ORIGINAL ARTICLE

Endodontic Shaping Performance Using Nickel–Titanium Hand and Motor ProTaper Systems by Novice Dental Students

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Background/Purpose: Preparing a continuous tapering conical shape and maintaining the original shape of a canal are obligatory in root canal preparation. The purpose of this study was to compare the shaping performance in simulated curved canal resin blocks of the same novice dental students using hand-prepared and engine-driven nickel–titanium (NiTi) rotary ProTaper instruments in an endodontic laboratory class.
Methods: Twenty-three fourth-year dental students attending China Medical University Dental School prepared 46 simulated curved canals in resin blocks with two types of NiTi rotary systems: hand and motor ProTaper files. Composite images were prepared for estimation. Material removed, canal width and canal deviation were measured at five levels in the apical 4 mm of the simulated curved canals using AutoCAD 2004 software. Data were analyzed using Wilcoxon's rank-sum test.
Results: The hand ProTaper group cut significantly wider than the motor rotary ProTaper group in the outer wall, except for the apical 0 mm point. The total canal width was cut significantly larger in the hand group than in the motor group. There was no significant difference between the two groups in centering canal shape, except at the 3 mm level.
Conclusion: These findings show that the novice students prepared the simulated curved canal that deviated more outwardly from apical 1 mm to 4 mm using the hand ProTaper. The ability to maintain the original curvature was better in the motor rotary ProTaper group than in the hand ProTaper group. Undergraduate students, if following the preparation sequence carefully, could successfully perform canal shaping by motor ProTaper files and achieve better root canal geometry than by using hand ProTaper files within the same teaching and practicing sessions. [*J Formos Med Assoc* 2008;107(5):381–388]

Key Words: canal deviations, endodontic curriculum, endodontic shaping performance, NiTi hand and motor ProTaper, simulated curved canals

The gold standard of root canal shaping is to prepare a continuous tapering conical shape[1] and to create a minimum taper of 6% at the apical third for true 3D obturation of the root canal system.[2] Nickel–titanium (NiTi) was first introduced to endodontics in 1988.[3] It is widely accepted that rotary NiTi instruments have revolutionized endodontic techniques, with consistent canal shapes, good centering, less debris extrusion and faster preparation time.[4] A major advantage of NiTi alloy is its ability to retain flexibility with increased taper. A root canal prepared to a taper of 8–10% is the ideal shape for optimal irrigation and cleaning with sodium hypochlorite to render it aseptic, suitable for obturation.[5,6] Formerly, canal cleaning and shaping was achieved by stainless steel

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hand instrumentation techniques; now motor rotary instrumentation is commonly taught in many dental schools.[7] The NiTi rotary system is widely used, but new learners are still afraid of the rotary speed, possible instrument separation, and the screwed-in effect in the root canals during preparation procedures. This may be the reason for the lower usage rate by general dentists in Taiwan and other countries.[8] Hand NiTi instruments may be an appropriate introduction to the motor rotary NiTi system for beginners, as the cutting and shaping speed can be controlled by the operators and this gives more confidence in canal preparation.

Hand-prepared and engine-driven ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) NiTi instruments possess the same design features, multiple and progressive tapers (2–19%), triangular convex cross section with sharp cutting edges, and a variable helical angle and non-cutting tip. Root canal instruments of this cross-sectional design claim to cut dentine more effectively.[2,9] Shaping file no. 1 (S1) should be used on the coronal third of the canal, whereas shaping file no. 2 (S2) is designed to prepare the middle third of the root canal. The finishing files (F1, F2, F3) progressively expand the shape in the middle third and prepare the apical third of the root canal.[10] The F1 file has a size 20 at the tip of the instrument, the F2 file tip is equal to size 25 and the F3 file is 0.30 mm in diameter at the tip.

Studies using the NiTi rotary ProTaper have been reported.[11–13] We wanted to evaluate the performance of undergraduate students in the hand and motor ProTaper techniques, and whether use of the NiTi rotary instrument should be taught at the beginning of the cleaning and shaping endodontic curriculum in dental schools.[14] Research dealing with NiTi rotary instrumentation performance in dental students has been discussed.[15–18] However, studies evaluating the differences in preparation of hand-prepared and engine-driven ProTaper rotary NiTi systems in dental schools throughout the world remain few.

The purposes of this study were to evaluate the differences in the performance of canal shaping and apical deviation for new endodontic learners using hand and motor rotary ProTaper instrumentation techniques, and to justify teaching NiTi rotary instrumentation at the beginning of the endodontic laboratory curriculum.

Methods

Specimens and instruments

One hundred and thirty-eight simulated curved canal resin blocks (Endo Training-Bloc, 0.02 Taper; Dentsply Maillefer) were divided into two groups with 69 canals each. The degree of curvature was 40° according to the Schneider method,[19] and the average working length was 17 mm from the canal orifice. The diameter and taper of all simulated canals were equivalent to an ISO standard size 15 root canal instrument. Prior to instrumentation, a fissure burr drilled two parallel grooves perpendicular to the long axis of the canal,[17] and a piece of 5 mm scale paper was glued to the face of each block as a reference for superimposition and measurements (Figure 1). Four types of hand and motor ProTaper files (S1, S2, F1, F2) were used in this study.

Operators and preparation of simulated resin canals

Twenty-three fourth-year dental students attending China Medical University Dental School (Taiwan) were included in this study. The dental students had not taken the endodontic curriculum, and so they had no experience in canal preparation using any kind of stainless steel hand or NiTi rotary

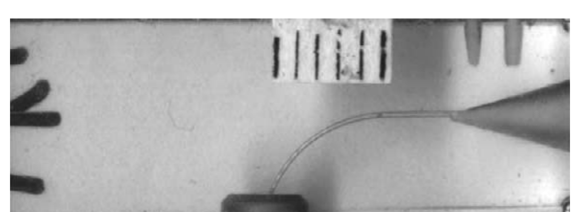

Figure 1. A fissure burr drilled two grooves perpendicular to the long axis of the canal and a piece of 5-mm scale paper was glued on the face of each block as a reference for superimposing and calculating.

instrumentation. Each student followed a 4-hour theoretical lecture and 4-hour laboratory course in two types of ProTaper instrumentation techniques for 2 weeks. Each student practiced on two resin blocks before testing on one block, which was assessed. The 46 resin blocks (23 pairs) in the assessment exercise were collected for evaluation.

Two new sets of motor and hand rotary ProTaper (S1, S2, F1, F2) instruments were used. Each resin block was immobilized by a stabilizer (MINI VISE SG-600; SOGO, Taiwan) (Figure 2). During preparation, each ProTaper file was coated with Glyde (Dentsply Maillefer) to act as a lubricant. Copious irrigation with 5 mL water was performed before and after the use of each file; a size 10 K file was used for patency check after each step. Files were routinely cleaned with alcohol gauze to remove resin debris.

Motor ProTaper group

The ProTaper files ran at a constant rotation of 300 rpm using a 16:1 reduction hand piece (W&H 975; Dental Work, Burmoos, Austria) and torque controlled motor (ATR; Tecnika, Pistoia, Italy). The instrumentation sequence was as follows:

1. A size 10-K file (0.02 taper) (Dentsply Maillefer) was used as the patency file.
2. A 15-K file (0.02 taper) was used as a glide path file for the root canal.
3. An S1 file opened the coronal by one- to two-thirds until resistance was felt, and then the painting and brushing method was used along the canal.
4. A size 15-K file (0.02 taper) was prepared to the full working length.
5. S1, S2, F1 and F2 files prepared the canal to the working length.

Every effort was made to ensure that the finishing files were taken to working length only once, and remained at that length for no more than 1 second.

Figure 2. A stabilizer immobilized the simulated curved canal resin block.

Hand ProTaper group

The instrumentation sequence was as follows:

1. Explore canal with size 10-K and 15-K files (0.02 taper).
2. Flare coronal with S1 until the depth of the 15-K file was reached.
3. S1, S2, F1 and F2 files prepared the canal to the working length.

The canal was lightly engaged by gently rotating the handle clockwise until the file was just snug, and the file was disengaged by rotating the handle counterclockwise whilst simultaneously withdrawing the file. The hand ProTaper shaping files were worked by hand in clockwise and counterclockwise rotation several times. The finishing ProTaper file F2 was rotated clockwise and counterclockwise down to the working length, rotated clockwise for one turn at the working length, and was then withdrawn.

The final apical size of the canal was completed by a ProTaper size F2 file (0.25 mm in diameter, 0.08 taper) in both groups.

Assessment of canal deviations

Instrument failure and ledge formation, resin thickness removed, total canal width, and centering canal shape were recorded in the two groups. Pre- and post-instrumentation resin blocks were scanned and stored as JPEG files. AutoCAD 2004 software (AutoDesk, San Rafel, CA, USA) and a BenQ Scanner 4300 U (BenQ, Taiwan) were used to evaluate the deviation of the canals. We measured the difference in the inner and outer walls of pre- and post-operated canals by superimposing images. Data from the apical 4 mm were collected every 1 mm. An experienced endodontic specialist assessed the canal deviation.

Statistical analysis

Resin thickness removed from the inner and outer walls of the canal, total canal width, and centering canal shape of both prepared canals by two methods were analyzed. The mean value for deviation of the canal was measured at the apex (0) and at distances of 1, 2, 3 and 4 mm from the apex. The data were compared by box-plots and Wilcoxon's rank-sum test separately at 10 measuring points of the outer and inner walls of the simulated canals.

Results

Instrument failure and ledge formation

Among 46 simulated canal preparations, none of the motor ProTaper files separated (0/23), but one hand ProTaper F2 file (1/23) separated at the apical 4 mm of the canal. There was one ledge formation at the beginning of the curve of the canal and one outer wall transportation at the apical 2 mm in the motor ProTaper group. The results for statistical analysis were based on the remaining 40 resin blocks (20 paired canals).

Resin thickness removed

The resin thickness removed from the inner wall was much greater in the hand ProTaper group than the motor ProTaper group for five measured points, and there was a significant difference ($p = 0.0400$) at the level of 4 mm (Table, Figures 3A and 3B). The resin thickness removed from the outer wall by the hand ProTaper group was significantly greater than that removed by the motor ProTaper group at four measured points, except at the 0 mm level (Table, Figures 3C and 3D).

Total canal width and centering canal shape

The total canal width prepared by the hand ProTaper group was statistically wider than the motor ProTaper group at four measured points, except at the 0 mm level in the outer wall (Table, Figures 4A and 4B). There was no significant difference between the two groups in centering canal shape except at the 3 mm level ($p = 0.0296$). A greater resin thickness was removed from the inner

Table. Resin thickness removed on the inner and outer walls, total canal width, and centering canal shape by motor and hand ProTaper instrumentation according to distance (0, 1, 2, 3, 4 mm)*

Distance (mm)	Inner wall			Outer wall			Total canal width†			Centering canal shape‡		
	Motor (Mean ± SD)	Hand (Mean ± SD)	$p^§$	Motor (Mean ± SD)	Hand (Mean ± SD)	$p^§$	Motor (Mean ± SD)	Hand (Mean ± SD)	$p^§$	Motor (Mean ± SD)	Hand (Mean ± SD)	$p^§$
0	0.000 ± 0.000	0.046 ± 0.083	0.0625	0.219 ± 0.141	0.235 ± 0.142	0.8596	0.219 ± 0.141	0.281 ± 0.164	0.2413	0.219 ± 0.141	0.189 ± 0.165	0.2753
1	0.081 ± 0.091	0.098 ± 0.122	0.5417	0.353 ± 0.090	0.448 ± 0.113	0.0107	0.433 ± 0.110	0.546 ± 0.145	0.0073	0.272 ± 0.143	0.351 ± 0.185	0.2024
2	0.167 ± 0.126	0.174 ± 0.109	0.7562	0.299 ± 0.076	0.393 ± 0.054	0.0006	0.465 ± 0.125	0.568 ± 0.101	0.0042	0.132 ± 0.165	0.219 ± 0.138	0.1429
3	0.282 ± 0.097	0.300 ± 0.072	0.5706	0.208 ± 0.053	0.298 ± 0.040	< 0.0001	0.490 ± 0.084	0.598 ± 0.060	< 0.0001	−0.075 ± 0.132	−0.001 ± 0.099	0.0296
4	0.361 ± 0.074	0.421 ± 0.089	0.0400	0.148 ± 0.072	0.209 ± 0.068	0.0020	0.508 ± 0.080	0.630 ± 0.095	0.0001	−0.213 ± 0.123	−0.212 ± 0.127	0.9563

*Comparisons were performed using Wilcoxon's rank-sum test ($n = 20$); †inner wall + outer wall; ‡outer wall − inner wall; §*p* value from Wilcoxon's rank-sum test.*

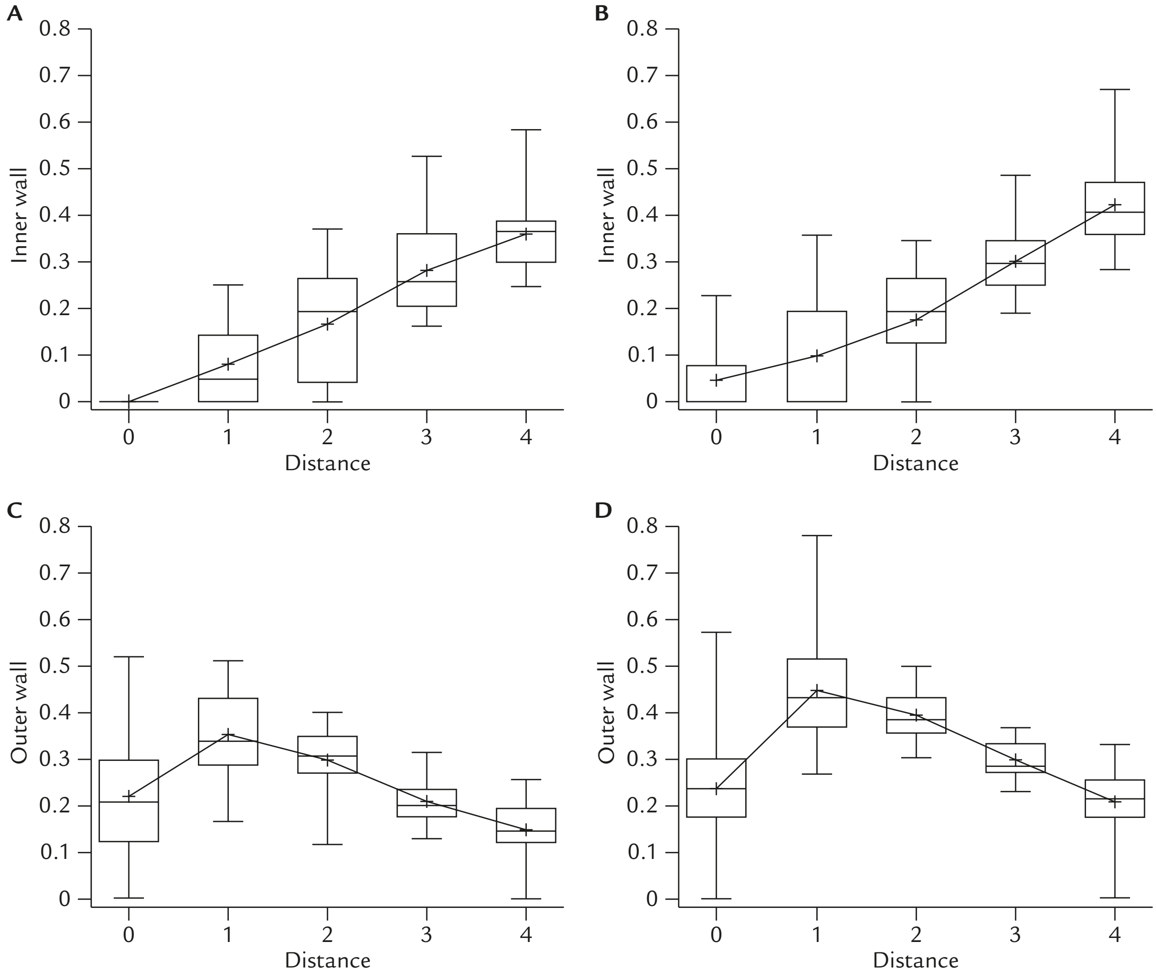

Figure 3. Deviation of inner and outer aspects of the canal wall from the apex to 4 mm is depicted on each X axis. The Y axis shows resin thickness removed (mm). Each box-plot shows the median, upper and lower quartiles, and the mean (marked with "+"). (A) Motor ProTaper inner wall; (B) hand ProTaper inner wall; (C) motor ProTaper outer wall; (D) hand ProTaper outer wall.

wall than from the outer wall at the 3 mm level of the canal in both ProTaper groups (Figures 4C and 4D). The ability to maintain the original curvature was better in the motor rotary ProTaper group than in the hand ProTaper group (Table, Figures 3 and 4).

Discussion

In relation to the total number of 92 hand ProTaper files used, only one (F2) file separated in the hand ProTaper group, giving a fracture rate of 1.09%. In this study, the fracture rate performed by novice dental students in the motor ProTaper group was 0%. The fracture rate of the motor ProTaper group in our study was lower than that in previous studies of expert dentists using the same preparation sequence.[14,15] The cause of instrument fracture in the hand ProTaper group was that the new learners were usually unfamiliar with the clockwise and counterclockwise rotating procedures, and with how much force should be exerted by the hand during file twisting. The canal deviations in this study were localized in the hand ProTaper group. We conclude that canal instrumentation by the hand ProTaper system was a more sensitive technique than the motor rotary ProTaper system among inexperienced students. This result was the same as in previous studies in which stainless steel hand files or hand NiTi rotary files were used in curved canals.[2,5,16,17]

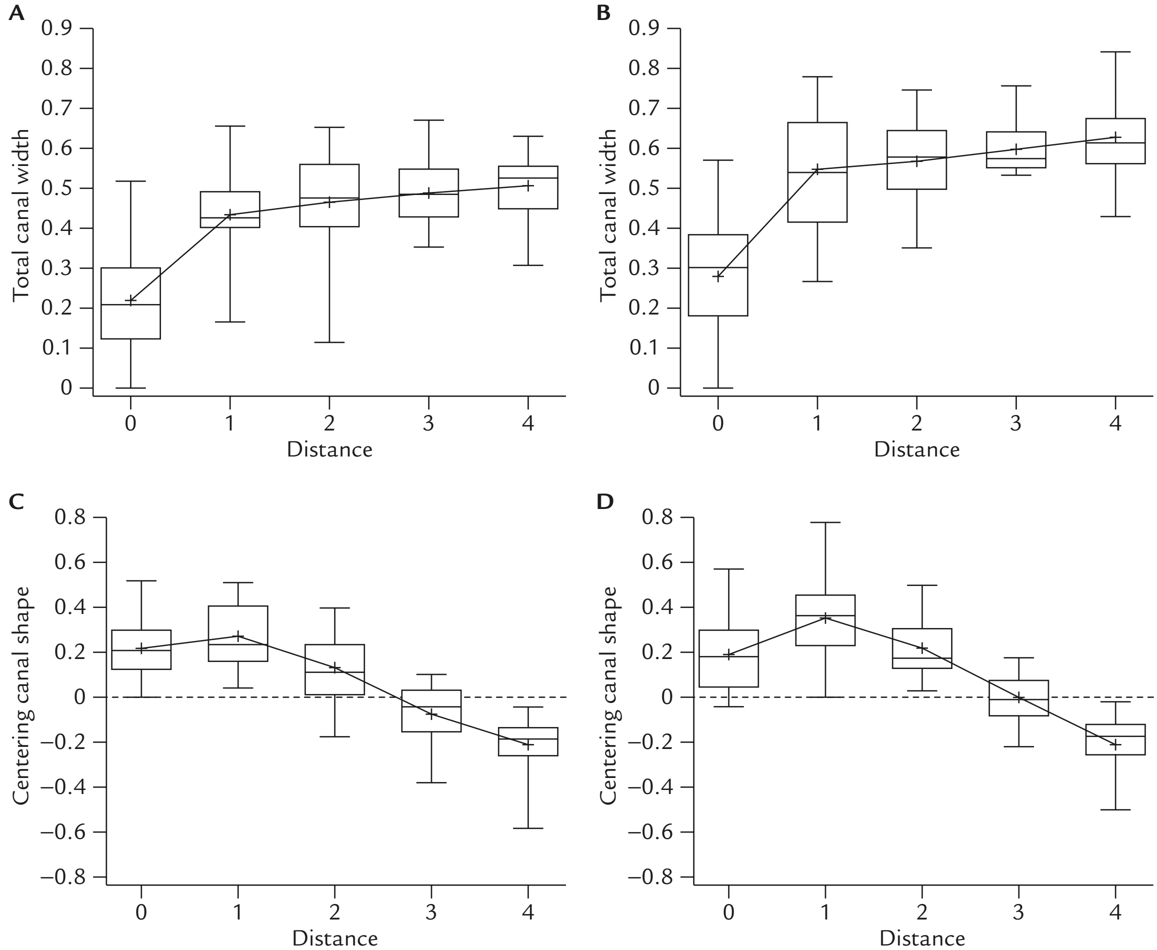

Figure 4. Total canal width and centering canal shape from the apex to 4 mm is depicted on each X axis. The Y axis shows resin thickness removed (mm). Each box-plot shows the median, upper and lower quartiles, and the mean (marked with "+"). (A) Motor ProTaper total canal width; (B) hand ProTaper total canal width; (C) motor ProTaper centering canal shape; (D) hand ProTaper centering canal shape.

The total canal width was cut much wider in the hand ProTaper group, except at the 3 mm level. This might be explained by the uncontrolled force in cleaning and shaping by the hand ProTaper system compared to the torque controlled motor rotary ProTaper system. The definite working length recognition was uncertain for untrained dental students, and the semi-cutting tip of the F2 made the apical 0 and 1 mm point canal cutting show more variety compared to the performances of expert dentists in previous research.[20,21] In centering canal shape, the motor and hand rotary ProTaper instrumentation maintained good canal curvature. This result corresponded with previous research.[16,18,22,23] Compared to the hand ProTaper system, the motor ProTaper system could help the operator to maintain the original canal shape. Accordingly, the hand ProTaper system in simulated curved canals was a more sensitive technique for novice students.

The objective during instrumentation of root canals is to maintain the original canal curvature to produce a continuously tapering and conical form, with the smallest diameter at the endpoint of the preparation.[1] Weine and coworkers observed that every file tends to straighten canals, with the positions of maximum transportation being at the apex, and at 2–4 mm from the apex.[24] Consequently, the present experiment was designed to compare the deviation and transportation at the apical 1–4 mm of the root canal, using two types of ProTaper preparation by novice students. The preparation of transparent resin blocks in simulated curved canals plays an essential role in preclinical dental education, in which evaluation is performed visually by instructors. Simulated canals in transparent resin blocks are used widely for standardized evaluation of the cutting characteristics of endodontic files, and for teaching and training purposes.[25–30] The other reason was that evidence-based performance in clear resin blocks could motivate dental students learning the new NiTi rotary instrumentation technique. After several sessions of practice on clear resin blocks, the dental students can integrate this kind of technique into their endodontic canal shaping practice with confidence.

In conclusion, motor ProTaper instrumentation can help the inexperienced operator to maintain original canal shape more effectively than the hand ProTaper technique can. The learning curve for novice students is shorter using the Motor ProTaper than the hand ProTaper. The motor ProTaper instrumentation technique can be taught to dental students at the beginning of the endodontic curriculum, instead of other hand instrumentation techniques.

Acknowledgments

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