Comparison of Remaining Root Dentine Thickness After Three Rotary Instrumentation Techniques By Cone Beam Computerised Tomography-An Invitro study

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ABSTRACT

Aim and Objectives: The aim of the study is to compare remaining dentine thickness at 3mm and 7mm from radiographic root apex before & after instrumentation with ProTaper, iRace and Heroshaper rotary files by Cone Beam Computerised Tomography.

Materials and Methods: For evaluation, 30 single rooted premolar teeth with less than 20% curvature were selected. Of these, 10 teeth were distributed for each group, where Group 1 included ProTaper rotary files; Group 2 included iRace rotary files and Group 3 included Heroshaper rotary files. Pre instrumentation and post instrumentation three-dimensional CT images with measurements were obtained from 3mm and 7mm radiographic root apex by cone beam computerized tomography and stored in the computer harddisk.

Result: It was observed that there was a significant difference at 7mm (P<0.05) and at 3mm there was no significant difference (P>0.05). ProTaper has removed more amount of dentin at 7mm when compared with iRace and Heroshaper rotary files and at 3mm almost all the three file systems removed same amount of dentin.

Conclusion: Under the conditions of the study we concluded that ProTaper should be used judiciously, as it causes higher thinning of root dentine at middle third of the root when compared with iRace and Heroshaper rotary files.

Keywords: Dentine thickness, Cone Beam Computerized Tomography; Nickel-titanium; ProTaper; iRace, Heroshaper rotary instrumentation.

INTRODUCTION

Successful root canal treatment depends upon many factors one of the most important factor is removal of microorganisms through chemomechanical instrumentation of the root canal system which includes removal of infected dentine and organic tissue by cleaning and shaping. This is done by enlarging and shaping of the canal to allow for adequate chemical debridement, while preserving the radicular anatomy.1

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Introduction of NiTi alloy for hand filing and later the launch of engine driven instruments have significantly altered the canal shaping procedure over past two decades. The advent of predefined tapered shapes to root canals was given great impetus with the introduction of NiTi titanium instruments. This strong and highly flexible alloy has allowed innovations in taper and flute design that had been impossible with stainless steel instruments.\(^2,3\)

Regardless of the instrumentation technique, cleaning and shaping procedures invariably lead to dentine removal from the canal walls but flaring the canals excessively decreases the dentin thickness resulting the reduction of remaining dentin thickness, thus increases the possibility of vertical root fracture.\(^4,5\) Thus, the remaining dentin thickness is important because the amount of dentine remaining enables the endodontically treated teeth to resist from fracture. Cleaning and shaping of the root canal space involves the elimination of pathogenic contents as well as attaining a uniform specific shape. However, the remaining root dentine thickness following the various intraradicular procedures is an important factor to be considered as an iatrogenic cause that may result in root fracture.\(^6\)

To measure the remaining root dentine thickness, methods such as scanning electron microscope,\(^7\) radiographic evaluation,\(^8\) photographic assessment\(^2,7\) and computer manipulation\(^9\) for comparative analysis were used for assessment of canal instrumentation. The above mentioned methods are invasive in nature, accurate repositioning of pre and post instrumented specimen is difficult, they are labor intensive, and there is a disadvantage of loss of specimen.\(^10\) As a result the information acquired by using these methods could be misleading. With the fast growing technological advances, what is demanded are non-invasive methods that would give precise information about canal preparation.

Recently, a non-destructive technology has been advocated for pre- and post instrumentation evaluation of canal. Cone Beam Computed tomography (CBCT) can render cross-sectional (cut plane) and 3D images that are highly accurate and quantifiable.\(^11\) Comparisons using CBCT have provided repeatable results and also have allowed non-invasive experimentation of various aspects of endodontic instrumentation. At any level, the amount remaining root dentine thickness can be viewed without loss of specimen.\(^11,12\)

**AIM AND OBJECTIVE**

The aim of the study is to compare remaining dentine thickness at 3mm and 7mm from radiographic root apex before & after instrumentation with ProTaper, iRace and Heroshaper rotary files by Cone Beam Computerised Tomography.

**MATERIALS AND METHODS**

30 single rooted premolar teeth, extracted for orthodontic reasons with less than 20% curvature according to criteria described by Schneider\(^13\) were selected. Teeth were stored in 10% formalin solution. An endodontic access cavity was prepared (figure 1). A patency K-file size #15 was passively introduced into the canal until it became visible from apical foramen. Working length was established at 1mm short of this point. Then teeth were divided into 10 teeth in each group (n=10). Occlusion rims are prepared (figure 2) with modeling wax with the size equivalent to bite plane (figure 3) of CBCT. Five teeth in each occlusal rims are inserted (figure 4), so each group consists of two occlusal rims with five teeth in each occlusion rim. To avoid confusion occlusal rims were marked with marker (figure 5) and pre instrumentation samples were scanned with CBCT (figure 6) at 3mm and 7mm from the radiographic apex and measurements are taken at four different levels on each slice (figure 8) and mean is calculated for each slice and stored in the computer hard disk (figure 9).

**Scanning & Imaging:** Three groups were scanned using CBCT (CS 3D IMAGING SOFTWARE 3.2.9) preoperatively before instrumentation. The CT scans were done by the CT scanner, at 60 KV and 5 mA, 76 μm thick sections. Two levels were chosen for evaluation in the CT. Sectioning was taken at 3mm and 7mm from radiographic root apex of the tooth. The images were stored in the computer’s hard disk for further comparison between pre instrumentation and post instrumentation data by using DiCom software.
GROUP 1 (ProTaper). Canals were prepared using a set of ProTaper instruments (Dentsply Maillefer). Canals were prepared using torque control endodontic handpiece (X-smart). The entire specimens were prepared according to the manufacturer's recommendation. The canals were finished when F3 reached the full WL.

Canals were irrigated with 3% NaOCl after each instrument, delivered by means of a gauge 27 needle, allowing for adequate back flow. PREP CANAL lubricant was used throughout the procedure. Post instrumentation teeth were then scanned under the same conditions as the initial scans (figure 11).

GROUP 2 (iRace). Canals were prepared using a set of iRace instruments (FKG Swiss Endo). Canals were prepared using torque control endodontic hand piece (X-smart). The entire specimens were prepared according to the manufacturer's recommendation. Canals were irrigated with NaOCl after each instrument, delivered by means of a gauge 27 needle, allowing for adequate back flow. PREP CANAL lubricant was used throughout the procedure. Post instrumentation teeth were then scanned under the same conditions as the initial scans (figure 11).

GROUP 3 (Heroshaper). Canals were prepared using a set of Heroshaper instruments (Micro-Mega). Canals were prepared using torque control endodontic hand piece (X-smart). The entire specimens were prepared according to the manufacturer's recommendation.

Canals were irrigated with NaOCl after each instrument, delivered by means of a gauge 27 needle, allowing for adequate back flow. PREP CANAL lubricant was used throughout the procedure. Post instrumentation teeth were then scanned under the same conditions as the initial scans (figure 11).

STATISTICS: All the analysis was done using SPSS version 16. A p-value of <0.05 was considered statistically significant. Comparison of mean pre and post values was done for each group with paired t test.

RESULTS

Table 1: Table showing mean and standard deviation at 3mm and 7mm for three groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>p-value</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>0.15</td>
<td>0.05</td>
<td>0.14</td>
<td>0.05</td>
<td>0.13</td>
<td>0.05</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0.05</td>
<td>0.13</td>
<td>0.05</td>
<td>0.14</td>
<td>0.05</td>
<td>0.13</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>0.684; NS</td>
<td>0.050.684; NS</td>
<td>0.050.684; NS</td>
<td>0.050.684; NS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ANOVA

Table 1 shows no significant difference was seen at 3mm level among the three groups (p=0.684) while there was significant difference in the mean difference among the three files at 7mm group (p=0.047). Hence post-hoc Tukey's test was performed to evaluate significant differences.

Graph 1: Graph showing amount of dentine removed at 3mm and 7mm respectively by each group.

Table 2: Table Showing Intergroup Mean Difference And Significant Value At 3mm And 7mm Respectively

<table>
<thead>
<tr>
<th>Intergroup</th>
<th>Mean Difference</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 vs 2</td>
<td>0.01</td>
<td>0.900; NS</td>
</tr>
<tr>
<td>1 vs 3</td>
<td>0.02</td>
<td>0.658; NS</td>
</tr>
<tr>
<td>2 vs 3</td>
<td>0.01</td>
<td>0.900; NS</td>
</tr>
<tr>
<td>7mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 vs 2</td>
<td>0.07</td>
<td>0.043; Sig</td>
</tr>
<tr>
<td>1 vs 3</td>
<td>0.05</td>
<td>0.046; Sig</td>
</tr>
<tr>
<td>2 vs 3</td>
<td>-0.02</td>
<td>0.749; NS</td>
</tr>
</tbody>
</table>

Post-hoc Tukey's test.
It was observed there was significant difference at 7mm (P<0.05) and at 3mm there was no significant difference (P>0.05) from Table II. Protaper has removed more amount of dentin at 7mm when compared with iRace and Heroshaper rotary files and at 3mm almost all the three file systems removed same amount of dentin.

**DISCUSSION**

In the present study we have used CBCT to evaluate the remaining root dentine thickness. During the last few decades, a number of methodologies have been described to evaluate
endodontic instrumentation, including plastic models 14, histologic sections 15, scanning electron microscopic studies 16, serial sectioning13,17,18, radiographic comparisons 19, and silicone impressions of instrumented canals 20.

One of the latest innovations in the industrial and medical field is the use of CBCT for study purposes; this scientific tool could develop a potential in endodontic research as well. Which provided a practical and nondestructive technique for assessment of remaining root dentine thickness before and after shaping according to Gluskin et al 21. It provided horizontal cut-planes along root length at right angle to the long axis of the canal, which provided standardized sectioning of all specimens. With thickness of 0.75 mm, these numbers of sections allowed accurate evaluation of any changes in dentin thickness along root length. CBCT image analysis software CS (3D IMAGING SOFTWARE3.2.9) allowed preinstrumentation and postinstrumentation measuring of remaining root dentine thickness and hence calculations of the amount of removed dentin during cleaning and shaping of the root canal without complicating procedures, destructive sectioning of the specimens, or loss of the root material during sectioning. There are also no instrumentation problems passing through sections that could affect the instrumentation outcomes. Also, CBCT scans allow easy measurement of canal changes, because each image has an accurate scale, decreasing the potential of a radiographic or photographic transfer error. 3

The trend to tapered canal shapes for cleaning efficacy and obturation mechanics has been a slow and measured conversion during the
Fig 11: Results showing pre and post instrumentation At 3mm And 7mm from radiographic apex.

last 2 decades. Step-back and/or crowndown strategies for shaping have been the established paradigm for creating tapered shapes during the last 20 years. The advent of predefined tapered shapes to root canals was given great impetus with the introduction of NiTi titanium instruments. This strong and highly flexible alloy has allowed innovations in taper and flute design that had been impossible with stainless steel instruments. In addition, increased taper combined with NiTi alloy allowed more predictable use of rotary methods to provide consistent canal shape.

Most dangerous for even experienced clinicians is the increased potential for structural loss during shaping. Adequate taper shape provides enough space for irrigants that are important to complete the canal cleaning and allows the placement of an effective root filling, the control of instruments, and the quality of root canal sealing. But at the same time removal of excess root dentine may lead to root fracture.

The results showed that there is a statistically significant difference at 7mm from radiographic root apex between protaper and iRACE and protaper with heroshaper because protaper has increasing taper 3.5% to 19% stated by Zhang et al. With regard to our study on extracted teeth, the amount of dentin removed by ProTaper was statistically significantly greater than that of Hero Shaper, which is in agreement with Uyanik et al but the amount of dentin removed by ProTaper was measurably greater than that reported in the study by Peters et al, presumably because of the last instrument used. Those researchers finished their instrumentation with the file F2, whereas the last file used in this study was F3 the reasoning behind use of all files for ProTaper in the present study was to achieve the same size with all tested instruments, thereby enabling comparisons.

At the middle level (7mm), Group1 (ProTaper) showed higher removal of dentine which can be mainly attributed to progressive taper along the cutting surface in combination with the sharp cutting edges. Progressively tapered design along with triangular convex cross sectional design could have led to aggressive cutting according to Ruddle CJ et al. The amount of dentine removed by iRACE and Heroshaper is less because of its less taper compared to protaper.
No statistical difference for remaining root dentine at apical level at 3mm between three groups could be attributed to the non cutting modified safety tip of the ProTaper, Heroshaper and iRace rotary files.

**CONCLUSION**

Under the circumstances of this study, we concluded that Protaper has good efficiency to remove infected dentine from root but at the same time it has the tendency to remove excess dentine from middle third of the root, which may lead to root fracture. This is an important finding which could be considered under clinical situations. Research should continue to further improve instrument design, preparation techniques, and methodologies that are used to evaluate the action of endodontic instruments inside the root canal, aiming at solving the problems inherent to shaping of canals an important and difficult phase of the endodontic therapy. According to study Protaper removed more remaining root dentine when compared with Heroshaper and iRace at 7mm from radiographic root apex, but at 3mm almost all the three rotary systems removed same amount of dentine.

**CONFLICT OF INTEREST**

No potential conflict of interest relevant to this article was reported.

**REFERENCES**

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