Comparison of the torsional fatigue resistance of PathFile nickel-titanium files with other small 0.02 mm taper files

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ABSTRACT

Objective: The purpose of this study was to compare the torsional fracture resistance of the following 0.02 mm taper files: PathFile size #13, #16, and #19, ProFile size #15 and #20, K3 size #15 and #20, Quantec LX size #15 and #20, and Liberator size #15 and #20. **Methods:** Eleven groups of files with 20 samples in each group were tested. The files were secured in the chucks of a torsiometer and rotated until fracture occurred. The maximum torque and degrees of rotation before fracture were recorded. Files of similar tip size were compared with one another for significant differences. One way ANOVA and Tukey's post hoc test were used to identify statistically significant ($p < 0.05$) differences between the groups. **Results:** The Liberator size #15 and #20 separated at significantly lower torque than all other similar sized files, while the PathFile size #16 separated at significantly higher torque than the size #15 files to which it was compared. **Conclusion:** The torsional fatigue resistance of PathFiles were better when compared to other small tip size #0.02 taper files.

Keywords: Endodontics. Fatigue. Rotary drilling.

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Introduction

Removal of bacteria and organic debris through chemomechanical cleaning and shaping of the root canal system is an essential step in root canal treatment.[1] Nickel-titanium (NiTi) rotary endodontic files are commonly used during root canal treatment and afford several advantages over stainless steel hand files. These advantages include the following: Improved ability to stay centered around curves, increased flexibility and torsional resistance, decreased transportation, ledging, zips and elbows and decreased instrumentation time.[2,3,4] Files occasionally separate in canals due to torsional or cyclic fatigue or a combination of the two.[5] If unable to be removed, the separated file can make further instrumentation of the canal difficult or impossible, especially if located in the apical third of the canal.[6] Small diameter files with small taper are more likely to fracture due to torsional fatigue than cyclic fatigue if the flutes of the file lock into dentin as the shaft continues to spin.[7,8]

It is important to create a glide path before instrumentation with rotary NiTi files to create a channel for the tips of the files to follow into the apical third of the root canal. This step has typically been accomplished using stainless steel hand files.[9] Most rotary systems recommend creating a glide path to at least a size #15 hand file before the use of NiTi rotary files.

The PathFile™ system (Dentsply Tulsa Dental Specialties, Tulsa, OK) has recently been introduced as a rotary method of establishing a glide path after the canal has been negotiated with a #10 hand file.[10] Berutti et al[11] reported that inexperienced clinicians produced more conservative glide paths with PathFiles than experienced endodontists with stainless steel hand files in plastic blocks.

The PathFile technique involves inserting rotary files to working length very early in the instrumentation sequence. While this has the potential of decreasing the time and effort required to instrument canals, these files could have sufficient engagement of the root canal wall which may exceed their threshold for fracture, especially in constricted canal spaces. A small separated instrument early in the shaping and cleaning process may inhibit the clinician from further access to the apical third of the root canal and may have a negative impact on the prognosis, especially in infected canals.[12] In addition to the PathFiles, there are several other 0.02 mm taper NiTi rotary file systems available with small diameter files. Even though these files have not been specifically made for the creation of a glide path, it is conceivable that they may be able to function in a similar manner to the PathFiles. To date, the torsional resistance to fracture of these various 0.02 mm taper small diameter files has not been compared. Therefore, the purpose of this study is to compare the torsional resistance of the following 0.02 taper files: PathFile size #13, 16, and 19 (Dentsply Tulsa Dental Specialties, Tulsa, OK), ProFile™ size #15 and 20 (Dentstply Tulsa Dental Specialties, Tulsa, OK), K3™ size #15 and #20 (SybronEndo, Orange, CA), Quantec LX™ size #15 and #20 (SybronEndo, Orange, CA), and Liberator™ size #15 and #20 (Miltex, York, PA).

Material and Methods

Torsional testing was accomplished in accordance with ANSI 58[13] and ISO 3630-1[14] standards using a torsiometer (Torsiometer/Memocouple, Maillefer, Ballaigues, Switzerland). Prior to file placement in the torsiometer, the handle was removed with wire cutters at the point where the handle was attached to the instrument shaft. The shaft end was then secured in the chuck of the torsiometer which was connected to a reversible, microprocessor-controlled rotating motor. The file's terminal three millimeters were secured into a digital torque meter. The NiTi files were then rotated in a clockwise direction as viewed from the shank end at a speed of 2 rotations per minute. The maximum torsional force and degrees of rotation at the moment of file fracture were recorded.

Eleven groups of 20 files each were tested. All files were 0.02 taper. Group 1: PathFile #13, Group 2: PathFile #16, Group 3: PathFile #19, Group 4: ProFile #15, Group 5: ProFile #20, Group 6: K3 #15, Group 7: K3 #20, Group 8: Quantec LX #15, Group 9: Quantec LX #20, Group 10: Liberator #15, and Group 11: Liberator #20.

Two variables were compared among the groups of files; maximum torque before fracture and degrees of rotation before fracture. One way ANOVA and Tukey's post hoc test were used to identify statistically significant ($p < 0.05$) differences between the groups. Files of similar tip size were compared with one another for significant differences. The size #13 and 16 PathFiles were compared with the size #15 group. The size #19 PathFiles were compared with the size #20 group.

Results

The results of the torsional testing are presented in Figure 1. The Liberator size #15 and #20 separated at significantly lower torque than all other similar sized files, while the PathFile size #16 separated at significantly higher torque than the size #15 files to which it was compared. The comparison of degrees of rotation before fracture is presented in Figure 2.

Discussion

Small stainless steel hand files are often used for creation of a glide path to size #15 or #20 before the use of rotary files. Allen et al[15] evaluated multiple types of hand files for this purpose. They compared the geometry, stiffness, efficiency and deformation during canal negotiation in plastic blocks and concluded that pitch, taper, cross-section, heat tempering, metal type, tip geometry, and operator skills all influence pathfinder efficiency when using hand files. When using PathFiles, the manufacturer recommends that the canal should be instrumented to working length to at least a #10 file before using PathFiles. It is therefore useful to consider these factors in selection of small hand files.

Pasquelani et al[16] conducted a study comparing PathFiles with stainless steel K files for the creation of a glide path using spiral computed tomography. They found that PathFiles stayed significantly more centered in the canal and created significantly less transportation in extracted human molars with moderate to severe curvature when compared with stainless steel hand files.

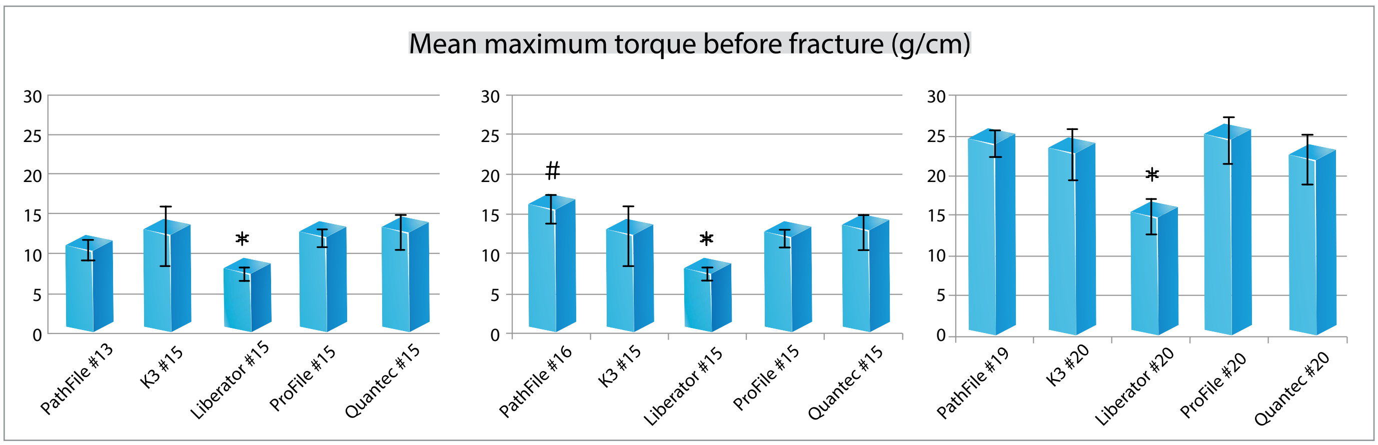

Figure 1. Mean maximum torque before fracture (g/cm). The asterisks indicate the file separated at significantly lower torque than all other files in the grouping. The (#) indicates the file separated at significantly higher torque than all other files in the grouping ($p < 0.05$).

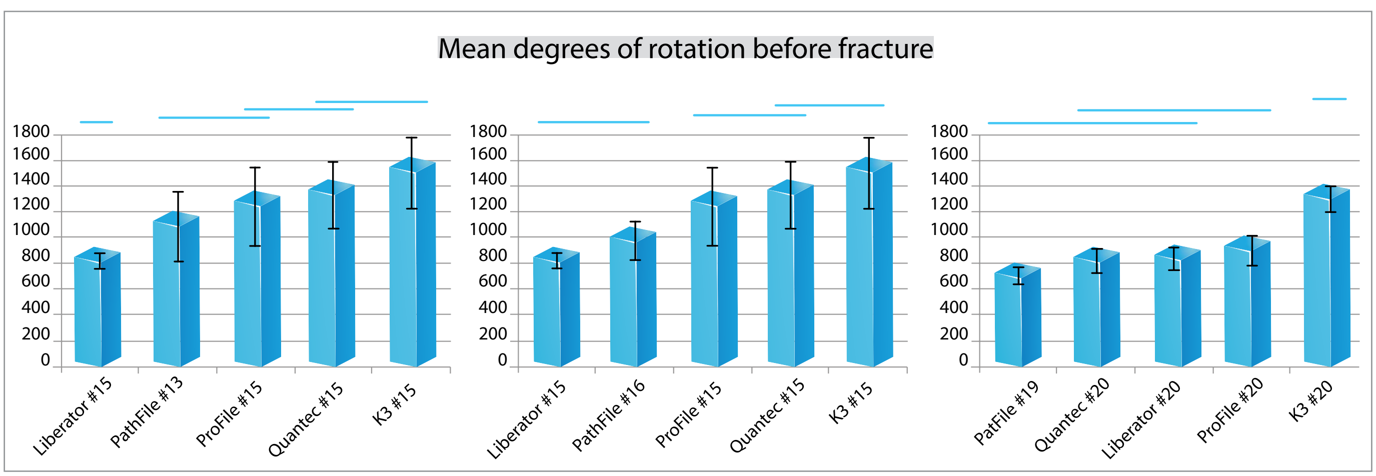

Figure 2. Within each grouping, the horizontal lines represent statistically similar groups. Two files are statistically different if they are not under the same horizontal line ($p < 0.05$).

Berutti et al[17] recently conducted a study showing that the creation of a glide path with PathFiles significantly reduced undesirable canal modifications when used in conjunction with the WaveOne system in plastic blocks.

The results of the present study indicate that rotary NiTi files with similar tip size and taper separated at a comparable torque, except for the Liberator groups. This result may be due to less bulk of metal at the breaking point of the Liberator compared to the other files or the specific type of NiTi metal used in the manufacturing process. Although there were significant differences in the degrees of rotation before fracture between some of the groups, the difference in rotation before fracture may not be clinically relevant as even the best group would have separated in less than 1 second spinning at 300 rpm with the file tip bound in dentin.

Using small rotary files to working length early in the shaping and cleaning process should be performed with caution as the torque required to break these files is very low. Many constricted canals are difficult to negotiate with a size #8 or #10 hand file, and small rotary files would surely encounter significant stress in tight canals. File separation due to torsional fracture early in the process could prevent further shaping and cleaning of the root canal space and could have a negative impact on outcome, especially in infected canals. Even though they are not currently marketed for development of a glide path, based on findings in this study, the 0.02 mm taper #15 and #20 K3, ProFile, and Quantec LX files may also be reasonable choices for development of a rotary glide path along with the PathFiles instruments. Although there was very little difference between the fracture resistance of the PathFiles and the size #15 and #20 NiTi rotary files compared in this study, the tip sizes of the PathFiles may offer a significant advantage when instrumenting tight canals. There is a 50% increase in size from a #10 to a #15 file whereas with PathFiles, the increase from #10 to #13 is only 30%. This smaller incremental increase may decrease binding of the file while developing a rotary glide path and help minimize file separation. This smaller percentage increase in size is also seen with the progression from the size #13 to #16 and from the size #16 to #19 PathFiles. Further research is needed concerning the use of small NiTi rotary files for the establishment of a glide path to determine their safety in clinical scenarios.

Conclusion

Under the parameters of this study, PathFiles were better when compared with other NiTi rotary files of similar diameter and taper.

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