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In Vitro Comparison of Shaping Abilities of ProTaper and GT Rotary Files

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This study analyzed the abilities of ProTaper and GT Rotary files to shape the curved canals of extracted mandibular molars. Twenty mesial canals with curvatures ranging from 23 to 54 degrees (Weine analysis) were radiographically selected from a group of 58 molars. The specimens, divided into two groups, were instrumented using the two systems according to the manufacturer's guidelines. Using a radiographic platform and a contrast medium, reproducible preinstrumentation and postinstrumentation radiographs were taken. A computer analysis allowed magnification and superimposition of the images to measure the preparation asymmetry and the linear amount of dentin removal at five points along the canals and to detect canal aberrations. Instrument failures, working time, and working length changes were recorded. The dentin removal and the mean asymmetry showed no significant differences between the two systems. Neither aberrations nor significant changes in working length resulted, but two instruments separated in each group. Working time was shorter for ProTaper files ($p < 0.05$).

Canal shaping is a critical aspect of endodontic treatment because it influences the outcome of the subsequent phases of canal irrigation and filling and the success of the treatment itself. Once the canal is prepared, it should have a uniformly tapered funnel shape, increasing in diameter from the end point to the orifice (1); this shape provides enough space for irrigants that are important to complete the canal cleaning and allows the placement of an effective root filling (2).

Canal shaping is relatively easy in straight roots but has always been challenging, demanding a high skill, when performed in curved roots (3). This difference is a result of the stiffness of stainless steel files, which are unable to follow canal curvatures without developing high lateral forces responsible for canal straightening and aberrations (4). With the creation of superelastic nickel-titanium (NiTi) instruments, achieving a correct canal shape, even in curved canals, appears to be more predictable and safe. Several studies demonstrate that, compared with instrumentation by stainless steel files, NiTi mechanical preparations are faster (5–7), more centered in canal lumen (5, 7, 8), rounder (5, 7), and better maintained in their original anatomy (5–7).

Once the value of the NiTi for endodontic applications was established, research was directed toward the study of various systems able to reduce the number of files necessary for the working sequence and, at the same time, to lower the risk of file separation. This trend has led to the introduction to the market of many NiTi instruments that are different in taper and blade design, but to date, no studies are available on ProTaper files (Dentsply-Maillefer), one of the latest NiTi rotary products.

The aim of the present study is to compare the shaping abilities of ProTaper and GT Rotary files (Dentsply-Maillefer) in the instrumentation of curved root canals. ProTaper files introduce a new design with progressively increasing tapers, a convex triangular section, and a modified guiding tip. On the other hand, GT Rotary files feature a U-shaped blade design, a noncutting tip, and different taper and tip sizes.

MATERIALS AND METHODS

Fifty-eight mandibular curved molars extracted for periodontal reasons and stored in physiologic solution were used in this study. An access cavity was opened in all teeth using a round diamond bur (Intensiv212) and an Endo-Z bur (Dentsply-Maillefer) on a high-speed handpiece. Radiographs were taken with a #8 file placed in the mesial canals. Canal curvatures, according to the Weine method (9), were measured on these radiographs, and 20 canals with curvatures ranging from 23 to 54 degrees were chosen. The crowns were shortened so that the teeth had the same working length of 19 mm. The selected specimens were randomly divided into two groups of 10 canals each; the first group was instrumented with ProTaper files, the second with GT Rotary files. Each file was used to enlarge as many as five canals and was replaced if it failed before then. Two sets for each kind of instrument were used.

Preparations were made by two expert operators using an ATR Teknica (Dentsply-Maillefer) endodontic engine. The speeds of rotation and torque were adjusted according to the manufacturer's indications. A chelating agent (Glyde File Prep; Dentsply-Maillefer) was introduced in the pulp chambers, and NaOCl 2.5% was used as a rinsing solution after the use of each instrument.

A radiographic platform was created to standardize the alignment of the teeth, the films, and the radiographic beam. The platform consisted of two plexiglas planes completely interlockable and connected with a Rinn film holder supporting the radiographic cone (EvolutionX 3000, 70 kVp). A piece of calibrated plastic tube was glued to the ring of the film holder to position the radiographic cone correctly. The superior plane had a slot for teeth placement, whereas the inferior plane had a slot for film (Ultra Speed) placement. This system, once assembled, allowed the movement of the teeth for instrumentation and their replacement in the same position.

Before instrumentation, the teeth were placed with the maximum canal curvature plane perpendicular to the radiographic beam and included in a silicon base (Provil; Hereaus-Kultzer) fitting the superior slot of the platform. A contrast medium (Iopamiro 300; Bracco) mixed together with amalgam powder (Valiant; Caulk De Trey Dentsply) was injected in canals using a syringe (Sherwood, 6 cc) and a 28-gauge needle (Endoneedle VMK, 25 mm). For each tooth, a radiograph (exposure time, 1 s) was taken before and after instrumentation.

Radiographs were developed for 16 s (Dental X-Ray Developer) and fixed for 3 min (Dental X-Ray Fixer). The canal outlines were easily detectable on the radiographs because of the contrast medium.

Canal Preparation

Group 1 was prepared with ProTaper files, a system made up of six instruments. The first, called Shaping X, is 19 mm long, with a D_0 diameter of 0.19 mm; its taper increases from 3.5% at D_0 to 19% at D_9, and from D_{10} to D_{14}, it decreases to a fixed 2%. The second two files are Shaping 1 and Shaping 2; they have lengths of 21 and 25 mm, respectively, and D_0 diameters of 0.17 and 0.25 mm, respectively, and their tapers increase from 2% and 4% at D_0 to 11% and 11.5% at D_{14}, respectively. The last group of three files includes Finishing 1, Finishing 2, and Finishing 3. Their D_0 diameters are 0.20, 0.25, and 0.30 mm, respectively, and their 0.07%, 0.08%, and 0.09% tapers at D_0 decrease along the blade length.

Preparation was performed as follows:

- A gliding path was created feeding a manual file size #10 to the working length.
- Shaping 1 was introduced with a pecking motion into the canal, 3 mm short of the supposed working length.
- Shaping X was fed into the canal with a brushing motion for ⅔ of its blade length.
- The #10 file was used to establish the working length.
- Shaping 1 was used to the working length.
- Shaping 2 was used to the working length.
- Finishing 1 was used to the working length for one second, and the canal was then gauged with a #20 file. If it fit closely at the apex, the preparation was concluded.
- When the #20 file did not fit correctly at the apex, instrumentation was continued with the Finishing 2 and the canal gauged with a #25 file. Once again, if it fit closely at the apex, instrumentation was concluded; otherwise, it was continued with the Finishing 3.

Group 2 was instrumented with GT Rotary files, a system composed of three groups of instruments. The first four instruments, designed for canal enlargement, have the same tip diameter of 0.20 mm, and 6%, 8%, 10%, and 12% tapers. The second four, used for apical preparation, have a fixed 4% taper and tip diameters of 0.20, 0.25, and 0.30 mm. The last group, designed for canal preflaring, is composed of three instruments with a 12% taper and tip sizes of 0.35, 0.40 and 0.45 mm.

Preparation was performed as follows:

- The first series of four instruments with a fixed tip diameter of 0.20 mm was gently inserted into the canal. The instruments were used in a crown-down approach starting with the 12% taper and then using the smaller ones (10%, 8%, and 6%) as resistance to the progression was felt.
- Apical preparation was finished using 4% taper instruments to the working length in the increasing order of 0.25, 0.30, and 0.35 mm.

Assessment of Canal Instrumentation

Instrumentation time was defined as the amount of time the instruments were used in the canal shaping, excluding time required for changing the instrument and rinsing the canal.

To evaluate the amount of dentin removal and the canal asymmetry, preinstrumentation and postinstrumentation radiographs were used. Films were mounted on frames (24 × 36) and scanned on a slide scanner (Nikon CoolscanIV ED). Using the software Scion Image (Windows version of NIH Image), the images were magnified (10×) and analyzed so that canals could be outlined and superimposed. The reference for perfect superimposition and calibration of the scale of the software for measurements was provided by a file fixed to the superior platform plane and radiographed with all teeth.

The removed dentin was measured at five reference points established on each canal median axis, using a method described by Calberson et al. (10):

- Point 1: the canal orifice (O)
- Point 2: the point halfway from the beginning of the curve to the orifice (HO)
- Point 3: the point where the canal deviates from the long axis of its coronal portion, called the beginning of the curvature (BC)
- Point 4: the point where the long axis of the coronal and apical portions of the canal intersect, called the apex of the curve (AC)
- Point 5: the point where the preparation ends (EP)

The measurements were performed at each of the five points on both the inner and the outer sides of the curvature. All measurements were made perpendicular to the axis of the preinstrumentation canal using the image analysis software (Fig. 1).

The asymmetry of preparation (expressed as an absolute value) was assessed by subtracting the amount of the removed dentin on the inner side from that of the removed dentin on the outer side, in accordance with a method introduced by Nagy CD, et al. (11).

Parameters considered to evaluate working safety were loss of working length, fractured instruments, and canal aberrations.

Variations of working distance were established by subtracting the preoperative from the postoperative length, while the number of separated instruments was recorded during instrumentation.

The presence of canal aberrations such as perforations, tip, elbows and ledges was assessed on the images of superimposed canals.

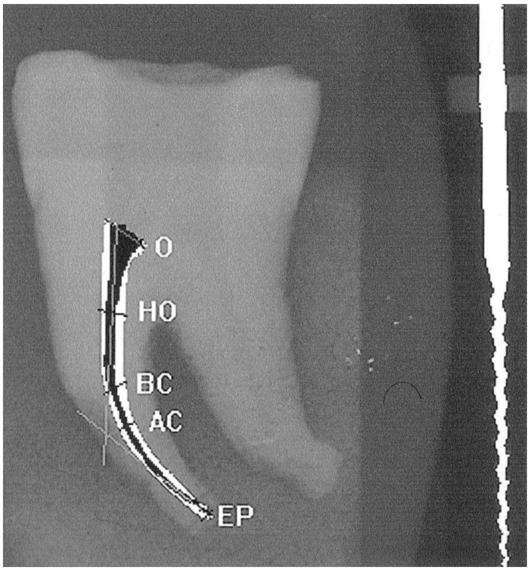

FIG 1. All measurements were made perpendicular to the axis of the preinstrumentation canal using the image analysis software.

TABLE 1. Instrumentation time (s)

GT Rotary	112.1
SD	±57.6
Pro Taper	59.6
SD	±25.8

A tip was an irregularly widened area continous with the apical foramen. An elbow was present where the canal width apical to the elbow, was greater than the width, coronal to that point. A ledge was a deviation from the original curvature where a new canal path was created or was beginning to form.

The Mann-Whitney *U*-test was used to identify any significant difference between the two groups.

RESULTS

Preparation Time

Table 1 shows the mean time required for canal instrumentation. ProTaper files were significantly faster than the GT Rotary file system ($p < 0.05$).

Canal Form

The mean amounts of dentin removal on the outer and on the inner side of the curvature are shown in Table 2. Mean canal widths after instrumentation were quite regular at all the reference points along the canal curvature, and no significant differences were found between the two systems.

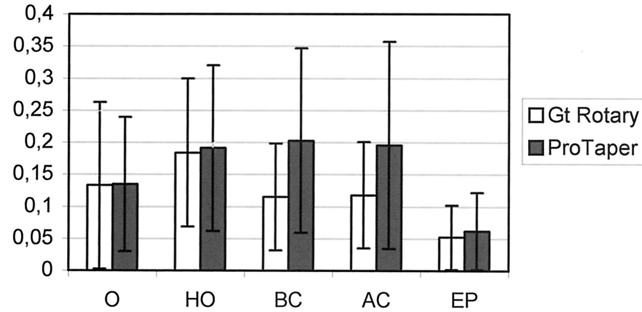

FIG 2. Preparation asymmetry mean values.

Preparation asymmetry mean values are presented in Fig. 2. Canal transportation values were quite low at all the reference points. At the apical level (EP), the preparation was almost perfectly centered in the canal. No significant differences were found between the asymmetry values of the two groups.

Working Safety

Working safety data are reported on Table 3. The numbers of canal aberrations and fractured instruments are shown in Table 3. The mean loss of working length is reported in Table 3. Both groups exhibit a loss of working length, although no significant differences were found.

DISCUSSION

Several methods (12–14) have been developed to evaluate how endodontic instruments maintain the anatomy of curved root canals. The method used in this study allows a relatively easy and repeatable comparison of preinstrumentation and postinstrumentation canals so that it is possible to analyze the amount of dentin removal and the respect of the original anatomy. The greater reliability of studies on extracted teeth, more similar to the clinical conditions than artificial canals made of acrylic resin, should also be considered. The limiting aspect of the method is that the analysis is made in only two dimensions.

Thanks to their features, NiTi endodontic instruments may reduce the difficulty of the instrumentation of curved canals compared with that of stainless steel files. Several systems have been produced with the aim of improving the breaking resistance of the instruments and to simplify and shorten the working sequences.

ProTaper files, one of the latest systems, introduce the multiple taper concept, *i.e.*, variable tapers in the same file are applied to specific areas of the canal, reducing the number of recapitulations necessary to arrive at the working length.

TABLE 2. Dentin removed at the measurement points along the canal (mm)

	Inner canal wall					Outer canal wall				
	O	HO	BC	AC	EP	O	HO	BC	AC	EP
GT Rotary	0.103	0.114	0.072	0.113	0.05	0.156	0.18	0.175	0.098	0.037
SD	±0.1	±0.1	±0.06	±0.09	±0.04	±0.1	±0.1	±0.07	±0.08	±0.01
Pro Taper	0.152	0.197	0.188	0.183	0.065	0.133	0.214	0.253	0.161	0.05
SD	±0.12	±0.09	±0.16	±0.016	±0.05	±0.13	±0.17	±0.19	±0.14	±0.05

TABLE 3. Working safety data

	Working Length	Fractures	Aberrations
GT Rotary	−0.5	2	0
SD	±0.4		
Pro Taper	−0.25	2	0
SD	±0.23		

The aim of this study was to evaluate the shaping abilities of ProTaper files in comparison with those of the well known and studied GT Rotary files, even though it must be noted that this system has been recently supplemented with a new one. The new system is called GT System and has different tip sizes and tapers.

The analysis of the canal diameters after instrumentation reveals, at all the reference points, no differences between the two groups and an even removal of dentin from both the inner and the outer canal walls. Preparations performed by the two instruments are quite centered in the canal, as shown by the low asymmetry values indicating a minimum tendency to transport the root canal curvatures. These findings could be a result of the noncutting tip that guides the blades of the instruments in the canal lumen. Also to be considered is the high flexibility of the NiTi alloy, which generates low restoring forces on the canal walls so that the risk of transportations is decreased.

Previous studies have demonstrated that GT Rotary files maintain canal curvature of 40-degree and 60-degree resin canals, although it was suggested not to exceed size 25 to instrument short, acute curvatures safely (10).

To date, no research is available on ProTaper files, but in this study, they showed a good ability to shape curved canals. The satisfactory maintenance of severely curved canal anatomy by ProTaper files here seems to confirm the results of previous articles on different types of NiTi instruments (15–17).

The working time required by ProTaper files was significantly shorter compared with that of GT Rotary files. This finding can be explained not only by the smaller number of files in the ProTaper system, but also probably by the greater efficiency of ProTaper files. ProTaper files cut almost the same quantity of dentin as GT Rotary files but in less time; this difference could be a result of their more aggressive triangular flute section. Compared with the manual instrumentation times reported in previous articles (5–7), both of these systems allow a notable reduction in working time.

Regarding working safety of the instruments, canal alteration did not occur, confirming again the ability of NiTi instruments to respect canal anatomy.

These data are in accordance with studies on other types of NiTi instruments in which no or very low aberration occurred in the instrumentation of curved canals (10, 15, 17, 18).

Working length showed minimal shortenings in both groups without significant differences. Minimal decrease in working length also resulted in previous articles on Hero 642 and Flexmaster (15, 16, 19), but the authors of these studies doubted the clinical relevance of the findings.

The number of fractures is still a major concern with the use of these instruments because they often occur without any visible deformation, jeopardizing the entire outcome of the endodontic therapy. In this study, two instruments separated in each group. The fractured GT Rotary files were two instruments having a diameter of 0.35 mm, whereas the fractured ProTaper files were a Shaping 1 and a Finishing 2. The failures of the GT Rotary files probably were caused by the attempt to reach the apex with a 0.35-mm instrument in all the teeth of the group, whereas in some cases, it would have been safer to stop the preparation at a diameter of 0.30 mm to reduce the stress of the instruments. The failures of the ProTaper probably are best explained by the fatigue accumulated by the instruments during their repeated use in the curved canals.

It is worth noting that no instruments fractured during the shaping of the first three canals; all fractures occurred during the fourth or fifth shaping. On the basis of these data, one should discard the instrument after a single use if the shaped canal exhibits great, abrupt curvatures (20).

Further studies are encouraged to evaluate better the behavior of the two systems using a three-dimensional analysis.

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References

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am 1974;18:269–96.
2. Musikant BL, Cohen BI, Deutsh AS. Simplified obturation of tapered canal preparations. Compend Contin Educ Dent 1998;19:1152–5.
3. Weine FS, Kelly RF, Lio PJ. The effect of preparation on original canal shape and on apical foramen shape. J Endodon 1975;1:255–65.
4. Roane JB, Sabala CL, Duncanson MG. The balanced force concept for instrumentation of curved canals. J Endodon 1985;11:203–11.
5. Glossen CR, Haller RH, Dove SB, del Rio CE. A comparison of root canal preparations using Ni-Ti hand, Ni-Ti engine-driven, and K-Flex endodontic instruments. J Endodon 1995;21:146–51.
6. Coleman CL, Svec TA. Analysis of NiTi versus stainless steel instrumentation in resin simulated canals. J Endodon 1997;23:232–5.
7. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand file instrumentation using computed tomography. J Endodon 1996;22:369–75.
8. Esposito PT, Cunningham CJ. A comparison of canal preparation with nickel-titanium and stainless steel instruments. J Endodon 1995;21:173–6.
9. Weine FS. Endodontic therapy. 3rd ed. St Louis: CV Mosby Co, 1982: 156–340.
10. Calberson FLG, Deroose CAJ, Hommez GMG, Raes H, De Moor RJ. Shaping ability of GT Rotary files in simulated resin root canals. Int Endod J 2002;35:607–14.
11. Nagy CD, Bartha K, Bernath M, Verdes E, Szabo J. The effect of root canal morphology on canal shape following instrumentation using different techniques. Int Endod J 1997;30:133–40.
12. Abou-Rass M, Jasrab RJ. The use of rotary instruments as auxiliary aids to root canal preparation of molars. J Endodon 1982;8:78–82.
13. Bramante CM, Berbert A, Borges RP. A methodology for evaluation of root canal instrumentation. J Endodon 1987;13:479–89.
14. Tachibana H, Matsumoto K. Applicability of X-ray computerized tomography in endodontics. Endod Dent Traumatol 1990;6:16–20.
15. Schafer E, Lohman D. Efficiency of rotary nickel-titanium Flex-Master instruments compared with stainless steel hand K-Flexofile, part 1: shaping ability in simulated curved canals. Int Endod J 2002;35:505–13.
16. Kum KY, Spanberg L, Cha BY. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. J Endodon 2000; 26:719–23.
17. Thompson SA, Dummer PMH. Shaping ability of Hero 642 rotary nickel-titanium instruments in simulated root canals: part 2. Int Endod J 2000;33:255–61.
18. Versumer J, Husmann M, Shafers F. A comparative study of root canal preparation using ProFile .04 and Lightspeed rotary NiTi instruments. Int Endod J 2002;35:37–46.
19. Thompson SA, Dummer PMH. Shaping ability of Hero 642 rotary nickel-titanium instruments in simulated root canals: part 1. Int Endod J 2000;33:248–54.
20. Pruett JP, Clement DJ, Carnes DL. Cyclic fatigue testing of nickel titanium endodontic instruments. J Endodon 1997;23:77–85.