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RESEARCH ARTICLE

Deviation of Root Canal Curvature Using Three Types of Rotary Instruments: An In Vitro Study

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ABSTRACT

One of the essential requirements for a successful endodontic treatment is efficient cleaning and shaping. Since its introduction, the nickel-titanium rotary system has gained popularity due to its elasticity and suppleness in the creation of curved root canals. To assess the deviation in root canal curvature in severely curved root canals following three different rotary file system preparations. Thirty-six human permanent mandibular first molars were chosen and stored in regular saline after being newly extracted with the curve mesial root. To standardize length at 13 mm, the mesial roots were separated from the tooth and the crown was removed. The three groups of teeth were A, B, and C. Groups A, B, and C were equipped with rotary variable taper instruments, reciprocating variable taper instruments, and rotary constant taper control memory instruments, respectively, in their mesio buccal canals. The instruments were never pressed apically; instead, they were employed in the canal with a constant, gentle passive movement. With frequent and copious irrigation using 5.25% sodium hypochlorite solution and 17% ethylene diamine tetra acetic acid, all canals were shaped and cleansed. To assess the curvature deviation, periapical radiographs were taken both before and after preparation. By using the Schneider method to measure the pre- and post-instrument canal curvatures, the deviation was found. The Wilcoxon test was employed for numerous pairwise comparisons across distinct groups, and the Kruskal-Wallis test was used to conduct statistical analysis among three groups. The p-value of less than 0.05 was deemed statistically significant. Compared to groups A and B, group C had the least variation of canal curvature. The current study concludes that a 4% rotating constant taper control memory instrument works better than a rotary variable taper instrument or a reciprocating variable taper instrument for shaping a curved canal.

Keywords: Curve canal, Deviation of Root canal Curvature, Rotary Instrument, RVG.

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1. Introduction

The crucial stage of endodontic therapy is cleaning and shaping. It affects the treatment's overall effectiveness [1]. The architecture of the root canal is not always as straight; there are several twists throughout its length [2] The root canal curvature is classified as follows: straight, less than 5°; moderate, 10°–20°; and severe, 25°–70° [3]. Canal curvature can be determined using several techniques, including Schneider's approach, Lutein method, Cunningham's method, Weine's method, and the Cone-beam computed tomography (CBCT) method. The periapical radiograph serves as the foundation for the Schneider, Weine, Lutein, Cunningham, and Senia methods. Schneider put up a strategy for calculating curvature using the angle formed by two straight lines. The first line crosses the long axis of the root canal parallel to it, while the second line travels through the apical foramen and joins the first line at the beginning of the curvature [4].

For a clinician, biomechanical preparation of the curved root canals becomes quite challenging. The most significant risk factor for procedural errors such as zipping, ledging, and transporting is thought to be the canal's curvature [5], [6]. In the past, root canal shaping was done with stainless steel devices; however, these instruments are inflexible and don't work well in narrow or curved canals.

The introduction of nickel-titanium (Ni-Ti) instruments addresses the shortcomings of stainless-steel devices [7]. The Ni-Ti device has significantly altered the process of preparing the canal and reduced procedural mistakes, particularly in the curved canal's apical region [8]. The Ni-Ti instrument has exceptional mechanical qualities, such as superelasticity and form memory.

Another crucial metal characteristic that keeps the file in its original form even after instrumenting a curved channel is shape memory. When instrumenting a curved canal, the file's propensity to revert to its original shape might cause root perforations, canal transportation, and ledging [9].

New designs with distinct kinematics have been introduced for technologically advanced rotary nickel-titanium (Ni-Ti) instruments, including continuous rotary variable taper, reciprocating variable taper, and continuous rotary constant taper instruments. According to the manufacturer, the aforementioned equipment significantly reduces operational error while maintaining the original canal geometry.

This multi-file system called the Continuous Rotating Variable Taper (Protaper Gold), consists of three shaping files (SX, S1, and S2) and five finishing files (F1–5). The device is more flexible for curve canal preparation when it has modified noncutting tips, changeable pitch, progressive taper, and helical angle [10]. A single file system in reciprocating motion, the reciprocating variable taper (Wave One Gold) was created using M-wire. Principal (taper/tip size: #25/0.07. Every file features a semi-active guiding tip and an alternating offset parallelogram-shaped cross-section. A further distinctive characteristic of the design is that every file has a fixed taper from D1 to D3, but a tapered design with a gradually decreasing percentage from D4 to D16. This helps to maintain the curvature of the root canal and preserve dentin [11].

With its features of controlled memory alloy, shape memory, non-active tip, and a convex triangular section modified with a wide and deep space between the blades, the continuous rotary constant taper (Orodeka Plex V) is a multi-file system Orifice Opener (15/0.8), PLEX V 15/.03, Plex V 20.04, and PlexV 25.04. These instruments are widely used for curve root canal preparation. Because the control memory wire has a reduced nickel concentration (52%), it softens the metal, which reduces the likelihood that the instrument would cut aggressively during instrumentation, keeping the instrument centered and reducing the possibility of canal curvature deviation [12].

There have been multiple techniques used to compare the effect of instrumentation on canal geometry such as periapical radiograph (RVG).

Therefore, the present study was designed to evaluate the deviation of canal curvature after preparation with these three types of rotary instruments by using a periapical radiograph (RVG).

2. Materials and Methods

After receiving approval from BSMMU's Institutional Review Board (IRB), this prospective quasi-experimental study was carried out in the department of conservative dentistry and endodontics from September 2021 to August 2022. The study was conducted in vitro for this purpose. Patients requiring tooth extractions for periodontal therapy who visited Bangabandhu Sheik Mujib Medical University's maxillofacial department made up the study population. The human mandibular permanent molar tooth's mesiobuccal canal, which has a curvature of 25° to 40°, served as the study sample. To choose the appropriate samples, radiographs of teeth taken in the buccolingual and mesiodistal directions were obtained. Excluded from the study was any tooth with an open apex, calcification, root resorption, and curvature less than 25°.

The extracted first permanent molar teeth on the lower jaw were gathered and kept in regular saline until needed. Using diamond discs, the mesial and distal roots of the teeth were identified, and the mesiobuccal side was marked. Diamond discs were used to remove the crown to a typical 12-mm mesial root. Blocks of modeling wax were created. The specimens were arranged in separate blocks. Patency was examined using 10 no K files. A 10-size K file (Dentsply Maillefer, Ballaigues, Switzerland) was placed at the apical foramen to visualize the tip when examined under magnification loupes in order to determine the working length. Periapical radiographs were obtained by holding the PID (position indicating device) perpendicular to this line and then subtracting 1 mm from the length. The fixed axis was traced from mesial to distal along the wax block, between the buccal and lingual canal opening of the root. Using Schnieder's Method, the pre-instrument canal curvature was determined. 36 tooth roots with a curvature ranging from 26° to 40° were chosen from the specimens.

Schnieder's Method was used to measure the pre-instrument canal curvature. A selection of 36 tooth roots with a curvature ranging from 26° to 40° was made from among the specimens The root canal was irrigated with 2 ml of 5.25% sodium hypochlorite solution and 17% ethylene diamine tetra acetic acid (EDTA) using a plastic syringe with a 27-gauge closed-end needle after each instrument was changed. The glide path was expanded to a rotary 2% 15 no file Proglider (Dentsply Maillefer, Ballaigues, Switzerland). Each instrument could only be used in one canal at a time. Using a size 25 instrument and the manufacturer's recommended instrument order, apical preparation was finished.

Continuous rotating variable taper Ni-Ti files (Pro taper gold, Dentsply Maillefer, Ballaigues, Switzerland) were used to instrument Group A.

Group B was equipped with a reciprocating endomotor (Canal Pro, CL2, Coltene) and a reciprocating variable taper Ni-Ti instrument (Wave One Gold).

Continuous rotational constant taper Ni-Ti files (4% Orodeka Plex V File) were used to instrument Group-C.

Lastly, sterile paper tips were used to dry the canals. Only the researcher prepared each channel. The following instrumentation, the same circumstances as for initials were used for the specimens to take radiographs using digital dental periapical imaging (Figs. 1–3). The identical method as previously described was used to take the post-operative photos. The same procedure was used to measure the specimens' canal curvatures. The initial measurement was of the post-instrument canal curvature.

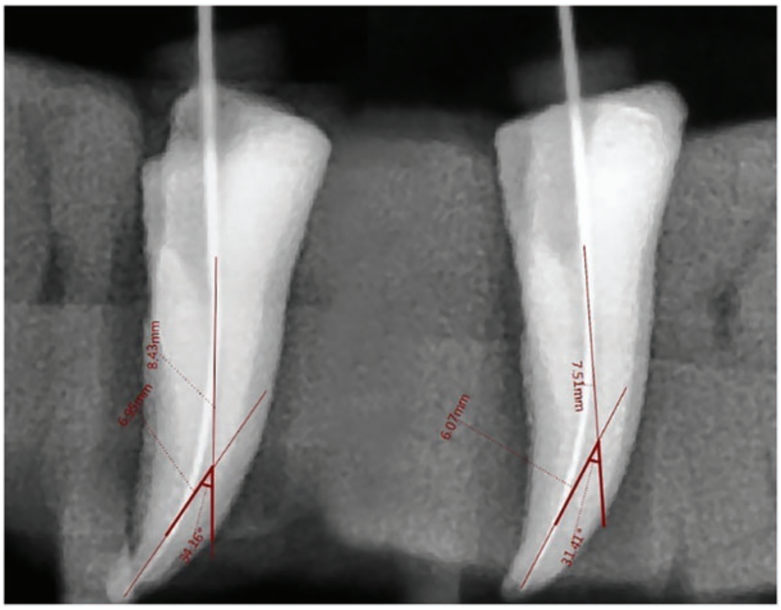

Fig. 1. Pre- and post-instrument curvature change in group A.

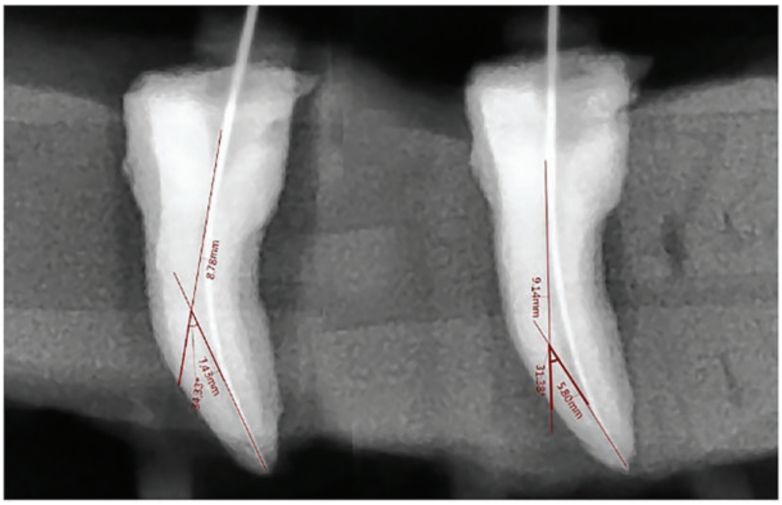

Fig. 2. Pre- and post-instrument curvature change in group B.

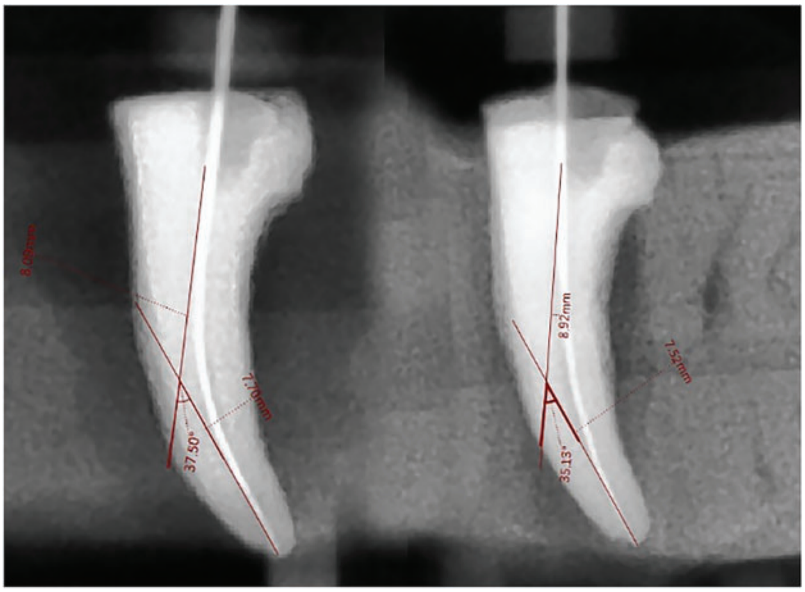

Fig. 3. Pre- and post-instrument curvature change in group C.

2.1. *Statistical Analysis*

SPSS version 26 was used to analyze the data (IBM, Armonk, US). The Kruskal-Wallis test and the Wilcoxon test, which are used for numerous pairwise comparisons among distinct groups, were utilized to conduct statistical analysis among three groups. p-values less than 0.05 were regarded as statistically significant.

3. Results

The distribution of all the parameters was not typical. p-values less than 0.05 are regarded as significant (Table I).

According to the current study, group C's canal curvature deviation—prepared by a continuous rotary 4% constant taper control memory instrument—was found to be less than that of groups B and A—prepared by reciprocating variable taper and continuous rotary variable taper, respectively (Table II).

A statistically significant difference in the percentage change in curvature between the three groups is indicated by the Kruskal-Wallis test. The mean % change in curvature for groups A (9.48 ± 3.21), B (7.52 ± 1.40), and C (6.31 ± 2.95) was displayed in Table II.

Pre- and post-instrument root canal curvatures, as well as the percentage change in curvature between groups A and B and between groups B and C, were not found to be statistically significant (p-values of 0.238 and 0.811, respectively); however, there was a significant difference (p = 0.018) between groups A and C (Table III). When comparing a continuous rotary constant taper control memory instrument with a continuous rotary variable taper instrument, a statistically significant difference was seen in the % change in curvature (Table III).

4. Discussion

In the current study, group C (teeth prepared by continuous rotary 4% constant taper control memory file) had the lowest deviation of root canal curvature and percentage change in curvature, followed sequentially by group B (teeth prepared by a reciprocating variable taper file) and group A (teeth prepared by a continuous rotary variable taper file). During instrumentation, metal may remain centered within the canal due to the control memory effect of continuous rotational constant taper instruments [13].

The root canal curvature deviation was lower in Group C (canals prepared by continuous rotational 4% constant taper control memory file) in this investigation, with a percentage variation in curvature of 6.31 ± 2.95. The root canal curvature and % change in curvature (9.48 ± 3.21) of group A (canals created using a continuous rotary variable taper) were significantly different from those of group C. A rotary 4% constant taper file may preserve the original curvature of root canals with a curvature of 26°–40° more effectively than a rotary variable taper file. This result was similar to that of the earlier investigation [7], which contrasted the canals created using constant and variable taper devices. The original curvature was better preserved in the canals constructed using constant taper rotary tools. A prior study [14] compared curve canals (28° or 35°) made with a 2% constant taper rotary

TABLE I: Comparison of Pre-Instrument, Post-Instrument Canal Curvature, and Percentage Change among Three Groups (N = 36)

	Kolmogorov–Smirnov			Shapiro–Wilk		
	Statistic	df	p-value	Statistic	df	p-value
Pre-instrument angle (degree)	0.202	36	0.001	0.912	36	0.007
Post-instrument angle (degree)	0.104	36	0.200*	0.969	36	0.397

TABLE II: Comparison of Pre-Instrument, Post-Instrument Canal Curvature, and Percentage Change among Three Groups (N = 36)

Canal curvature	Group A (n = 12) Mean ± SD	Group B (n = 12) Mean ± SD	Group C (n = 12) Mean ± SD	p-value (Kruskal Wallis test)
Pre-instrument	30.74 ± 3.52 (30.2)	31.12 ± 3.87 (31.2)	32.60 ± 2.67 (32.7)	0.375
Post-instrument	27.84 ± 3.48 (27.2)	28.80 ± 3.77 (28.3)	30.48 ± 1.72 (30.5)	0.128
% change incurvature	9.48 ± 3.21 (9.1)	7.52 ± 1.40 (7.1)	6.31 ± 2.95 (5.4)	0.021*
p-value (Wilcoxon test)	0.002*	0.002*	0.002*	

Note: *Data were expressed as mean ± SD, parenthesis indicate the median. The p-value was obtained from Kruskal–Wallis's test. A comparison of curvature change between the pre-instrument and the post-instrument individual group was performed by the Wilcoxon test.

TABLE III: Comparison of Mean Fracture Resistance among Groups (n = 40)

Canal curvature	Wilcoxon test		
	Group A vs. B p-value	Group A vs. C p-value	Group B vs. C p-value
Pre instrument	1.000	0.562	0.880
Post instrument	1.000	0.140	0.592
% change incurvature	0.238	0.018*	0.811

Note: *The p-value obtained by the Wilcoxon test; *significant.

instrument (RaCe) with a rotary variable taper instrument (Pro taper file). In comparison to the variable taper rotary instrument, the constant taper rotary instrument (RaCe) performed better. A comparison is made between the curve canal (15°–30°) produced by the Varitaper Ni-Ti instrument [15], the constant taper rotary instrument (RaCe file), and the variable taper rotary instrument (Pro taper file). While the variable taper rotary instrument (Pro taper file) revealed 6.070 deviations and the Varitaper Ni-Ti instrument showed 5.590 deviations, the constant taper rotary instrument (RaCe file) exhibited 5.500 deviations. Less canal curvature variation was seen in this instance using the constant taper rotary instrument, which is in line with the current investigation.

Although not statistically significant, group C'sroot canal curvature deviation and % change in curvature were both lower than group B's in this investigation. By using a reciprocating variable taper instrument, the deviation of root canal curvature was found to be 3°, while the continuous rotary 4% constant taper instrument yielded a result of 2°. Comparing the curve canal (25°–39°) prepared with a rotary constant taper file (Mtwo file) and reciprocating variable taper file (primary wave one gold) 8%, 25 no reciprocating files & rotary variable taper file (pro taper file), the results of this study were similar to those of the previous study [16]. In that study, the rotary constant taper file produced less deviation than the reciprocating variable taper instrument. The reciprocating variable taper file revealed 3°, the rotary constant taper 25 with no files, and the variation of the root canal curvature by 5% revealed 25 with no files. Additionally, the outcome of the earlier investigation was not statistically significant.

The variation of root canal curvature and the percentage change in curvature between groups A and B did not reach statistical significance. Group B and Group A both displayed a 3° deviation. (20°–40°) curve canals constructed using reciprocating variable taper equipment (wave one single file) and rotary variable taper instruments (pro taper) were compared in the preceding work [17]. The reciprocating variable taper instrument revealed (mean ± SD, 3.87 ± 2.65), which was likewise not statistically significant, while the variable taper rotary instrument showed (mean ± SD, 3.59 ± 2.66) deviation. The current study's results were in line with those of the earlier investigation. The curve canal (25°–39°) created with a variable taper rotary instrument and variable taper reciprocating instrument were compared in the previous study [16]. The results of the prior study were statistically not significant and in line with those of the current investigation.

5. Conclusion

A continuous rotating 4% constant taper control memory rotary instrument produced less deviation than a rotary variable taper instrument and a reciprocating variable taper instrument, according to the results of the current investigation.

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Ethical Issue

This research protocol was approved by the committee and permission for the study was taken from the Institutional Review Board (IRB) of Bangabandhu Sheikh Mujib Medical University (BSMMU/2021/8578).

Conflict of interest

Authors declare that they do not have any conflict of interest.

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