Comparison of apical transportation between ProFile™ and ProTaper™ NiTi rotary instruments

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Abstract

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Aim To use a newly developed radiographic technique to compare apical transportation and loss of working length (WL) between .06 taper ProFile™ Series 29 and ProTaper™ nickel–titanium (NiTi) rotary instruments *in vitro*.

Methodology Mesio-buccal canals of 40 extracted mandibular molars were randomly divided into two groups. Group 1 was instrumented with ProFile™ and group 2 with ProTaper™ instruments according to the manufacturers' directions. A specially constructed radiographic jig with a Schick digital radiographic system (Schick Technologies Inc., Long Island City, NY, USA) was used to take pre- and postoperative radiographs of the samples at predetermined angulations. Using AutoCAD 2000 (Autodesk Inc., San Rafael, CA, USA), the central axes of initial and final instruments were radiographically superimposed to determine the loss of WL and degree of transportation at D_0, D_1, D_2 and D_4 from the WL. Data were analysed using repeated-measures ANOVA.

Results A statistically significant difference in apical transportation was found at the D_4 level between the two groups ($P = 0.05$). There was no statistical significance regarding postinstrumentation change in WL between groups. Spearman's Bivariate Correlation analysis indicated no statistically significant relationship between the radius of curvature and transportation.

Conclusion The results indicate that both ProTaper™ and ProFile™ instruments are comparable to each other in regards to their ability to optimally enlarge root canal with minimal transportation and loss of WL *in vitro*.

Keywords: NiTi rotary instrumentation, ProFile™, ProTaper™, root canal treatment.

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Introduction

The advent of nickel–titanium (NiTi) rotary instrumentation has revolutionized root canal treatment by reducing operator fatigue and time required to finish the preparation and minimize procedural errors associated with root canal instrumentation (Glosson *et al.* 1995, Bryant *et al.* 1998a, Park 2001, Ferraz *et al.* 2003). Since the introduction of these instruments, a number of NiTi rotary systems have been introduced in the market. These systems essentially differ from one another in the design of the cutting blades and taper of their files. Much of the success of ProFile™ instruments (Dentsply Tulsa Dental, Tulsa, OK, USA) has been attributed to its U-file design (Bryant *et al.* 1998a, Ottosen *et al.* 1999, Kum *et al.* 2000, Versumer *et al.* 2002). In this design, the cutting edges are supported by radial lands, which are believed to keep the instruments centred in the root canal, leading to minimal transportation and other procedural accidents. A number of other instruments systems, i.e. Lightspeed™ (Lightspeed Inc., San Antonio, TX, USA) and Quantec™ (SybronEndo, West Collins Orange, CA,

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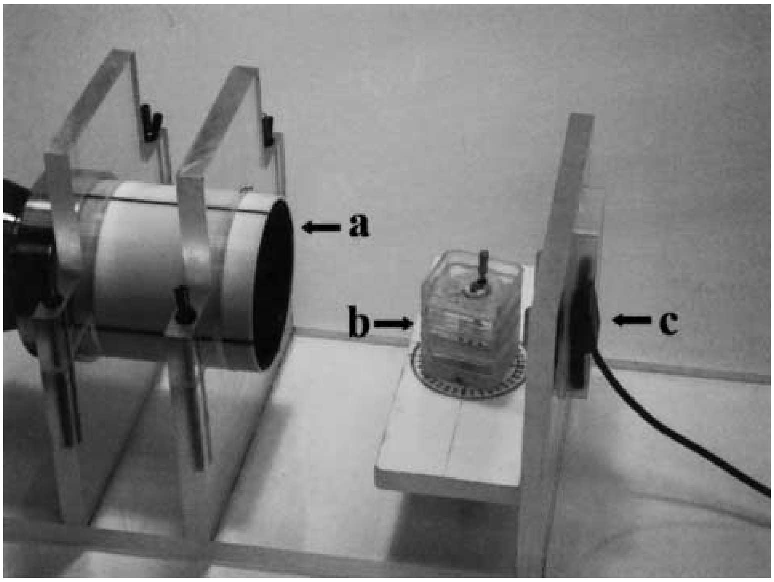

Figure 1 Plexiglas jig holding X-ray tube head (a) at a fixed distance from turntable containing the specimen (b) and digital radiographic sensor (c).

USA) also utilize the concept of radial lands into their design as a safety measure against root canal transportation and instrument breakage. Recently, the manufacturers have departed from this traditional design by introducing instruments whose cutting edges do not have radial lands and at the same time display comparatively more positive rake angles, e.g. ProTaper™ (Dentsply Tulsa Dental). A unique feature of ProTaper™ is said to be its convex triangular cross-section, which is claimed to reduce the contact area between the file and dentine. Nevertheless, this feature also predisposes the canal to greater transportation because of which the manufacturer cautions against taking these instruments to length more than one time, and for more than 1 s (ProTaper, directions for use: Dentsply Tulsa Dental).

A number of methods have been used for assessing changes in root canal configuration after instrumentation. The high-resolution computed tomographic technique is promising but expensive and time consuming (Peters *et al.* 2001). Bramante's technique is associated with difficulties resulting from reassembling cross-sectioned teeth (Bramante *et al.* 1987). In the double radiographic superimposition method, radiographs taken before and after root canal preparation provide means for two-dimensional study of the longitudinal shape of the root canal. However, the technique utilizes buccal and proximal views for evaluation of apical transportation, even though roots do not always display their maximum curvatures in the mesio-distal or bucco-lingual planes (Backman *et al.* 1992).

The Maggiore's technique (Maggiore 1994) used in this study can truly identify the plane of maximum curvature of the canal and set it perpendicular to the X-ray beam. A preliminary analysis proposes to radiographically identify the plane of the curvature of the canal and set it perpendicular to the X-ray beam; the projection of the canal curvature and the real curvature will coincide, allowing for an exact evaluation of angle and radius of the curvature. Thus, the purpose of this study is to use the Maggiore's technique for comparing apical transportation and loss of working length (WL) between ProFile™ and ProTaper™ instruments.

Materials and methods

A standard Plexiglas jig was designed as shown in Fig. 1 and described in detail in an earlier publication (Iqbal *et al.* 2003). A turntable consisted of three clear plastic boxes (Store-it, Nicole™, Mt. Laurel, NJ, USA), which were snapped on top of each other. On the upper most box, the extracted teeth were secured with the help of cold-cured acrylic. The degree of rotation of turntable was measured with the help of a protractor that was glued to the platform immediately below the turntable (Fig. 1). The sensor of the digital radiographic unit was secured to the Plexiglas wall located behind

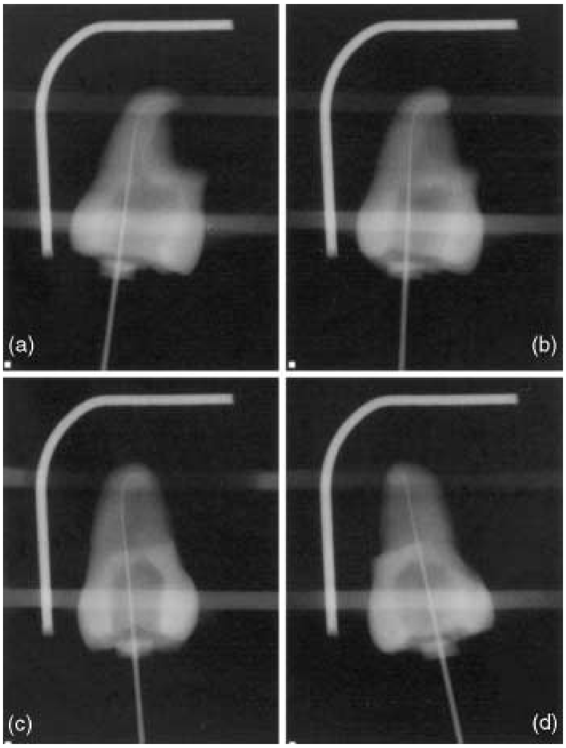

Figure 2 Illustrates the method used for determining the plane of maximum curvature of the root canal with a #15 K-file in place. In the initial radiograph (a), the file exhibits a certain degree of curvature. In radiographs (b,c), the specimen is incrementally rotated to reduce the curvature until the image of the file appears as a straight line (d).

the turntable. Two segments of orthodontic wire, square in cross-section, were set perpendicular to each other and glued to the Plexiglas wall facing the digital sensor. The projected images of these wires on the digital radiograph simulated a Cartesian system that was used for superimposing the pre- and postinstrumentation radiographs.

Determination of the maximum curvature of the canal

Forty extracted mandibular molars with varying degrees of root curvatures were selected for this study. The teeth were accessed with a no. 4 round bur in a water-cooled, high-speed handpiece, and the mesiobuccal canal was preflared coronally with Gates-Glidden burs 4, 3 and 2. The WL was determined by subtracting 1 mm from the length at which the file tip extruded apically when viewed under the microscope.

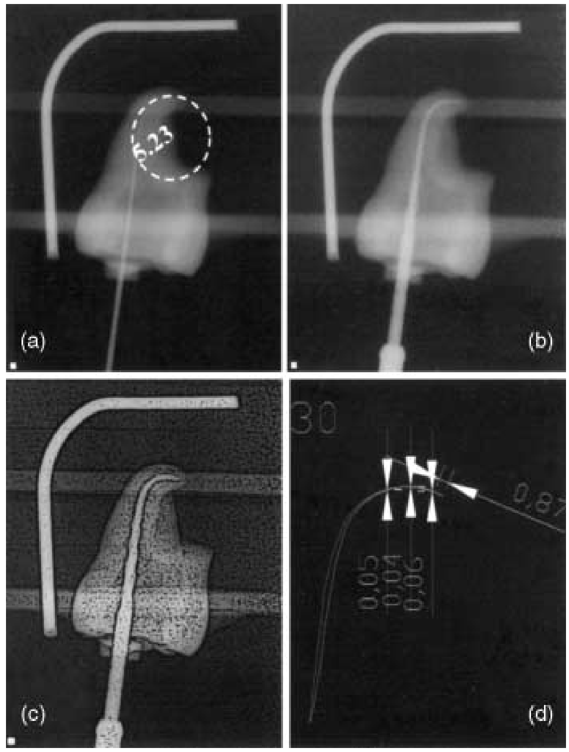

Figure 3 The radiograph (a) identifies the plane exhibiting maximum curvature of canal by rotating the specimen 90° from the position at which the image of the file appeared as a straight line. AutoCAD 2000 was used to determine the radius of curvature. The postinstrumentation radiograph (b) is taken from exactly the same angle as that for the initial radiograph. ADOBE PHOTOSHOP was used to posterize the edges of the final instrumentation radiograph (c). The central axes of pre- and postinstrumentation radiographs are superimposed, and distances between two axes are determined at 0, 1, 2 and 4 mm from the WL (d).

Apical preparation was then performed using stainless steel .02 taper K-files to the WL.

A size 15 K-file was placed in the root canal and a series of radiographs were taken, each time incrementally rotating the turntable until the file in the root canal appeared straight on the radiograph (Fig. 2). The box was then rotated 90° to reveal the maximum curvature of the root canal and a preoperative radiograph of the tooth was obtained (Fig. 3a). The degree at which the final radiograph was taken was noted, and all subsequent radiographs of the sample were taken at the same setting. Canals with double curvatures were not included in the study as maximum curvature in these cases exists in two separate planes.

The radius of curvature of the central axis of the K-file was calculated by using AutoCAD 2000 (Autodesk Inc., San Rafael, CA, USA; Fig. 3a) and teeth were accordingly stratified into two groups in such a manner that the average curvature of root canals in each of the groups was as close to each other as possible. In both the groups, five canals were instrumented with one set of instruments. All canals were irrigated with 10 mL of 2.5% NaOCl between each instrument and kept flooded with irrigant during instrumentation.

Group 1 was instrumented with ProFile™ .06 Series 29 (Dentsply Tulsa) according to the manufacturer's direction. A size 6 ProFile™ was introduced into the canal at 300 r.p.m. in a high torque electrical motor. The instrument was withdrawn when resistance was felt and followed by sizes 5, 4, 3 and 2 ProFiles used sequentially until resistance was met and withdrawn. The cycle was repeated until a size 6 ProFile™ (Green) reached the WL.

Group 2 was instrumented with the help of ProTaper™ instruments according to the manufacturer's direction. The root canal that had already been enlarged to a size 15 K-file was progressively instrumented with ProTaper™ instruments. S1 was taken into the canal just short of the depth at which the hand file was taken previously. Then, shaping the 'SX' instrument was used to move the coronal aspect of the canal away from furcal danger and to improve radicular access. This step was continued with the SX until about two-thirds of the overall lengths of the cutting blades were below the orifice. This was followed by using S1 and then S2 to length. The finishing of the canals was performed until F3 reached the full WL. Maximum effort was made to take the files to length only one time, and for no more than 1 s.

The instrumented teeth were repositioned on the radiographic jig at the previously established degree of rotation and a postoperative radiograph was taken with a size 6 (Green), .06 ProFile™ or F3 ProTaper™ at the WL (Fig. 3b).

Software for analysis

The digital radiographs were downloaded in Targa format from the Schick digital radiographic system and imported into ADOBE PHOTOSHOP (Adobe Systems Inc., San Jose, CA, USA). The images were first passed through artistic filters to posterize the edges for better contrast (Fig. 3c). The images were then transferred to AutoCAD 2000 to draw the central axis of the K-file.

The postinstrumentation radiograph of the tooth was processed in a similar manner as the preoperative radiograph. The reference lines' outlining the Cartesian system was used to superimpose the central axis of files in the pre- and postoperative radiographs (Fig. 3d). AutoCAD was used to measure the distance between these two central axes at 0, 1, 2 and 4 mm from the WL. Any loss of the WL between the initial and final files was also calculated. Mean and SDs were obtained for each group and repeated-measures ANOVA was performed to find any significant differences between the groups. All statistical analyses were performed on a Personal Computer using SPSS 10.0 (SPSS Inc., Chicago, IL, USA).

Results

One tooth in group 1 was lost because of a separated size 5 ProFile™ instrument. The statistical analysis was performed on the remaining 39 teeth. Means and SDs of apical transportation are depicted in Table 1. The transportation at the 0-mm level could not be measured in every sample because of loss of WL. Statistically significant difference ($P = 0.05$) in apical transportation between the groups was found only at the D_4 level. Furthermore, there was no significant difference

Table 1 Means and SDs of transportation (mm) at different apical levels

	Apical level			
Group	D_0	D_1	D_2	D_4
ProFile™				
Mean ± SD	0.22 ± 0.13	0.16 ± 0.12	0.16 ± 0.13	0.24 ± 0.21
n	8	19	19	19
ProTaper™				
Mean ± SD	0.12 ± 0.06	0.10 ± 0.09	0.11 ± 0.10	0.11 ± 0.08
n	5	20	20	20
Total				
Mean ± SD	0.18 ± 0.12	0.13 ± 0.11	0.13 ± 0.12	0.17 ± 0.17
n	13	39	39	39

SD, standard deviation; n = sample size.

Table 2 Loss of WL (mm) in two groups

Group	*n*	Mean ± SD
ProFile™	19	0.31 ± 0.28
ProTaper™	20	0.41 ± 0.28
Total	39	0.36 ± 0.28

SD, standard deviation; *n* = sample size.

Table 3 ANOVA between means (mm) of radii of curvature between Profile™ and ProTaper™ groups

Group	*n*	Mean ± SD	*F*	*P*-value
ProFile™	20	19.18 ± 16.2	0.049	0.953
ProTaper™	20	18.93 ± 14.68		

SD, standard deviation; *n*, sample size.

regarding postinstrumentation change in WL between groups (Table 2). Spearman Bivariate Correlation analysis indicated no statistically significant relationship between the radius of curvature and transportation. ANOVA showed no statistically significant differences between the radius of curvatures of samples between the two groups (Table 3).

Discussion

The study demonstrated that two different mechanical designs of NiTi rotary instruments produced similar results with minimal transportation and loss of WL. Although the degree of transportation exhibited by ProTaper™ instruments was generally lower than that exhibited by ProFile™ instruments, nevertheless, no statistically significant differences were observed except at the D_4 level. The clinical significance of greater transportation at D_4 level by the ProFile™ instruments is not known and probably minimal. At the critically important levels, 1–2 mm from the WL, both the instruments performed equally well. The amount of apical transportation found in this study was minimal and the results correspond well with other studies conducted with NiTi instruments (Bryant *et al.* 1998b, Kum *et al.* 2000,Versumer *et al.* 2002). The greater transportation exhibited by ProFiles™, although not statistically significant, could be because of the fact that in the ProFile™ group, the canals were enlarged apically to size 6 (ISO size 0.360) compared to the ProTaper™ group in which the canals were enlarged apically to a size F3 (ISO size 0.30). However, the finding that apical transportation occurred, although minimal, confirms the need to follow manufacturers' recommendations for use, with NiTi instruments. The design features of instruments such as NiTi metal, noncutting tip, radial lands and the use of a high-torque, constant-speed rotary handpiece have been traditionally cited to explain this outcome. Although the presence of generous radial lands is a hallmark of ProFile™ instruments, this feature is almost nonexistent in ProTaper™ files. The results of this study have shown that the ability of the files to remain centred in root canal may not entirely rest upon the U-file design or presence of generous radial lands. In addition, the variable taper design of the ProTaper™ instrument also dampens the 'screw in' effect of the rotary instruments. Thus, a simpler convex triangular design, as exhibited by ProTaper™ instruments, is capable of performing equal to or slightly better than the more complex U-file design. Some of the other factors that may have contributed to minimal transportation in this study could have been the preliminary enlargement of canals to a size 15 K-file and use of Gates-Glidden drills. The data for transportation for some of the samples at D_0 was not available because of loss of WL (Table 1). Nevertheless this finding points towards the degree of precision with which measurements can be obtained when using AutoCAD.

During the course of this study, only one instrument, size 5 ProFile, separated in group 1 at the apical third level, therefore no conclusions can be drawn regarding propensity of one file system to fracture more than the other system. Despite the fact that some of the curvatures encountered in the study were pronounced (Fig. 3), the incidence of file separation was low. A probable reason for this finding could be that all root canals with double curvatures were excluded. In clinical situations, enlarging extremely curved canals with NiTi rotary instruments is not advisable because it may lead to file separation (Bryant *et al.* 1998a, Szep *et al.* 2001).

Conclusion

The results of this study indicate that ProTaper™ files are comparable to ProFile™ .06 Series 29 files as far as apical transportation and loss of WL are concerned.

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