angle burs of the LA Axxess kit. The line angle burs are made of stainless steel and come in three tip diameters for orifices of various sizes. They are parabolic safe ended tip instruments. In lieu of using the TF orifice openers, these line angle burs can be used to not only remove the cervical dentinal triangle, they can also instrument the straightaway portion of the coronal third if desired. Use of Gates Glidden drills is not advised due to the risk of strip perforation in many anatomies relative to the safer options listed here: the line angle burs and/or 0.12 and 0.10 TF.

Fig. 5: The Global Surgical Operating Microscope, Global Surgical, St. Louis, MO, USA.

Fig. 6: File Eze, Ultradent, South Jordan, UT, USA.

Anticipating the correct prepared orifice size in advance is important. Larger orifices and roots (palatal roots of upper molars) will usually accept a .12 or .10 TF easily. Medium sized orifices and roots (bicuspids) will usually accept a .10 and possibly .08 TF easily. Small and highly curved roots and constricted orifices will usually accept .08 or .06 TF at the orifice easily. The diameter created at the orifice should be proportional to the final prepared taper (this concept will be expanded upon in greater detail later).

3. Effective orifice management is essential to manage the apical curvature. An orifice that is managed correctly can allow excellent cleansing and shaping below. The converse is true. The orifice must be shaped ideally before the clinician can and should go further. The removal of dentin should never be toward the furcation to minimize any chance of strip perforation. Used inappropriately, some orifice openers can "screw into" the canal and cause strip perforation. Patience is cautioned. Initially, in managing the canal, the clinician should only enlarge the orifice and not be concerned with any more apical part of the preparation.

The insertion of the initial TF file (likely a 0.10 or 0.12 TF) or the line angle burs takes place with the clinician having a full visual and tactile command over the orifice. Ideally, this access will take place under the Surgical Operating Microscope (SOM) (Global Surgical, St. Louis, MO, USA) *(Fig. 5)*. The rubber dam is mandatory and the legal and ethical standard of care in endodontics. SOM visualization allows the clinician to visualize the debris that will result from the aforementioned insertion of the 0.10 TF. Opening up the orifice at this stage correctly will allow greater volumes of irrigants to be rapidly placed further apically than they otherwise would be in a Step Back technique. Orifice management, as described here, allows the greatest tactile control and reduction of iatrogenic events at all subsequent steps in the process.

4. In the presence of a significant amount of either vital or necrotic pulp, a viscous EDTA gel like File EZE (Ultradent, South Jordan, UT, USA) should be placed into the chamber to hold the pulp tissue in suspension and keep it from being propelled apically down the root canal system. It is possible to rapidly occlude a canal system (especially a highly curved apical one), with pulp tissue if a viscous EDTA gel is not utilized.

Ideally, the clinician should irrigate whenever debris is present in the chamber. Instant removal of debris can minimize inadvertent propulsion of debris. The SOM can make visualization and clearance of debris simple and efficient. In clinical practice, File Eze is placed in the pulp chamber to the occlusal surface. Orifice size dependent, the (0.12, 0.10 or 0.08) TF file is inserted into the canals passively if the coronal third is open, patent and negotiable.

After TF removal, the chamber is irrigated with sodium hypochlorite to remove the slurry of EDTA gel and pulp debris and recapitulated. File Eze is placed again and the cycle repeated as needed. After the coronal third pulp is removed, the use of File Eze can be discontinued and the clinician should change the irrigant. Primarily, sodium hypochlorite is used in vital teeth and 2.0% chlorhexidine (or sodium hypochlorite) can be used in non-vital teeth. Both of these liquid solutions will lubricate TF instrumentation more than adequately, irrespective of the canal anatomy. Chlorhexidine and sodium hypochlorite are never mixed due to the precipitate that will form. A liquid EDTA solution like SmearClear (SybronEndo, Orange, CA, USA) can be used to flush out either sodium hypochlorite or 2% chlorhexidine before the other solution is used. It is also used before obturation to clear the smear layer *(Fig. 6)*.

After the coronal third is shaped with a TF of appropriate taper the middle and apical third can be shaped in the manner described below (a SF or CD technique). As with the coronal third, the middle third is made ready for TF enlargement with hand files. The clinician should place hand files into the middle (and apical third if they can be easily accepted) to make sure that the canal space is open, patent and negotiable to at least the size of a #15 hand file in the area of the next desired TF enlargement (middle third alone or middle and apical third). Once the middle or apical third, canal anatomy dependent, has at least the diameter of a #15 hand file, the clinician is ready to progress further apically with TF.

Crown Down versus Single File TF technique

With TF, the entire canal space can be enlarged CD, or possibly with just one TF instrument in a SF technique.

1. Crown Down:

To use TF CD, the clinician would simply insert TF in diminishing tapers to the estimated working length (EWL). Assuming that the canal was negotiated first, as it should be by hand, and a glide path created, once the first hand file reaches the EWL, the TWL should be taken. An excellent device for this purpose is the Elements Diagnostic Unit apex locator (SybronEndo, Orange, CA, USA). Once the TWL is determined, the clinician can continue to move from larger TF tapers to smaller until the desired final taper is reached at the TWL (assuming that multiple TF files are needed, SF TF technique will be described below). To make this enlargement as efficiently as possible, the tactile recommendations for TF contained in this paper should be observed.

For larger canals, the final desired taper (palatal roots of upper molars, distal roots of lower molars, will usually be a 0.10 taper. For medium sized canals (bicuspids), the final desired taper would generally be a 0.08. For smaller roots (lower anterior teeth) the final desired taper will generally be 0.06 or possibly 0.08, case dependent. The 0.04 TF is very flexible and can negotiate even the most challenging curvatures relatively easily. This said, if it is possible to get a 0.04 TF to TWL (which for open and negotiable canals it should be) it is usually possible to subsequently make a larger tapered preparation (0.06 or 0.08 taper). In the root in Fig. 1, a 0.06 TF could reach the TWL assuming a 0.04 TF preparation was first created.

In clinical practice, if a 0.12 TF is used at the orifice, generally, the 0.10 TF can be used to the TWL to assure a continuous taper for most average roots seen in general practice. If a 0.10 TF is chosen as the orifice opener, generally a 0.08 TF can easily go to TWL, etc. Interestingly, TF cuts so well and tracks canals with such excellent tactile control that it usually takes approximately 2-3 insertions of a given TF file (or possibly two to three TF files) to reach the TWL. In other words, with a very limited number of TF insertions, the canal can be shaped for many common anatomies.

In any event, it is important to avoid an abrupt change of taper in the preparation. Said differently, the difference between a 0.12 and 0.10 taper is very slight with regard to canal shape. Use of a 0.12 TF at the orifice and 0.10 taper throughout the preparation is ideal for many larger roots. But, using a 0.12 taper in the coronal half of the root and a 0.06 in the apical half will result in an abrupt taper change at mid root. Without a continuous taper, it is easy to create a "Coke bottle" preparation, big taper at the top, rapidly diminishing taper apically. Such abrupt taper changes violate one of the principles of canal enlargement, i.e., provide a continuous taper with narrowing cross sectional diameters. Abrupt taper changes also do not allow ideal irrigant

Fig. 7-9: Clinical cases treated with one to three TF files.

exchange and predictable debris removal in the less tapered portion of the canal where it is needed most *(Figs. 7-9)*.

2. The Single File TF technique:

Due to TF's superior cutting ability and fracture resistance, it is possible in many canals to use a single TF file to prepare the entire canal or in many others to use only two to three TF files in a CD sequence as described above. TF flexibility, cutting ability and fracture resistance make this functionality possible combined with the correct tactile control. TF is not forced to length at any time to reduce the number of instruments needed.

TF should advance almost effortlessly as it moves apically. If undue pressure must be placed on the TF to advance it, it should be withdrawn and consideration given to a multiple file sequence. In SF technique, the file is inserted with the tactile control described above, withdrawn, the flutes wiped, the canal irrigated and recapitulated and the same TF file reinserted. When the given TF in SF technique meets resistance, the file can be removed and subsequently reinserted as needed to reach the EWL. With this cycle of insertions, irrigation, recapitulation and reinsertion, in many canals that are not excessively curved, the clinician can move TF passively to the EWL. If TF does not want to move apically with ease, a smaller TF can be chosen.

In any event, irrespective of the TF sequence used, SF or CD, the smear layer is removed with SmearClear* liquid EDTA solution. The final prepared canal is matched with a TF paper point and TF gutta percha (SybronEndo, Orange, CA, USA). For clinicians using RealSeal bonded obturation (as I do), the 0.06 20 RealSeal cone can be easily trimmed and used for bonded TF obturation. I use PermaFlo delivered via the Skini syringe and the 17 mm Navi tip to bond the chamber and provide my coronal build up (Ultradent, South Jordan, UT, USA). Achievement of early and excellent coronal seal is consistent in the endodontic literature with enhanced clinical success *(Fig. 10)*.

To expand on the question asked by my friend about the case featured in Fig. 1, several relevant applications of the above TF strategies can be interpreted for this particular case:

1. First off, serious consideration should be given to treating this patient in one visit. If the tooth can be treated in a reasonable time, 90 minutes or less, there is no arbitrary reason that this has to be divided into two visits. In fact, a strong case could be made for performing the treatment in one visit so as to make sure that mental focus was not lost as well as maximize the use of resources (the office's and the patient's). It should be remembered that once anesthesia is obtained, access made and the coronal third is enlarged, the hardest part of the procedure is often done.

2. At the apex of the distal root, it is important to consider that the canal can and probably does bend not just in the mesial to distal direction but also in a buccal to lingual dimension. It will be especially important to make sure that the apical third of the distal root is negotiated by hand first before TF or any other RNT file is brought into the canal space.

3. Negotiating the distal canal(s) of this tooth with a #6 hand file will require an optimal coronal shape be prepared first. Irrigation must be copious at all times. The clinician says in the question that they are not sure they are at the apex with hand files. Every effort must be made first to establish patency first with hand files, and once patent, determine the true working length (with an electronic apex locator). Negotiating the curvature will require precurved hand files using an EndoBender pliers.* The precurved hand files

Fig. 10: PermaFlo, Ultradent, South Jordan, UT, USA.

Fig. 11: The M4 Safety Handpiece, SybronEndo, Orange, CA, USA.

(usually starting with a #6's) are inserted gently and passively and done so with the intent of assuring patency and not to shape the canal at this time. It may require multiple insertions from different orientations in order to gain patency and determine the TWL, especially if there is a blockage or ledge present. After the #6 has reached the EWL, it is important to establish patency beyond the curvature. Maintaining this patency at all times is key to delivering an excellent result through the prevention of blockage of the canal with debris. Patency can be verified with the Elements Diagnostic Unit electronic apex locator.**

A radiograph that shows a small hand file slightly beyond the radiographic apex can also assure patency. Once the #6 has passed the MC and patency is established/assured, one strategy to manage the curvature is to place the hand K file in the canal in the distal root to the TWL. While the tooth is under the rubber dam, the M4 Safety handpiece attachment*** can be attached to the file. The M4 is a reciprocating handpiece attachment that can reciprocate a hand K file 30 degrees clockwise and 30 degrees counterclockwise safely and efficiently to create a minimal enlargement of the canal space virtually without risk of fracture and transportation. In this clinical case, with the M4, it would be a simple matter to enlarge the canal from a #6 hand K file to the diameter of a #8 and use a #8 with the M4 to enlarge the canal to a #10 hand K file, etc. What is vital for enlargement is that the tip of the hand file be at or slightly beyond the MC to minimize any chance of possibly transporting the apical anatomy of the canal. The M4 attachment fits into any E type attachment as is present on most electric endodontic motors. The electric motor speed is set at 900 rpm on the 18:1 setting and the M4 is used with vertical amplitude of motion of approximately 1-3 mm. In about 15 seconds, the #6 placed to the TWL will have created the diameter of a #8 hand file as described above. Using successively larger hand files with the M4 will, in essence, create a glide path to give the needed minimal enlargement before TF. The M4 eliminates hand fatigue and reduces chances for canal blockage. Dentin debris produced by the M4 is routinely channeled onto the pulpal floor where it can be easily irrigated away *(Fig. 11)*. (*,**,*** all SybronEndo, Orange, CA, USA).

4. Once the M4 has allowed creation of a glide path, TF instrumentation can be accomplished as described elsewhere in this paper. With TF, special precautions would not need to be taken in this clinical case due to the curvature. Given this degree of curvature, the final TF would likely be a 0.06 taper to length (possibly 0.08). It may be necessary to create a 0.04 TF taper first to the TWL and then enlarge it to a 0.06 and then possibly 0.08. Determining the optimal final shaping sequence would be dependent on the length of the canal, the severity of the curvature and the diameter of the canal (i.e. how calcified it is). Having extensive experience with TF, it would easily track, negotiate, and enlarge the curvature present.

In any event, after preparation, the tooth could be easily obturated with SystemB technique and the Elements Obturation unit after TF preparation, especially under the SOM. (SybronEndo, Orange, CA, USA).

A clinically relevant method for cleaning, shaping and obturating a long and acutely curved root canal system has been presented utilizing the new Twisted File technology. Strategies have centered on universal principles applicable to all RNT systems and yet highlight how the Twisted File would manage this challenging anatomy safely and efficiently.

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