22

The Quantec™ Rotary NiTi Instrumentation System

John T. McSpadden, Gary D. Glassman, Kenneth S. Serota

The K-type steel file has remained the instrument of choice for preparing root canals for over three quarters of a century. Until recently, we have been limited to stainless steel for the fabrication of endodontic instruments. With the emergence of exotic metals, the most notable of which is nickel-titanium, there has been a surge in the manufacture of instruments made of this material because of its flexibility and more importantly, its ability to accommodate more stress in curved root canals.

WHY NICKEL-TITANIUM?

The significant advantage of a nickel-titanium file is its unique ability to negotiate curvatures during continuous rotation without undergoing the permanent deformation or failure that stainless steel files might incur. Nickel-titanium is termed an exotic metal because it does not conform to the normal rules of metallurgy. As a super-elastic metal the application of stress does not result in proportional strain.

This unusual property is the result of undergoing a molecular crystalline phase transformation when stressed. External stresses transform the austenitic crystalline form of nickel-titanium into the more forgiving martensitic crystalline form. Restated, nickel-titanium is the only readily available material that has the flexibility and strength necessary for use as an effective rotary endodontic file.

WHY ROTARY INSTRUMENTATION?

One benefit of mechanical rotation is the enhanced ability to collect and remove debris from the canal system. Hand instrumentation using file insertion motions without rotation or with counter-clockwise motion pushes debris into the intricacies of the canal anatomy or even apically through the portals of exit. In contrast, continuous rotation augers debris only in a coronal direction from the root canal space.

Mechanical rotation of nickel titanium files can provide better control for maintaining the central axis in curvatures that results a more conservative canal preparation. The most obvious benefit is the reduction in the time required for instrumenting canals. Although rotary instrumentation can offer the operator numerous advantages, the prevention of file failure requires greater consideration.

The most important relationships of the components of NiTi ground files designs and canal anatomies that enable us to improve our technique include:
- A file with a more efficient cutting design requires less torque and/or pressure to accomplish the same degree of root canal enlargement.
- In a straight canal, the ability of a file to withstand torque varies directly with the square of its diameter.
- In a curved canal, the ability of a file to resist fatigue varies inversely with the square of its diameter.
- The torque required to rotate a file varies directly with the surface area of the file's engagement in the canal.
- Fatigue of a file increases with the number of rotations of the file in the canal.
- Fatigue of a file increases with the degree of curvature of the canal.
- To improve efficiency, the smaller the surface area of a file engaged in the canal, the greater the rotation speed should be.

- The more spirals a flute has per unit length around the shaft of a file, the greater the torque is required to rotate a file and the more stress concentration points there are for potential failure, but the more flexible it is.
- The fewer spirals a flute has per unit length around the shaft of a file, the more it resists deformation, but the more rigid it is.
- The sharper the cutting blade of a file, the fewer spirals per unit length the file should have.
- The greater the number of flutes with similar helix angles, the greater tendency a file has to screw into the canal and become bound.
- Maximum engagement of a file occurs when it progresses into the canal at a rate that is equal to its feed rate.

WHAT CAUSES BREAKAGE? WHAT IS TORSION?

Breakage is directly related to excessive stresses of torsion and fatigue. Torsion is the axial force of being twisted that results when one part of a file rotates at a different rate than another part. Any distortion of a file that results from twisting, such as unwinding, is caused by stress of torsion. When a file resists rotation during hand instrumentation, excessive torque can be perceived and file breakage can usually be avoided. However, as torque is essentially impossible to sense during automated instrumentation, understanding the factors of file breakage is the most important aspect for learning this modality for canal preparation.

WHAT IS FATIGUE?

File fatigue is the result of repetitive stress predominantly during flexion while rotating around a canal curvature. A file can withstand more stress during a single rotation around a curvature than it can after numerous rotations. Metal fatigue usually begins at the surface where minute defects act as points where stresses become concentrated. A fatigue failure is particularly insidious because it can occur without any obvious warning. Knowledge of the relationships of file sizes and canal anatomy is especially important when dealing with the combined stresses of torque and fatigue. Computerized handpieces address some of the problems of torque but offer no future promise for replacing the dentist's judgment for appropriate technique.

WHAT ARE THE SMALLEST FILE DIAMETERS THAT CAN BE USED TO MEET THE TORQUE REQUIREMENTS THAT WE ARE LIKELY TO ENCOUNTER IN CANALS?

The smaller the diameter the file has when it becomes bound the more likely it is to break. However, binding of a small diameter can usually be detected and prevented if that part of the instrument that is likely to become bound is the only part that is engaged in the canal. If the torque and pressure required for rotation of an engaged larger diameter of a file exceeds the torque required to break the smaller diameter should it become bound, the file is particularly vulnerable.. Even establishing glide paths (canals enlarged to a diameter larger than the tip of a subsequent file) is no assurance that a small tip size cannot be pushed into aberrations such as fins or anastomoses when the force necessary for engaging the larger diameter is applied.

WHAT CAUSES FATIGUE?

On the inside of the curvature, a rotating file is compressed. On the outside of the curvature the file undergoes tension. As a file rotates around a curvature each surface undergoes compression and release destruction. When tension is applied, faults in the file are propagated. Generally, the greater the distance between the stress of tension and the stress of compression, the greater the total stress on the instrument. The smaller the diameter of a file, the longer it can rotate around a curvature without fatigue failure. The file's resistance to fatigue varies inversely with the square of the diameter. Therefore, a size .20 diameter can resist fatigue 50% more than a size .25 diameter. As the diameter of a tapered file increases as it progresses through a curvature the stress on the file eventually reaches the point of potential failure and the use of the file should be terminated in favor of a smaller diameter or smaller tapered file.

WHAT IS THE LARGEST FILE DIAMETER OR TAPER THAT CAN BE USED IN CURVATURES THAT WE ARE LIKELY TO ENCOUNTER?

If one attempts to bend the largest diameter handle end of a 25/.02 file, it is easy to imagine how quickly this .57 mm diameter would fail in a curvature. The ri-