Evaluation of Time to Fracture and Vertical Forces Applied by a Novel Gentlefile System for Root Canal Preparation in Simulated Root Canals

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Abstract

Introduction: A great number of studies performed in the last 3 decades have shown the superior mechanical features of nickel-titanium files as compared with stainless steel files. A novel file system recently developed, Gentlefile, defies these findings and claims to have superior qualities despite the fact it is made from stainless steel. **Methods:** Three file systems were used in this experiment: ProTaper Next (X1, X2, and X3), RevoS (SC2, SC3, and AS30), and Gentlefile (GF1, GF2, and GF3). Time to fracture, rotations to fracture, and vertical forces applied to a simulated root canal, which was fabricated from a metal block with a Plexiglas cover, were measured. **Results:** The GF system required significantly longer time and more rotations to fracture compared with the ProTaper and RevoS systems ($P < .001$). The GF system applied significantly less vertical force to the canal in comparison with the ProTaper and RevoS systems ($P < .01$). **Conclusions:** Under the limitations of this study the GF system showed better mechanical properties in comparison with the ProTaper and RevoS systems. Further investigation is needed to assess the clinical meaning of these findings. *(J Endod 2016;42:505–508)*

Key Words

Cyclic fatigue, Gentlefile, NiTi, ProTaper Next, Revo S, stainless steel, vertical force

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Cleaning and shaping of the canal system is one of the most important stages of root canal treatment and has the greatest impact on its success (1). This stage of treatment may present a great challenge to clinicians, especially when treating curved canals (2). Proper and safe cleaning and shaping of root canals depend on the mechanical behavior of endodontic instruments (3, 4). Files manufactured from nickel-titanium (NiTi) alloy were reported to have greater flexibility and greater resistance to torsional fracture (5). NiTi alloys have a special feature known as superelasticity. Cyclic fatigue occurs when the file rotates inside a curved canal, sometimes causing files manufactured from NiTi to fracture unexpectedly (6–8). This is due to alternating cycles of tension-compression generated at the point of maximum bending of an instrument when it is rotated in a curved canal (6), as opposed to stainless steel (SS) files, which undergo deformation before breaking (9). In a recent study it was shown that multiple file systems with cutting edges create root microcracks as opposed to files with an abrasive surface that scrape the dentin and cause no microcracks (10).

Recently a new system was introduced: Gentlefile (GF) (MedicNRG, Kibbutz Afikim, Israel), made from SS. The apical portion of the file consists of a main central braided cable with a diameter of less than 0.15 mm. Coiled on top of it is a second wire with a diameter of less than 0.20 mm. In the middle and upper portions of the file a third wire of less than 0.35 mm diameter is coiled. The apical 0.5 mm of the end of the file sharpened at a 45° angle results in a non-active passive tip. All files have a constant 4% taper. The single-use files, which have a rough surface after undergoing particle blasting, enlarge the canal walls by gently scraping the dentinal walls. The files are operated by a special fully automated handpiece at a maximal speed of 6500 rpm. The velocity changes automatically, depending on the force applied to the file during rotation in the canal. Speed and torque cannot be manually controlled by the operator. The GF system consists of 6 files, an orifice opener 18 mm long and 5 preparation files 25 mm long (Fig. 1*A*). According to manufacturer's instructions, canals should be prepared by using 2 to 3 files. The variety of files in the system is designed to allow the operator to choose the most suitable file combination for the specific canal anatomy.

The aim of this study was to compare the time to fracture and to measure the vertical force applied by the GF system with those of the ProTaper Next (PT) and Revo-S (RS) systems in simulated curved root canals.

Materials and Methods

File Systems

Three file systems were compared in this study. The files were operated according to the manufacturer's instructions.

ProTaper Next. X1 with tip size 0.17 mm, X2 with tip size 0.25 mm, and X3 with tip size 0.30 mm were used with a 16:1 gear reduction electric handpiece (WaveOne endodontic motor; Dentsply Maillefer, Ballaigues, Switzerland) at 300 rpm.

Revo-S. SC2 with tip size 0.25 mm 4%, SC3 with tip size 0.25 mm 6%, and AS 30 with tip size 0.30 mm 6% were used with a 16:1 gear reduction electric handpiece (WaveOne endodontic motor; Dentsply Maillefer) at 300 rpm.

GF. GF1 with tip size 0.22 mm, GF2 with tip size 0.25 mm, and GF3 with tip size 0.27 mm were activated by using a specially designed handpiece at 6500 rpm.

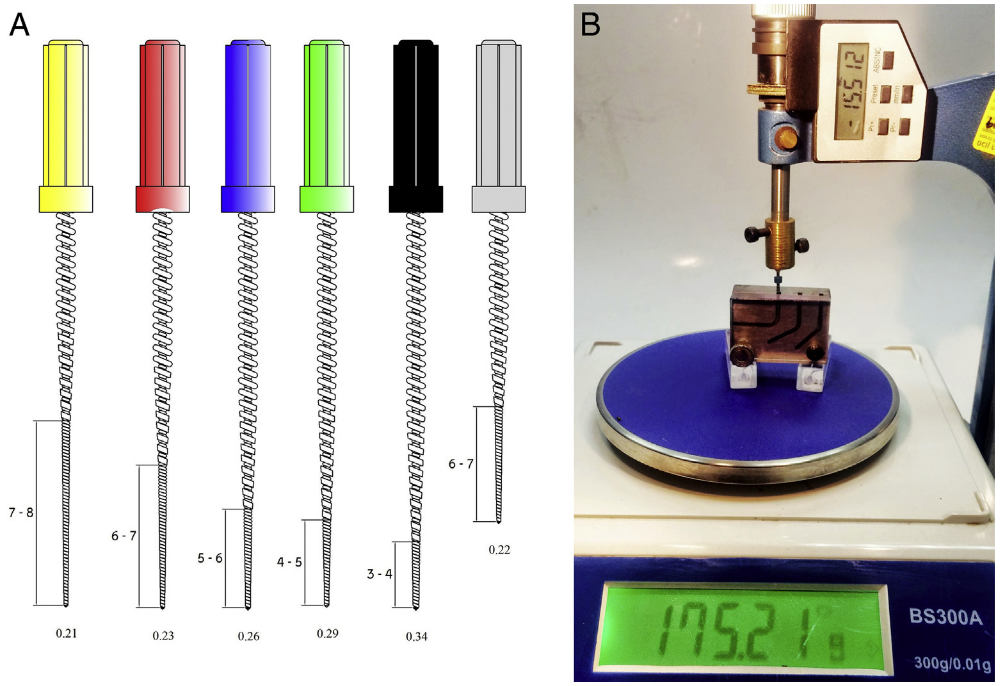

Figure 1. (*A*) The 6 files of the GF system: the 18-mm-long orifice opener and five 25-mm-long preparation files. (*B*) A novel system designed to measure the vertical force applied by different files, consisting of a micrometer connected to an analytic digital scale.

To standardize the experiment, the files compared in this study, commonly used in endodontic treatment, were of similar apical size.

Time to Fracture

Simulated root canals were fabricated from a metal block with a Plexiglas cover. Grooves of 1-mm depth with a curvature of 90° and a radius of 2 mm were prepared in the blocks.

Earlier models used only the angle of curvature to describe canal anatomy (10). Pruett et al (9) suggested using the radius of curvature as well to best describe the canal.

The files were placed in the corresponding handpieces, inserted into simulated canals, and advanced until the tip was 3 mm beyond the curvature. The handpieces were then activated, and the files were rotated until fracture occurred.

Each file was used according to the manufacturer's instructions.

Group 1 consisted of 15 PT files: 5 files X1, 5 files X2, and 5 files X3. Group 2 consisted of 15 RS files: 5 files SC2, 5 files SC3, and 5 files AS 30. Group 3 consisted of 15 GF files: 5 files GF1, 5 files GF2, and 5 files GF3.

Time to fracture was measured for each file with the aid of an electronic digital stopwatch, and the results were analyzed statistically.

Vertical Force Applied by Files in Simulated Curved Root Canals

To evaluate the vertical forces, a system was designed consisting of a digital micrometer and an analytical scale (Radwag Wagi Elektroniczne PS 510/C/1, Radom, Poland).

The block with the simulated root canals, used as described above, was placed on the scale. The files were attached to a digital micrometer and inserted into a simulated root canal until the beginning of the curvature and slowly advanced apically. The apical force was registered by the analytical scale (Fig. 1*B*)

Measurements were made every 2 mm until an 8-mm depth beyond the curvature was reached. Each measurement was repeated 5 times. The force applied by the files at each measurement point was recorded by the analytical scale, and the results were analyzed statistically.

Statistical Analysis

Time to fracture was analyzed by using two-way analysis of variance with Bonferroni correction for multiple comparisons. Rotations to fracture were analyzed by using two-way analysis of variance with Bonferroni correction for multiple comparisons. Vertical force was analyzed by using analysis of variance with repeated measurements.

Results

Rotations to Fracture

A comparison of the different file systems showed that the GF required significantly more rotations to fracture than the other systems ($P < .001$). No significant difference was found between the PT and the RS systems (Fig. 2*A*). A comparison of the different files within the GF system showed that the number of rotations required to break the GF1 was significantly higher than that required for the GF2 and GF3 ($P < .01$ and $P < .001$, respectively). There was no significant difference between GF2 and GF3.

Time to Fracture

A comparison of the different file systems showed a significantly longer time to fracture for the GF versus the other systems in all file sizes

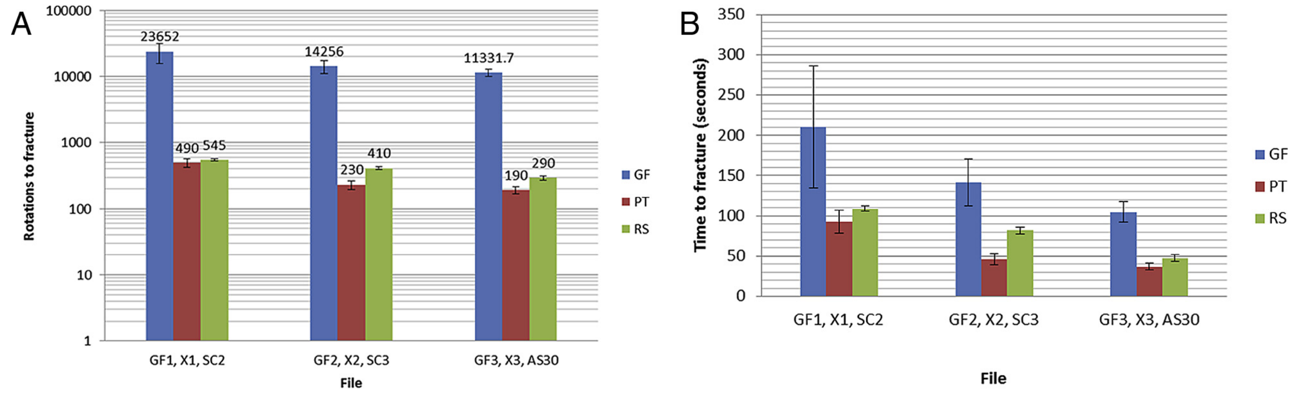

Figure 2. (*A*) Rotations to fracture of the different file types inside 90° simulated canals on a logarithmic scale. (*B*) Time to fracture of the different file types inside 90° simulated canals.

($P < .001$). There was no significant difference between the PT and the RS systems (Fig. 2*B*). A comparison of the different file sizes within the GF system showed that the time to fracture was significantly higher for the GF1 file ($P < .001$). There was no significant difference between the GF2 and GF3 files. The mean time to fracture is shown in Figure 2*B*.

Vertical Force

The analysis showed a highly significant difference between all 3 file sizes of each system and between all 3 systems as well as differences derived from the 4 insertion depths. All the interactions were highly significant ($P < .001$) (Fig. 3).

A comparison of 2 systems, GF and RS and GF and PT, showed the same highly significant differences ($P < .001$). The difference was significant at the .01 level on comparison of RS and PT.

Discussion

The present study shows that the GF system can withstand a significantly higher number of rotational cycles before breaking than both the

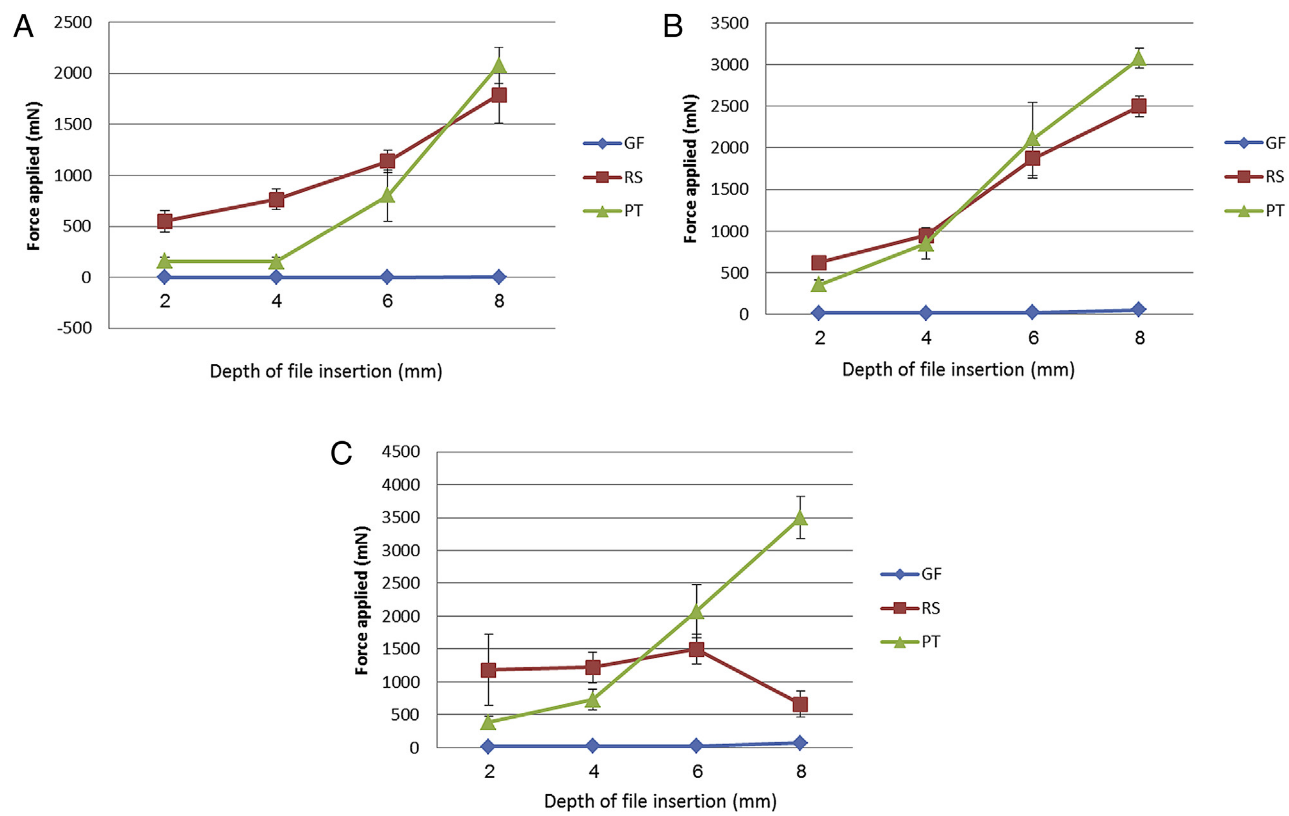

Figure 3. Force applied by the different file types at 2, 4, 6, and 8 mm from the beginning of the curvature in a 60° simulated curved canal. (*A*) GF: GF1, PT: X1, RS: SC2. (*B*) GF: GF2, PT: X2, RS: SC3. (*C*) GF: GF3, PT: X2, RS: SC3.

PT and the RS files. Also, the GF system applies significantly less vertical force on bent canals.

Generally, NiTi files show greater resistance to cyclic fatigue than SS files (3, 11). Although the GF system is made from SS, the number of cycles to fracture was significantly higher than that of the other file systems tested.

In previous studies, cycle to fracture was evaluated. Because of the very high rotational speed of GF it performs the same number of rotations as the other systems in a fraction of the time. Because such a comparison would skew the results greatly, we decided to compare cycles with fracture as well as time to fracture. The mean number of cycles to fracture of the PT and RS files was similar to those previously reported (3, 12). It might be expected that the extremely high rotation speed would cause the GF to fracture much faster, but there was a significant advantage in this parameter as well.

NiTi alloys are more expensive than SS. This and the fact that NiTi files are more complicated to manufacture make the NiTi files significantly more expensive than SS files (13, 14). The GF's low cost enables practitioners to discard them after a single use, thus minimizing the risk of file fracture.

The vertical forces applied to the canal wall can be measured by evaluating the force projected by the file. As the force applied by the file on the canal wall increases, so will the risk of procedural errors (canal transportation, perforations, cracks, ledges, etc). In the present study to assess the vertical force applied by the file on the canal, a new technique was applied. A high-precision digital micrometer was used to precisely control the advance of the file within the canal, and the forces were measured at different points by using an analytical scale.

Greater file stiffness results in greater forces that are applied to the canal walls after insertion of the file beyond the curvature. This in turn may result in alterations of canal anatomy. Files made from NiTi alloy were reported to reduce procedural errors such as apical transportation ledging or stripping, compared with conventional SS files (15). The results of the present study show that the SS GF generated far less force on the canal than the NiTi files. Therefore, it is conceivable to assume that use of the GF in curved canals may result in less damage to the dentin of the root canal wall.

Conclusions

The present study shows that the mechanical properties of the GF system are superior to those of PT and RS. Further investigation is required to assess the clinical meaning of these findings.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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