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In Vitro Transportation of Curved Canals Following Glide Path Preparation by Path File and Scout RaCe Rotary Systems versus Manual Instrumentation Using Cone-Beam Computed Tomography

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A B S T R A C T

Objectives: This study aimed to assess root canal transportation of curved canals following glide path preparation by PathFile and Scout RaCe rotary systems compared with manual instrumentation with stainless steel (SS) hand files using cone-beam computed tomography (CBCT).

Materials and Methods: This in-vitro experimental study was conducted on extracted human mandibular first and second molars (n=51) with 25-45° canal curvature in their mesiobuccal root. All teeth underwent CBCT and were randomly divided into three groups (n=17). In group 1, a glide path in the mesiobuccal canal was created using SS hand files to the working length. In groups 2 and 3, after canal negotiation with a #8 SS hand file, a glide path was created with PathFile and Scout RaCe systems, respectively. The teeth underwent CBCT. Pre- and postoperative CBCT scans were compared to calculate the magnitude of canal transportation at 3, 6, and 9 mm from the apex. The results were analyzed using the Kruskal-Wallis and Freedman tests (P<0.05).

Results: Manual instrumentation caused significantly higher canal transportation at 3 and 9 mm from the apex compared with rotary systems (P<0.05). PathFile and Scout RaCe were not significantly different at 3 (P=0.39) or 9 mm (P=0.99). No significant difference was noted in canal transportation among the three groups at 6 mm (P=0.15).

Conclusion: Scout RaCe and PathFile cause less canal transportation than manual instrumentation with SS files when used for glide path preparation in curved canals, especially in the apical third.

Keywords: Cone-Beam Computed Tomography; Dental Instruments; Equipment Design; Root Canal Preparation; Stainless Steel; Nickel; Titanium

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INTRODUCTION

Root canal treatment of curved and S-shaped canals has always been challenging for dental clinicians [1-3]. Endodontic treatment of such root canals is associated with higher risks of procedural errors, such as ledge formation and transportation. As a result, parts of the root canal system may not be efficiently cleaned. Perforation or inadequate seal are among other possible complications, which have a higher risk of occurrence in such canals [4].

Providing a glide path in curved canals prior to root canal cleaning and shaping decreases the risk of procedural errors and helps preserve the original canal path and position of the apical foramen [5-7]. Also, it has been reported that coronal preflaring, which is performed to create a glide path, is the first step for safe use of rotary instruments because it prevents instrument fracture and procedural errors in root canal shaping [6-9]. Creating a glide path refers to the primary enlargement of the canal such that a smooth and centered path from the canal orifice to its physiological end is created [10]. Evidence shows that the use of stainless steel (SS) hand instruments can be problematic for the creation of a glide path [9,11]. The use of SS files is associated with the risk of canal transportation (and subsequent perforation), ledge formation, and apical zipping due to their relative hardness. Recently, rotary nickel-titanium (NiTi) files have been introduced to the market to provide a primary glide path and eliminate the need for manual instrumentation [9,12].

PathFile is a NiTi rotary system that includes three instruments with a square-shaped cross-section and a 2% taper [2,9,12,13]. It was introduced for use along with the ProTaper rotary system [2,13], aiming to provide a mechanized primary glide path [12,13]. Scout RaCe and G-File are among other systems introduced to serve this purpose [1,14,15].

Studies on the efficacy of PathFile and other rotary systems such as Scout RaCe for the prevention of canal transportation have reported controversial results. Some studies have reported the optimal efficacy of NiTi rotary systems for the formation of a glide path [1,2,13] since they had less deviation from the original canal anatomy compared with hand files. However, another study concluded that both hand instruments and rotary files are suitable for the formation of a glide path with no difference between them regarding the frequency of apical transportation or canal deviation [14].

Since cone-beam computed tomography (CBCT) enables three-dimensional (3D) assessment of canal dimensions and provides various cross-sections of root canals, this imaging modality is suitable for accurate assessment of changes in the root canal system following instrumentation [16].

Preservation of the original canal path in curved canals is the first and most important step in root canal treatment of such teeth and prevention of procedural errors. Thus, this study aimed to assess and compare root canal transportation of curved canals following glide path preparation by PathFile and Scout RaCe rotary systems compared with manual instrumentation with SS hand files using CBCT.

MATERIALS AND METHODS

This in-vitro experimental study was conducted on human mandibular first and second molars extracted for various reasons (e.g. periodontal disease). The teeth had no defects, resorption, or fracture in the roots, and their crowns were relatively sound. The teeth had not undergone endodontic treatment and had an average length of 19 to 21 mm. The mesial root of the teeth had a distal deviation by 25° to 45°, which was considered severe curvature according to the Schneider's classification [17].

The study was approved by the ethics committee of Qazvin University of Medical Sciences. The sample size was calculated to be 17 in each group using G Power 3.1.9.2 sample size calculation software assuming alpha=0.05, beta=0.20, and effect size of 0.99.

A total of 51 extracted human mandibular first and second molars were collected using convenience sampling. The teeth were immersed in 5.25% sodium hypochlorite (NaOCl) for 24 hours and rinsed under running water 24 hours prior to the experiment. They were cleaned with pumice paste and rubber cup and stored in saline. For standardization, the canals that naturally had a smooth glide path to the apex negotiated by a #15 or larger K-file were excluded. Calcified canals in which a #8 K-file could not reach the working length were excluded as well.

The Schneider's methods [17] was used to determine the root curvature. For this purpose, the teeth underwent digital periapical radiography (RVG 5100; Kodak, France). Next, using the respective software, a line was drawn perpendicular to the longitudinal axis of the canal on the tooth (the first line). A second line was drawn from the apical foramen to the starting point of the canal curvature such that the two lines intersected. The acute angle formed between the two lines was measured and compared with the Schneider's classification. According to the Schneider's classification, canals with a curvature angle ≤5° were considered straight, those with 10° to 20° curvature angle were considered to have moderate curvature, and canals with a curvature angle of 25° to 70° were considered as having severe curvature [17].

In our study, teeth with a canal curvature out of the range of 25° to 45° were excluded. The 51 teeth that met our eligibility criteria were coded. An access cavity was prepared using a 008 fissure bur (Tizkavan, Iran) and a high-speed handpiece. To determine the working length, a #10 K-file (Dentsply Maillefer, Switzerland) was introduced into the mesiobuccal canal until the file tip was visible at the apex. The working length was determined 0.5 mm short of this length. Next, the teeth were randomly divided into three groups (n=17) using the WinPepi software. The mean canal curvature in all groups was almost the same. To enhance taking CBCT scans and to create a reproducible position for CBCT, the teeth were mounted in auto-polymerizing acrylic resin in the form of a dental arch. Due to limitations in arch size, the 51 teeth were mounted in 4 arches (2 arches each with 12 teeth, 1 arch with 13 teeth, and 1 arch with 14 teeth). One layer of wax was applied around each arch to simulate the soft tissue. Next, all teeth underwent CBCT using the NewTom CBCT system (V6; Verona, Italy) to determine the shape and dimensions of the mesiobuccal canal prior to root canal preparation. We assessed the cross-sections at 3, 6, and 9 mm from the apex in this study and saved the images of these cross-sections in a computer. The following interventions were then made:

Group 1 (SS): Negotiation and glide path preparation in the mesiobuccal canal in this group were performed using SS hand K-files in the following order: #8, #10, #15, and #20, all to the working length.

Group 2 (PathFile): A #8 SS K-file was used to the working length for the negotiation of the mesiobuccal canal. Mechanical preparation of the glide path was then performed with PathFile rotary system (Dentsply Maillefer, Switzerland) using #13, #16, and #19 files with 0.02 taper attached to an endodontic motor (NSK, Japan) according to the manufacturer's instructions (1.0 Ncm torque and 300 rpm speed).

Group 3 (Scout RaCe): A #8 SS K-file was used for the negotiation of the mesiobuccal canal to the working length. Mechanized scouting for glide path preparation was then performed using #10, #15, and #20 Scout RaCe rotary instruments (FKG Dentaire, Switzerland) with 0.02 taper attached to an endodontic motor according to the manufacturer's instructions (1.0 Ncm torque and 600 rpm speed).

All root canal preparations were performed by the same calibrated operator with excellent intra-examiner reliability. In all groups, the root canals were rinsed with 5 ml of 5.25% NaOCl between every two filings. After the completion of glide path preparation, each canal was finally rinsed with 3 ml of 5.25% NaOCl. Each instrument was used for 5 canals and was then discarded. Next, CBCT scans were obtained again of the teeth under similar conditions. The images were saved. To calculate the magnitude of transportation of the mesiobuccal canal, the following formula was used [18]:

Magnitude of transportation= (a1-a2)-(b1-b2)

On the preoperative CBCT scans of each tooth, the largest buccolingual diameter was determined, and its length was measured by the software ruler (the BL line). The BL line served as a guide. Next, a point (point C) was selected at the center of the BL line with equal distances from the buccal and lingual root canal walls. A line was drawn perpendicular to this point (the MD line). The length of the BC line was measured by the software. The same was performed for postoperative CBCT scan of the same tooth, and the a1 and b1 values were calculated by the software as follows:

A1: Distance from the outermost margin of the root section at the mesial to the mesial margin of the unprepared canal on the MD line.

B1: Distance from the outermost margin of the root section at the distal to the distal margin of the unprepared canal on the MD line.

The a2 and b2 values were also calculated as such on postoperative CBCT scans as follows:

A2: Distance from the outermost margin of the root section at the mesial to the mesial margin of the instrumented canal on the MD line.

B2: Distance from the outermost margin of the root section at the distal to the distal margin of the instrumented canal on the MD line.

To calculate a2 and b2, the BL, DC, and MC lines were also drawn on postoperative CBCT scans. To ensure the reproducibility of CBCT scans and their equal conditions, the length of the BL, DC, and MC on postoperative CBCT scans had to be equal to the corresponding values on preoperative CBCT scans of each tooth. In the formula mentioned above, any result other than 0 would indicate the occurrence of canal transportation in the respective section. Data were analyzed using SPSS version 19 (SPSS Inc., Chicago, IL, USA) via the Kruskal-Wallis and Friedman tests with the level of significance set at 0.05. The Dunn's post-hoc test was used for pairwise comparisons.

RESULTS

Table 1 presents the magnitude of mesiobuccal canal transportation in the three groups. In the manual instrumentation group, a significant difference was noted in the magnitude of canal transportation at 3, 6, and 9 mm from the apex (P=0.020). Pairwise comparisons revealed a significant difference in this regard between 3 and 9mm levels (P=0.009) but the difference between 3 and 6mm (P=0.088) and between 6 and 9mm (P=0.287) levels was not significant.

Table 1. Magnitude of mesiobuccal canal transportation (mm) in the three groups

Group	Level*	Mean	Median	SD
Manual	3 mm	0.135	0.1	0.086
	6 mm	0.088	0.1	0.069
	9 mm	0.064	0.1	0.060
PathFile	3 mm	0.058	0.1	0.050
	6 mm	0.052	0.1	0.051
	9 mm	0.011	0	0.033
Scout RaCe	3 mm	0.041	0	0.05
	6 mm	0.047	0	0.051
	9 mm	0.011	0	0.033

*All distances are measured from the apex
SD: Standard Deviation

In the PathFile group, a significant difference was noted in the magnitude of canal transportation at 3, 6, and 9 mm from the apex (P=0.008). Pairwise comparisons revealed a significant difference in this regard between 3 and 9mm levels (P=0.003) and between 6 and 9mm levels from the apex (P=0.009). However, the difference between 3 and 6mm levels was not significant (P=0.731).

In the Scout RaCe group, a significant difference was noted in the magnitude of canal transportation at 3, 6, and 9 mm from the apex (P=0.056). Pairwise comparisons revealed a significant difference in this regard between 3 and 9mm levels (P=0.043) and between 6 and 9mm levels from the apex (P=0.020).

However, the difference between 3 and 6mm levels was not significant (P=0.731). Figure 1 shows canal transportation in the three groups at 3 mm from the apex. At this level, there were significant differences in canal transportation between the manual instrumentation and PathFile (P=0.004) groups and between the manual instrumentation and Scout RaCe (P=0.0006) groups. However, the difference between PathFile and Scout RaCe was not significant at this level (P=0.33).

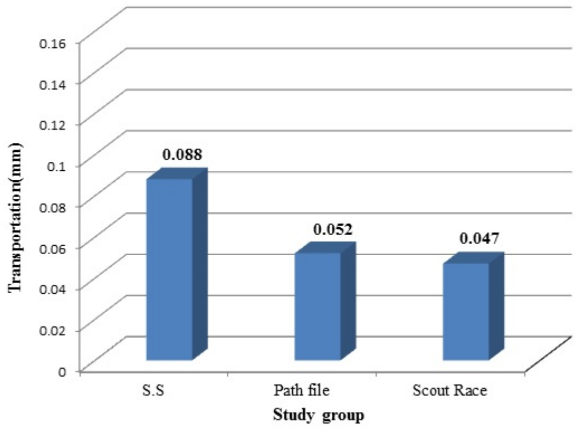

Fig. 1. Canal transportation in the three groups at 3 mm from the apex

Figure 2 shows canal transportation in the three groups at 6 mm from the apex. At this level, the three groups were not significantly different regarding the magnitude of canal transportation (P=0.153).

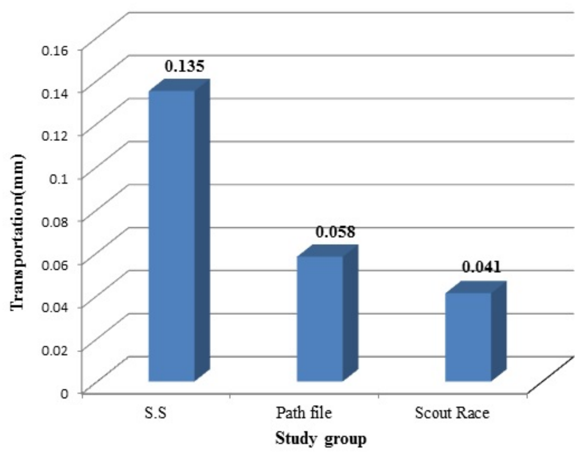

Fig. 2. Canal transportation in the three groups at 6 mm from the apex

Figure 3 shows canal transportation in the three groups at 9 mm from the apex. At this level, there were significant differences in canal transportation between the manual instrumentation and PathFile (P=0.004) groups and between the manual instrumentation and Scout RaCe (P=0.004) groups. However, the difference between PathFile and Scout RaCe was not significant at this level (P=1.00).

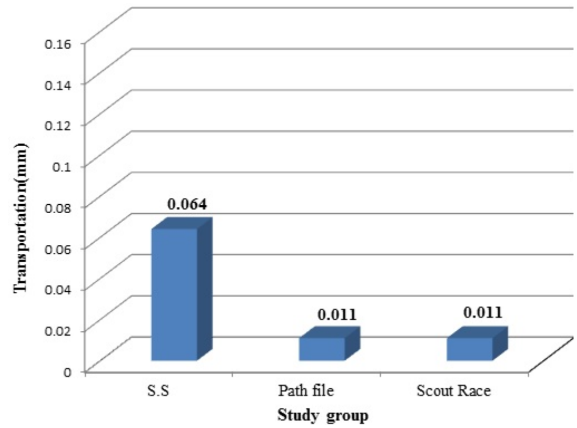

Fig. 3. Canal transportation in the three groups at 9 mm from the apex

DISCUSSION

Preserving the original canal shape during mechanical cleaning and shaping of the root canal system is an important goal in endodontic treatment [19]. Some procedural errors, such as apical transportation, may occur during the shaping of curved canals [20]. Thus, it has been suggested to create a glide path in curved and S-shaped canals to minimize the risk of occurrence of procedural errors. Conventionally, SS hand files are used for this purpose [5-7]. Considering the increasing popularity of rotary systems, this study aimed to assess root canal transportation in curved canals following glide path preparation by PathFile and Scout RaCe rotary systems compared with manual instrumentation with SS hand files using CBCT.

Several methods are employed for the assessment of canal transportation by endodontic instruments and their centering ability. Ajuz et al [1] and D'Amario et al [14] superimposed preoperative and post-operative images. However, this technique has some drawbacks such as difficult accurate repositioning of samples before and after instrumentation [18]. Thus, in the present study, CBCT was used for this purpose similar to studies by Nazarimoghadam et al [15], Madani et al [21], Gergi et al [2], and Gambill et al [18]. Evidence shows that CBCT is more accurate for the assessment of canal transportation compared with other methods; also, it does not require the destruction of the tooth structure and provides several images of different root sections [18,22]. The same was reported by Nazarimoghadam et al [15]. Berutti et al [9] and Ajuz et al [1] used resin blocks for the assessment of canal transportation. However, we used natural human teeth in the present study to better simulate the clinical setting. Our results were in line with those of Vorster et al [13] and Zheng et al [23] although they both used micro-computed tomography while we used CBCT for the assessment of canal transportation.

Our results showed that in the manual instrumentation group, maximum canal transportation was noted at 3 mm from the apex with a significant difference with the value at 9 mm from the apex (P=0.009). However, canal transportation at 3 and 6 mm from the apex was not significantly different (P=0.088). In the study by Ajuz et al [1], maximum canal transportation by manual instruments was noted at 6 mm from the apex, which was different from our result. The difference between the results of the two studies can be due to the fact that we used natural human teeth while they used resin blocks.

In the PathFile group of our study, maximum canal transportation was noted at 3 mm from the apex while maximum canal transportation was noted at 6 mm from the apex in the Scout RaCe group with no significant difference with the value at 3 mm from the apex (P=0.731). In all three groups, canal transportation at 9 mm from the apex was less than that in other levels. Since maximum curvature is at the apical third, greater canal transportation in the apical third is justified [24,25].

The comparison of the amount of canal transportation at different levels in this study revealed that at 3 and 9 mm from the apex, maximum canal transportation was noted in the manual instrumentation group with significant differences with the PathFile and Scout RaCe groups (P=0.004 and 0.0006 at 3 mm from the apex, respectively, and P=0.004 at 9 mm from the apex). However, the PathFile and Scout RaCe groups had no significant difference with each other in canal transportation at 3 and 9 mm from the apex (P=0.33 and 1.00, respectively). Berutti et al [9] and Ajuz et al [1], in their study on glide path preparation, reported that hand files had higher errors than NiTi rotary files. In contrast, D'Amario et al [14] and Alves et al [12] found no significant difference in canal transportation by hand-files and NiTi rotary files. It should be noted that both the aforementioned studies used the superimposition method for the assessment of canal transportation, which is probably not as accurate as CBCT [18,22]. At 6 mm from the apex, the manual instrumentation group showed maximum transportation but the difference between the groups was not significant. In general, based on the current findings, rotary NiTi files caused less transportation compared with SS hand files during glide path preparation. This result was in line with the results of studies by Ajuz et al [1], Gergi et al [2], and Berruti et al [9].

Canal transportation can be due to a number of factors, such as the technique of canal preparation, physical properties of the file alloy, and instrument design [21]. Also, the material of the files used for glide path preparation should have specific mechanical properties, such as optimal flexibility to prevent iatrogenic changes in the canal path [26]. Thus, the superiority of NiTi files in this study to SS hand files may be due to their higher flexibility, which helps in passing the canal curvatures [26]. Fatigue resistance is another important characteristic that helps in canal negotiation by the instrument. Lopes et al [26] reported that the fatigue resistance of Scout RaCe and PathFile was significantly higher than that of SS hand files.

Scout RaCe and PathFile both have a square-shaped cross-section and equal taper (0.02). However, their D0 values are different, which are 0.13, 0.16, and 0.19 mm for the PathFile system files and 0.10, 0.15, and 0.20 mm for the Scout RaCe system files. In the present study, at 3 and 6 mm from the apex, the Scout RaCe system showed less transportation than the PathFile although this difference was not significant. This difference may be attributed to the smaller D0 of the first file of the Scout RaCe system. Also, in the study by Lopes et al [26], the flexibility of the Scout RaCe was higher than that of the PathFile. Since flexibility is important in canal negotiation, this may explain the relative superiority of the Scout RaCe in the present study.

It should be noted that with all rotary systems that form a glide path, including the two systems evaluated in this study, a #8 or #10 SS hand file should be used for the primary negotiation of the canal because the buckling resistance (known as resistance to lateral deformation due to the application of compressive forces along the longitudinal axis) of SS files is higher than that of NiTi files [26]. Thus, primary canal negotiation with a SS hand file is recommended. For the preparation of narrow curved canals, the use of NiTi rotary instruments, such as Scout RaCe and PathFile, after a primary negotiation with a #8 or #10 SS hand file seems appropriate.

This study had an in-vitro design. Therefore, the generalization of the results to the clinical setting must be done with caution. Also, the CBCT software used in this study had a 0.1mm accuracy. Using a software with higher accuracy would yield more accurate results.

Further studies on other NiTi files used for canal negotiation and glide path formation are required. Also, transportation in S-shaped canals should be investigated in future studies. Last but not least, rotary NiTi files must be compared with NiTi hand files regarding canal transportation.

CONCLUSSION

Within the limitations of this study, it seems that the use of Scout RaCe and PathFile rotary systems for the formation of a glide path in curved canals, especially in their apical third, causes less transportation compared to manual instrumentation with SS hand files.

CONFLICT OF INTEREST STATEMENT

None declared.

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