Canal Transportation and Centering after Using PathFile and R-Pilot in Mesiobuccal Canals of Maxillary Molars Using Cone-Beam Computed Tomography

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Introduction: This study aimed to compare the changes in root canal anatomy following the use of PathFile and R-Pilot using cone-beam computed tomography (CBCT). Methods and Materials: In this in vitro, experimental study, 60 extracted maxillary first and second molars with 20 to 40° mesiobuccal root curvature, minimum of 19 mm of root length, no calcified root canals and no history of previous treatment were divided into two groups (n=30). CBCT scans were taken before and after the treatment, and sections at 1, 2 and 3 mm from the apex were compared. Pairwise comparisons were carried out using the Mann Whitney-U test. The centering ratio data were analyzed using the Chi-square test and Fisher’s exact test. All statistical analyses were carried out using Sigma Stat 4 software. Results: The difference between PathFile and R-Pilot in canal transportation in mesiodistal direction was significant at 1 and 2 mm from the apex (P<0.01). The R-Pilot file was significantly superior to PathFile in centering ability in mesiodistal direction at 1 mm from the apex (P<0.05). Canal transportation direction was towards the mesiolingual and distobuccal in R-Pilot and PathFile groups, respectively. Conclusion: Within the limitations of this study, the results showed that R-Pilot with reciprocal movement is a safe and easy to use instrument for creating a glide path.

Keywords: Canal Transportation; Cone-Beam Computed Tomography; Glide Path; PathFile; R-Pilot

Introduction

Root canal instrumentation is performed aiming to achieve a uniform taper from the access cavity towards the apex while preserving the original shape of the canal [1, 2]. Glide path refers to a straight path from the canal orifice to the physiologic root end. Several files can be used to create a glide path. The minimum file size is #10, which should be placed loose in the canal [3]. Not creating a glide path would result in ledge formation, canal transportation, canal obstruction and consequently under-filling of the root canal [4].

Apical transportation is defined as transportation of the physiologic apex of the canal to a new iatrogenic location on the external root surface [5, 6]. Also, creating a glide path prevents fracture of endodontic instruments. It serves as a safety feature in endodontic treatment and can be created manually or mechanically [7]. Stainless steel hand K-files can be used to create a glide path. The advantages of using hand K-files include excellent tactile sense and lower risk of file fracture. Using a small-size K-file in the root canal helps the operator to better perceive the curvature of the canal. It also helps in detection of calcified canals [8].

In 2008, a reciprocating handpiece attached to small size K-file was introduced for creating a glide path. Its main advantages include decreased time required for creating a glide path and less hand fatigue in narrow canals compared to the conventional manual techniques [8]. The R-Pilot characteristics include ISO 12.5 tip size and 4% taper. It is made of M-wire and has a reciprocating movement [9].
PathFile rotary files are also used to create a glide path, which include three rotary instruments with a tip diameter of 0.13, 0.16 and 0.19 mm. They have a non-cutting tip to prevent ledge formation or zipping. This tip has a square-shaped cross-section with four cutting angles that increase the efficacy of PathFile for use in long, calcified canals. These files are made of nickel titanium alloy and have 2% taper, which increases their flexibility [4]. This in vitro study aimed to compare the change in root canal anatomy following creation of a glide path with two rotary systems in the mesiobuccal canal of maxillary first and second molars using cone-beam computed tomography (CBCT).

Materials and Methods

This in vitro, experimental study evaluated 60 maxillary first and second molars extracted for periodontal disease or prosthetic problems that met the following inclusion criteria. The inclusion criteria were mature apices [10], having a mesiobuccal root with two canals and separate apices or canals fused at the apical 5 mm [10, 11], 20-40° curvature (according to Schneider’s method) [12], minimum length of 19 mm, from the tip of the mesiobuccal cusp to the apex [13], absence of canal calcification [14] and no history of previous treatment [14].

The teeth were mounted in silicon impression material (Speedex, Coltene/Whaledent, Altstatten, Switzerland) to have a standardized position for radiography. Mounted samples underwent parallel periapical radiography and a buccolingual radiograph was obtained to determine the position of canals. Coronal access cavity was prepared using a #4 round carbide bur (Dentsply Maillefer, Ballaigues, Switzerland). A #10 K-file was used (Speedex, Coltene/Whaledent, Altstatten, Switzerland) to have a standardized position for radiography. Mounted samples were sectioned at the furcation area and the mesial half of the root and crown was separated. The working length was determined 1 mm short of the apical foramen using a #10 K-file. A periapical radiography was also obtained to ensure correct working length. Specimens were then randomly divided into two groups. The crowns were mounted in silicon putty impression material and scanned using a NewTom VGI CBCT system (QR SRL Co., Verona, Italy) with the following parameters: 9.5 mA, 110 kV, 5.4 sec scanning time, 0.125 mm voxel size and 0.125 mm axial thickness. The slices were obtained from the apical towards the coronal with 0.9 mm slice thickness, and sections at 1, 2 and 3 mm from the apex were evaluated. For easier introduction of files into the canals, coronal flaring was first performed with ProTaper rotary system (Dentsply Maillefer, Ballaigues, Switzerland) operating at 350 rpm with brushing movement using a 16:1 contra-angle handpiece [15].

In group 1, PF1 (0.13 mm) (Dentsply Maillefer, Ballaigues, Switzerland), PF2 (0.16 mm) and PF3 (0.19 mm) were used in an orderly fashion operating at 300 rpm and 5 N/cm torque with in-and-out movement to the working length, powered by an electric torque controlled motor (VDW Co, Munich, Germany). The canals were rinsed with 2 mL of distilled water using a 27-gauge needle after each use of rotary file [15].

In group 2, R-Pilot single file (VDW Co, Munich, Germany) was attached to the electric motor (Silver Reciproc Endomotor; VDW Co., Munich, Germany) and root canal was prepared with reciprocating movement of the file. Rinsing was performed as in group 1.

CBCT scans were taken again of the teeth using the same exposure settings to assess canal transportation and centering ratio. Canal transportation was determined using the formula below: \((B_1-B_2)/(A_1-A_2)\) where \(A_1\) is the shortest distance from the mesial or lingual root margin to the mesial or lingual margin of the instrumented canal, \(B_1\) is the shortest distance from the distal or buccal root margin to the distal or buccal margin of the instrumented canal, \(A_2\) is the shortest distance from the mesial (lingual) root margin to the mesial (lingual) margin of the canal after instrumentation and \(B_2\) is the shortest distance from the distal (buccal) root margin to the distal (buccal) margin of the canal after instrumentation.

Centering ability was calculated using the formula below (Figure 1) [14]: \((B_1-B_2)/(A_1-A_2)\) or \((A_1-A_2)/(B_1-B_2)\).

Statistical analysis

Data regarding the amount of transportation did not have a normal distribution. Thus, pairwise comparisons were carried out using the Mann Whitney-U test. The centering ratio data were analyzed using the Chi-square test and Fisher’s exact test. All statistical analyses were carried out using Sigma Stat 4 software (Systat Software, Inc, San Jose, CA, USA).

**Figure 1.** Centering ability was calculated using the following formula \((B_1-B_2)/(A_1-A_2)\) or \((A_1-A_2)/(B_1-B_2)\)
Results

Canal transportation and centering ratio were evaluated for the two file types at three levels from the apex. Table 1 summarizes the results in this respect. As shown in Table 1, PathFile and R-Pilot were significantly different in terms of canal transportation in mesiodistal direction at 1 and 2 mm from the apex \((P<0.01)\), but this difference was not significant at 3 mm from the apex. In terms of centering ratio in the mesiodistal direction, R-Pilot showed the highest centering ratio at 3 mm from the apex \((46.7\%)\) and the lowest centering ratio at 1 mm from the apex \((10\%)\). Chi-square test showed that this difference in centering ratio was statistically significant \((P<0.025)\). For the PathFile, the difference in centering ratio was not significant at three levels from the apex \((P=0.5)\).

Table 1 shows canal transportation and centering ability of PathFile and R-Pilot in buccolingual direction at different levels from the apex. As shown, canal transportation in buccolingual direction was significantly smaller following canal preparation with R-Pilot compared to PathFile at 1 mm from the apex. The difference in this respect was not significant at 2 and 3 mm from the apex \((P<0.7)\). The Fisher’s exact test showed that the higher centering ratio of PathFile at 1 mm from the apex and R-Pilot at 3 mm from the apex was significant compared to other levels \((P<0.05)\). The difference in centering ability of the two files in buccolingual direction was not significant at any level from the apex \((P<0.4)\).

Statistical analyses revealed that the R-Pilot system had the highest canal transportation towards the mesiolingual at 1, 2 and 3 mm from the apex. The PathFile system had the highest canal transportation towards the distobuccal at 1, 2 and 3 mm from the apex. In terms of centering ability, canal centering ratio was greater following the use of R-Pilot system at 1 and 2 mm from the apex (except for 2 mm level in buccolingual dimension) compared to the use of PathFile. This was reverse at 3 mm from the apex and the R-Pilot showed less centering ability than PathFile.

Table 1. Mean canal transportation and centering ratio for PathFile and R-Pilot at different levels from the apex (MD=mesiodistal, BL=buccolingual, WL=working length)

<table>
<thead>
<tr>
<th>Sample</th>
<th>MD Transportation</th>
<th>MD Centering Ability</th>
<th>BL Centering Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>PathFile1</td>
<td>0.95 (1.1)</td>
<td>1.36 (0.71)</td>
<td>26.7</td>
</tr>
<tr>
<td>PathFile2</td>
<td>1.2 (0.88)</td>
<td>1.4 (0.67)</td>
<td>36.7</td>
</tr>
<tr>
<td>PathFile3</td>
<td>0.8 (0.88)</td>
<td>0.9 (0.71)</td>
<td>36.7</td>
</tr>
<tr>
<td>R-Pilot 1</td>
<td>0.8 (0.55)</td>
<td>1.03 (0.7)</td>
<td>10</td>
</tr>
<tr>
<td>R-Pilot 2</td>
<td>0.8 (0.84)</td>
<td>1.3 (0.46)</td>
<td>20</td>
</tr>
<tr>
<td>R-Pilot 3</td>
<td>0.6 (0.62)</td>
<td>1.06 (0.46)</td>
<td>46.7</td>
</tr>
</tbody>
</table>

Discussion

Preserving the original anatomy of the root canal system is the cornerstone of a successful endodontic treatment. Many rotary systems have been introduced aiming to better preserve the original anatomy of root canals [10]. Preparation of curved canals is challenging and may be associated with procedural errors such as changing the degree of curvature or apical transportation. Creating a glide path is imperative to preserve canal anatomy and prevent endodontic instrument fracture [16, 17].

The current study compared canal transportation and centering ratio following canal instrumentation with R-Pilot and PathFile using CBCT. Both systems showed no significant difference in terms of canal transportation and centering ability. Our findings demonstrated that R-Pilot caused less transportation at 1 and 2 mm from the apex and had higher centering ability at 1 mm from the apex.

According to Peters [18], canal transportation by 0.1 mm or less is clinically acceptable. In the current study, the mean apical transportation was less than this value.

Dhingra et al. [10], in 2016 evaluated and compared canal transportation and centering ability of V Glidepath2 and PathFile and showed that PathFile caused greater transportation and had lower centering ability. Their findings were in agreement with ours. They had a methodology similar to ours but assessed sections at 0 to 7 mm from the apex. They reported the magnitude of transportation and centering ratio following the use of PathFile at 0 to 7 mm from the apex. Also, they reported that transportation was towards the distal on all sections except for 0 mm from the apex, on which, transportation was slightly towards the mesial; and at 5 mm from the apex, which did not show any transportation. Their findings were comparable to our results [19].

Another study evaluated change in anatomy of curved canals of mandibular first molars following the use of V Glidepath2 and PathFile on CBCT scans. The results revealed that both files...
caused transportation towards the distal, which was in accord with our observations. However, centering ability of PathFile in their study was higher than that in our study [15]. This difference in the results may be due to the reciprocating movement or packing of debris.

The R-Pilot system has safe reciprocating movement in counterclockwise direction and then in clockwise direction for 10 cycles/sec. It gets involved with dentin and moves forward [20, 21]. This movement is highly safe and evidence shows increased longevity and decreased fatigue in use of this movement. The current results confirmed those of previous studies that used instruments with reciprocating movement [22-24]. Significant difference between R-Pilot and PathFile in this study may be due to the type of reciprocating movement and type of M-wire alloy in R-Pilot, which are associated with increased flexibility.

Use of CBCT in endodontic treatments has gained increasing popularity due to general access to software programs such as Photoshop [25]. This technique is more accurate than the conventional methods. This technique does not require destruction of samples and its results have high reproducibility. It provides numerous images of canals and comprehensive information about root canals before, during and after mechanical preparation [21, 26-29]. Also, it has small equipment and is affordable [30]. Despite the numerous advantages of CBCT, micro-CT remains the gold standard for the assessment of centering ratio of different files [13].

In the current study, mesiobuccal root canals of maxillary first and second molars were used because these canals often have significant curvatures [25, 31]. These roots are very thin and wide, which highly complicate their mechanical preparation [32]. On the other hand, the second mesiobuccal canal orifice is hardly detected because a dentinal ledge masks it [33]. Its orifice has a mesiobuccal slope over the pulp chamber floor. Canal path in the coronal section has one or two curvatures that further complicate the procedure [25, 34].

**Conclusion**

Comparison of canal transportation and centering ratio following canal preparation with R-Pilot and PathFile systems on CBCT scans showed that the two systems were significantly different in this respect. R-Pilot caused less transportation at 1 and 2 mm from the apex and higher centering ability at 1 mm from the apex.

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Conflict of Interest: ‘None declared’.

**References**