A comparative evaluation of root canal area increase using three different nickel-titanium rotary systems: An *ex vivo* cone-beam computed tomographic analysis

Adrija Deka, A.C. Bhuyan, Darpana Bhuyan

Abstract

Background and Objectives: The present study was undertaken to compare and evaluate the area increase of root canals with ProTaper, iRaCe and Revo-S systems using cone beam computed tomography for analysis. **Materials and Methodology:** Forty five extracted human mandibular premolars having single canal and straight root were collected. Teeth were randomly assigned to three groups (n=15). Samples were decoronized by maintaining root length at 14 mm. Pre-instrumentation cone beam computed tomography scan was done after stabilizing the samples on wax blocks. The working length was determined at 1 mm short from the apical foramen by using a ISO 15 K-file tip protruding at apical foramen. Preparation was carried out according to the manufacturer's instructions. Finally, canals were instrumented upto 30/.06 apically for each group. After each instrumentation, root canals were irrigated with 2ml of 3% sodium hypochlorite solution followed by 2 ml of 17% EDTA solution. Final irrigation was done with 5ml of saline. Post instrumentation cone beam computed tomography scans of all samples in the 3 groups were acquired. **Results:** Mean percentage of area increase in different thirds of the canal was highest for ProTaper followed by i-RaCe and Revo-s system which was statistically significant. **Interpretation and Conclusion:** Root canal area increase was highest for ProTaper followed by i-Race and Revo-S systems.

Keywords: Area increase, cone beam computed tomography, i-RaCe System, ProTaper System, Revo-S System

Introduction

Mechanical preparation of the root canal system is recognized as one of the most important stages in root canal treatment.[1] The quality guideline of the European Society of Endodontology states that the elimination of residual pulp tissue, the removal of debris, and the maintenance of the original canal curvature during enlargement are the primary objectives of root canal instrumentation.[2]

Various nickel-titanium (Ni-Ti) instruments have been developed for manual use or for use with rotary endodontic handpieces since 1988 the first Ni-Ti files were evaluated (Walia *et al*).[3] As different Ni-Ti systems are available commercially, detailed investigation of their shaping effect is becoming more important to understand how design features affect performance.[4,5]

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The amount of dentin being removed during instrumentation is an important parameter to avoid procedural mishaps such as strip perforations.[3,6] Currently, experimental results have shown that Ni-Ti rotary systems cause less canal transportation and produce a more centered and tapered preparation. Advanced instrument designs including noncutting tips, radial lands, different cross sections, and varying tapers have been developed to improve working safety, to shorten working time and create a greater flare of preparations.[7,8]

Radiographic examination is essential in diagnosis and treatment planning in endodontics.[9] Conventional radiographic technologies provide two-dimensional representations of three-dimensional (3D) objects.[10,11] To overcome the shortcomings of conventional radiographs, advanced digital imaging modalities were introduced in dentistry, one of which is cone-beam computed tomography (CBCT).

Computed tomography was initially used in endodontics to confirm the diagnosis of root fractures, to analyze root canal walls and pulp chamber anatomy. More recently, this method has been used to evaluate root canal preparations.[12,13]

Thus, acknowledging the importance of preserving the remaining dentinal thickness through proper usage of various instrument systems, the purpose of this study was to compare and evaluate the area increase of root canals using three different Ni-Ti rotary systems ProTaper, i-RaCe, and Revo-S systems.

Materials and Methods

Forty-five freshly extracted human mandibular premolars having single canal and straight root were collected. Samples were stored in normal saline solution until use. They were randomly divided into three groups containing 15 specimens in each of them. Buccal and proximal radiographs (Dental Intraoral E-speed films) were made to ensure that the teeth had only one canal.

Test apparatus

Samples were decoronized by maintaining root length at 14 mm. Preinstrumentation CBCT scan was done after stabilizing the samples on wax blocks [Figures 1-3]. The working length was determined at 1 mm short from the apical foramen using an ISO 15 K-file tip protruding at apical foramen.

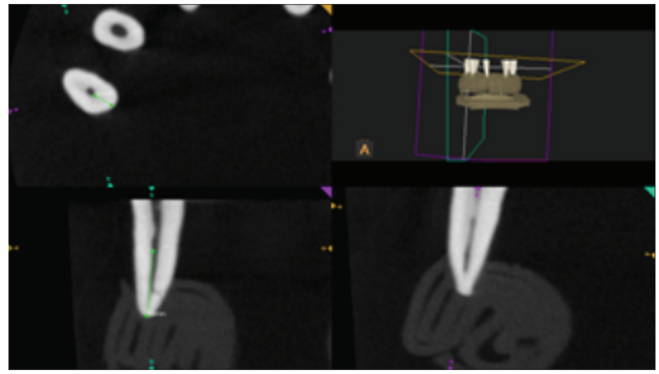

Figure 1: Preoperative CBCT scan at coronal third

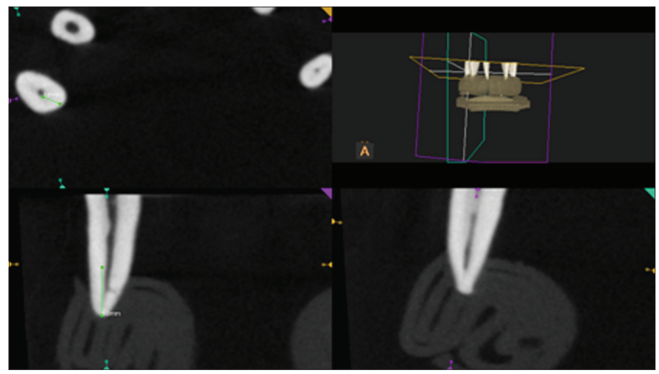

Figure 2: Preoperative CBCT scan at middle third

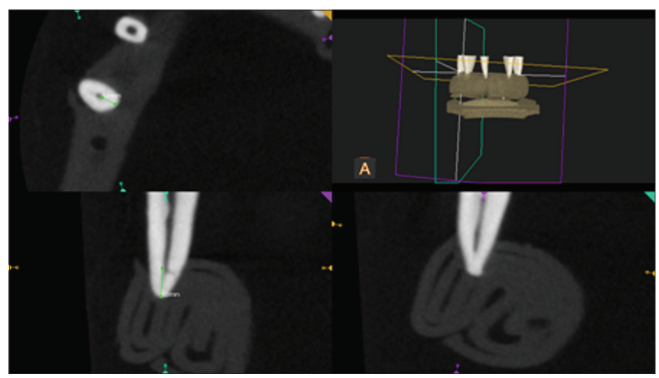

Figure 3: Preoperative CBCT scan at apical third

Root canal preparation

All root canals were widened to an ISO 20 K-file (Denstply, Maillefer) inserted with balanced force movements through the working length, avoiding apical pressure, and under abundant irrigation.

Rotary instruments were used with Endomate DT (NSK, Japan) according to manufacturer's recommendation.

For ProTaper (Dentsply Maillefer) group, first SX instrument was used up to one-third of the working length and proceeded with S1, S2 instruments at 300 rpm and a torque of about 3 Ncm till two-third of the working length. This was followed by instrumentation with F1, F2, and F3 up to the working length, avoiding apical pressure, and applying gentle strokes against the canal walls.

For i-RaCe group, instruments were used in a crown-down manner at 600 rpm and a torque of 2 Ncm. File sequences used were: Size 15/0.06 was used up to working length, followed by sizes 20/0.04, 25/0.06, and 30/0.06 all up to the working length. Size 15 K-file was used at the working length between each file in order to prevent the apical blockage.

For Revo-S (Micro-Mega) group, instruments were used with a rotation speed of 400 rpm and a torque of 2 Ncm. Instrument sequence used were: Size 25/0.06 up to two-third the working length, sizes 25/0.04 and 25/0.06 until the apex was reached. This shaping was done in free progressive strokes without pressure. Finally, canals were instrumented up to size 30/0.06 for apical finishing. Recapitulation with smaller size files was done during chemomechanical preparation.

After each instrumentation, root canals were irrigated with 2 ml of 3% sodium hypochlorite solution (Vensons, Bengaluru, India) followed by 2 ml of 17% EDTA solution (Deor Care, Kerala, India). Final irrigation was done with 5 ml of saline (Claris Lifesciences, Ahmadabad, India). After each rinse, an ISO 10 K-file was inserted inside the canal to check apical patency.

Sample analysis

Postinstrumentation CBCT scans of all samples in the three groups were acquired. The images were saved and were edited with CS3 Photoshop software (Adobe Systems Inc.), recorded in Tagged Image File Format and analyzed by Image Tool 3.0 software for Windows software (University of Texas Science Center, USA). The area of each canal was measured at the apical (3 mm from the tip of the radiologic apex), middle (5 mm from the tip of the radiologic apex) and cervical (7 mm from the tip of the radiologic apex) thirds before and after instrumentation for comparison among the three rotary systems as well as to evaluate the area increase in the three-third of the canal [Figures 4-6].

Data were analyzed using one-way ANOVA test for multiple comparisons followed by Tukey's *post-hoc* test for group comparisons. Comparisons of area measurements before and after instrumentation were carried out by Student's *t*-test.

Results

Tables 1 and 2 shows the means and standard deviations in root canal area for each system pre- and post-operative values at different thirds.

Table 3 depicts mean percentage of area increase in different thirds of the canal for each system. At apical third, the mean percentage of area increase was highest ($P < 0.05$) with ProTaper (36.921) followed by Revo-S (30.76) and least with i-RaCe (29.70). Similarly, at the middle third and coronal third, the mean percentage was highest for ProTaper (31.43) and (33.16) followed by Revo-S (30.33) and (30.71) and least with i-RaCe (28.79) and (28.78), respectively.

Discussion

There is overwhelming evidence that the reduction in intracanal micro-organisms is the major goal of endodontic therapy. The primary goals that an endodontist must achieve with root canal treatment are complete disinfection of the canal space, elimination of the progression of the periradicular tissue inflammation and thereby creation of favorable conditions for periradicular healing. This can be achieved using a proper chemo-mechanical preparation which is essential for successful endodontic treatment.[14]

However, traditional hand instruments often failed in achieving these objectives. Most canals are curved, whereas endodontic instruments are manufactured from straight metal blanks. This results in uneven force distribution in certain contact areas and a tendency of the instrument to straighten itself inside the canal. Consequently, apical canal areas tend to be overprepared toward the outer curve or the convexity of the canal, whereas more coronal areas are transported toward the concavity.[1,2]

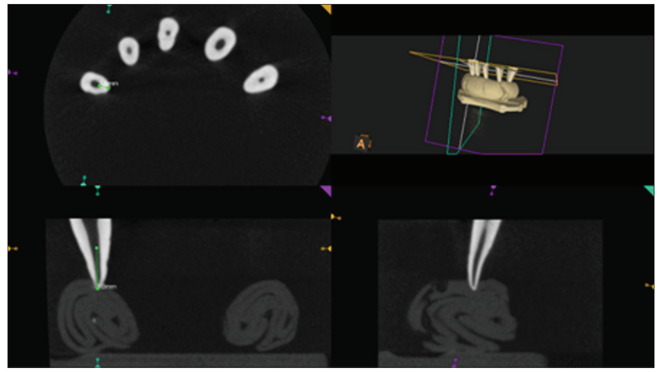

Figure 4: Postoperative CBCT scan using proTaper at coronal third

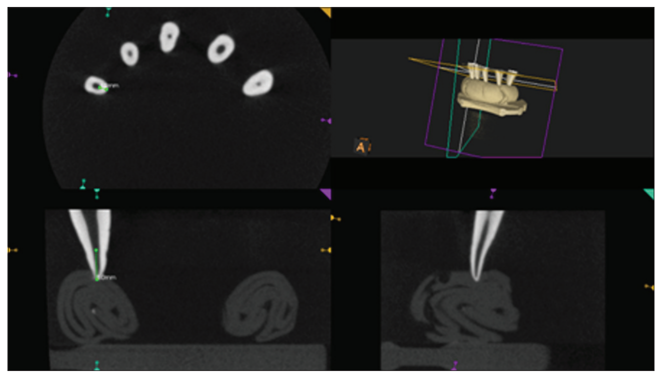

Figure 5: Post operative CBCT scan using ProTaper at middle third

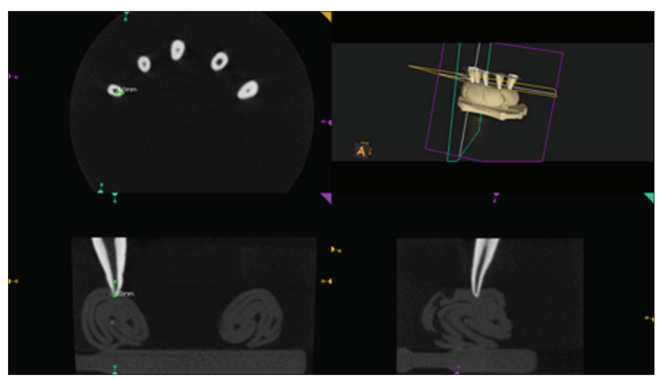

Figure 6: Postoperative CBCT scan using ProTaper at apical third

Table 1: Means and standard deviations in root canal area for ProTaper and i-RaCe systems pre operative and post operative values at different thirds

ProTaper and i-RaCe	Mean±SD			
	Preoperative	Postoperative	Preoperative	Postoperative
At apical 3rd	0.93±0.371	0.59±0.276	1.42±0.286	1.00±0.203
At middle 3rd	1.29±0.439	0.85±0.285	1.72±0.267	1.22±0.200
At coronal 3rd	1.54±0.489	1.05±0.304	1.96±0.235	1.40±0.259

SD: Standard deviation

Table 2: Means and standard deviations in root canal area for Revo-S system pre operative and post operative values at different thirds

Revo-S	Mean±SD	
	Preoperative	Postoperative
At apical 3rd	1.21±0.140	0.84±0.140
At middle 3rd	1.52±0.179	1.02±0.133
At coronal 3rd	0.84±0.140	1.20±0.164

SD: Standard deviation

Table 3: Mean percentage of area increase in different thirds of the canal for each system

Levels	ProTaper±SD	i-RaCe±SD	Revo-S±SD
Apical 3rd	36.921±9.285	29.70±5.562	30.76±8.290
Middle 3rd	31.43±11.668	28.79±6.454	30.33±8.359
Coronal 3rd	33.16±8.441	28.78±8.063	30.71±8.479

SD: Standard deviation

Various studies have investigated the efficiency of Ni-Ti rotary instruments, but few have examined the ability to increase root canal area.[13] In the present study, three Ni-Ti rotary systems namely ProTaper, i-RaCe, and Revo-S were used to investigate the canal area increase before and after instrumentation.

Varieties of rotary systems are available commercially, but one has to choose tactfully considering each canal morphology as unique in order to avoid untoward iatrogenic errors. According to Peters, an important mechanical objective is to leave as much radicular dentin as possible so as not to weaken the root structure, thereby preventing vertical fractures. Although no definitive minimal radicular thickness has been established, 0.2 mm is considered critical. [15,16]

In the present study, a crown down instrumentation sequence was performed as recommended by the manufacturers for the three rotary systems. According to Schafer *et al*., this technique is mandatory to reduce intracanal friction and thus minimize the risk of instrument separation.[17]

In the present study, ProTaper showed a greater amount of dentin removal compared to i-RaCe and Revo-s especially for the middle and coronal thirds. The greater cutting ability of ProTaper in the middle and coronal parts has been confirmed by Paqué *et al*. This could probably be related to the sharp cutting edges of the convex triangular cross-sectional design and its flute design that combines multiple tapers within the shaft up to 19%.[13,18]

The i-RaCe instruments have alternating cutting edges, and this design is alleged to have two functions: (i) To eliminate screwing in and blocking in continuous rotation and (ii) to reduce the working torque. In the present study, Revo-S and i-RaCe seemed to remove the less dentin from both middle and coronal portions compared to ProTaper, which is statistically significant and in accordance with previous studies.

Revo-S (Micro-Mega, France), another Ni-Ti rotary system was developed with a distinctive asymmetric cross-section intended to decrease the stress on the instrument. Revo-S showed less dentin removal than ProTaper and i-RaCe at all the different thirds. This is in agreement with the previous *in vitro* studies.[19]

No file separations occurred in the present study. However, studies have showed that ProTaper systems are more prone to file separation.

In endodontics therapy, the quality and quantity of the information obtained from radiographic examinations are very important, because they affect the diagnosis, treatment planning, and prognostic stability.[2]

Volumetric or CBCT, a relatively new diagnostic imaging modality has been used in endodontic imaging.[4] A review of digital and 3D applications for endodontic uses published by Nair and Nair summarized the CBCT portion by stating that such technology has proved useful for localization and characterization of root canals, treatment planning of periapical surgery and detection of root fractures in extracted teeth.[20,21]

In the present study, we have used CBCT, which provided a practical and nondestructive technique for assessment of canal morphology before and after shaping according to Gluskin *et al*.

Cone-beam computed tomography image analysis software was used which allowed pre- and post-instrumentation measuring of root canal area increase. Under the circumstances of this current *in vitro* study, it suggests that ProTaper showed maximum canal area increase in middle and coronal thirds of the root canal compared to i-RaCe and Revo-S systems which were statistically significant. On the other hand, i-RaCe had removed the least dentin compared to ProTaper and Revo-S systems. Moreover, the mean percentage of area increase showed that ProTaper achieved the most followed by Revo-S and i-RaCe systems. Further research is needed in order to confirm and elaborate on its canal transportation, uninstrumented surface area, and preservation of dentin thickness which affects the prognostic stability of the teeth.

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