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RESEARCH ARTICLE

AN IN-VITRO EVALUATION OF PREPARATION OF FLAT-OVAL CANALS USING SELF-ADJUSTING FILES AND ROTARY NI-TI SYSTEM, BY CBCT

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ABSTRACT

The purpose of this study was to evaluate the root canal preparation in flat-oval root canals of distal roots of mandibular molars treated with either Rotary or Self-Adjusting File (SAF) by using CBCT analysis. *Method*: Forty human mandibular molars extracted due to non-restorability and periodontal reasons were selected. Teeth were accessed by using high-speed diamond burs. Mesial roots of all teeth were separated at furcation by using a diamond disc.Apical patency of single distal canal was determined. Forty Specimens were randomly divided to two experimental groups (n = 20) according to the instrumentation technique. Group A: Rotary ProTaper, Group B: SAF. Specimens from both groups were scanned using Cone Beam Computed Tomography before and after instrumentation with Rotary ProTaper and SAF. Three levels were chosen for measurements: apex (level 1), middle (level 2) and coronal (level 3). For evaluation of root canal preparation, the differences in pre- and post-instrumentation measurements were obtained for the samples in each group. The values of differences thus obtained were subjected to statistical analysis using independent t-test and the mean values of differences at four coordinates (buccal, lingual, mesial and distal) were obtained at three levels of the canals (apex, middle and coronal). *Results:* From the statistical analysis, it was observed that both the groups prepared canals satisfactorily. The mean values of differences in pre and post instrumentation measurements were not statistically significant at all three levels. However, at each level the performance of both the instrument systems was different in all four directions. Although the statistical analysis of the coronal, middle and apical third showed no difference between both the groups, the results clearly showed that both the instrument groups differed from each other in preparing flat-oval shaped canals. *Conclusion:* SAF prepares flat-oval shaped canals homogenously at coronal and middle third, resulting in uniform, and circumferential removal of dentin. However at the apical third, Rotary ProTaper is more effective in canal preparation.

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INTRODUCTION

Endodontic therapy involves treating vital and necrotic dental pulps so that patients can retain their natural teeth in function and esthetics. Although successful therapy depends on many factors, one of the most important steps in any root canal treatment is canal preparation. Root canals have different shapes in cross section, including oval shapes, and difficulties have been noted in cleaning these oval canals (Ove, 2004). The goal of instrumentation is to provide a continuously tapered preparation that maintains original root canal anatomy, keeping the foramen without any ledge and transportation from the original canal curvature.

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A variety of instruments are available for the root canal instrumentation. For many years, hand files are the most commonly used for endodontic instruments. Since the early 1990s, several endodontic instrument systems manufactured from nickel-titanium (NiTi) have been introduced into endodontic clinicpractice (ÖzkanAdiguzel, 2011). As long as the canals are simple, straight and narrow, with a round crosssection, NiTi instruments are likely to achieve the goals of root canal instrumentation and shaping. Nevertheless, rotary instruments may fail to meet the challenge of either oval or curved canals. This need currently remains unmet due to (a) the challenge of three-dimensional (3D) cleaning and shaping of oval and curved canals, (b) the microbiological challenge of infected oval canals and (c) the challenge of 3D obturation of oval canals. Above and beyond all of these, (d) the challenge of maintaining the integrity of the remainingradicular dentin, was recently recognized (Zvi Metzger, 2014). To overcome the inherent problems of the nickel-titanium instruments, a new concept in cleaning and shaping is warranted; hence, the self-adjusting file (SAF) was developed (Zvi Metzger, 2010). The SAF is the first file that does not have a solid metalshaft. The file hasan asymmetrically positioned tip, located at the wall of the tube as opposed to the symmetrically centered tips found in all conventional nickel titanium rotary files. The SAF system is extremely flexible and also extremely compressible. The compressibility also enables the file to adapt to thecross-sectional shape of the canal (Zvi Metzger, 2014). Hence the purpose of this study was to evaluate the root canal preparation in flat-oval root canals of distal roots of mandibular molars treated with either rotary or SAF by using CBCT analysis.

MATERIALS AND METHODS

Forty human mandibular molars extracted due to non-restorability and periodontal reasons were selected. Tissue fragments and calculus were removed. 0.5% sodium hypochlorite (NaOCl) was used in wide mouthed plastic jars for initial collection and storage medium. Teeth were radio graphed in mesiodistal and buccolingual directions to check for the single distal canal and to confirm flat-oval canal. Teeth were accessed by using high-speed diamond burs. After confirming that there is single distal canal, mesial roots of all teeth were separated at furcation by using a diamond disc.Apical patency of single distal canal was determined by inserting a size10 K-file into the root canal until its tip was visible at the apical foramen;working length (WL) was set 0.5 mm shorter of this measurement. Aglide path was confirmed at least to a size #20 K-file.

Forty Specimens wererandomly divided to two experimental groups (n = 20) accordingto the instrumentation technique.
Group A: Rotary ProTaper
Group B: SAF

In order to standardize the position for the preoperative and postoperative CBCT scans of the specimen, a template was fabricated using rubber base putty form impression material. Specimens in each group were mounted on a template in such a way that crowns were embedded in the template and roots were exposed in air. This template allowed accurate repositioning of the specimens and enabled us to maintain the standard pre and post instrumentation position of the specimens throughout the study.

Pre instrumentation CBCT Scanning

Specimens from both groups were scanned using Cone Beam Computed Tomography (with the acquisition as Kv: 60, X-Ray Tube Current: 2.5 mA and Exposure time: 5 seconds) before instrumentation. The templates were fitted on a Fox scale and adapted to a Cone Beam I – Cat Tomograph. The images were captured in a small field of view (5 cm) with a matrix of 1280 X 1280 pixels. These images were then transferred to InVivo Dental Viewer software and measurements were done. The linear measurements (mm) were taken from the canal wall to the external surface of the root in buccal, lingual, mesial and distal sides. Three levels were chosen for measurements: apex (level 1), middle (level 2) and coronal (level 3).

Group A

Root Canal Preparation with Rotary ProTaper Instruments: In group A for each specimen, the canals' orifices were enlarged using ProTaperSX rotary files (Dentsply-Tulsa Dental), which were used with a brushingmotion. The S1 rotary file was used next until the working length wasreached followed by the S2, F1, and F2 rotary files. All Rotary Pro Taper files were operated at 300 rpm. All files were always coated with RC Prep before insertion into the canal, and all canals were irrigated after each file use with 2 mL 3% sodium hypochlorite.

Group B

Root Canal Preparation with SAF

A 1.5-mm diameter SAF (ReDent-Nova) was operated for 4minutes by using a trans-line (in-and-out) vibrating handpiece (Gentle-Power Lux 20LP; KaVo, Biberach, Germany) adapted with a RDT3 head(ReDent-Nova) at a frequency of 83.3 Hz (5000 rpm) and amplitude of0.4 mm. The instrument was used with a manual in-and-out motion tothe WL. Continuous irrigation with 2.5% NaOCl was applied throughoutthe procedure at 5 mL/min by using a special irrigation apparatus (VATEA; ReDent-Nova).

Post-instrumentation Scanning

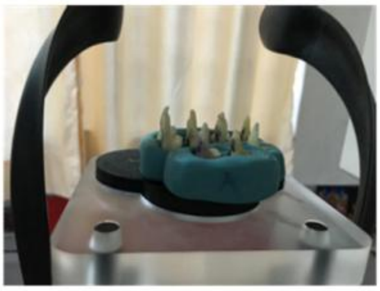
Post instrumentation CBCT scanning was done for the specimens in both the groups using same parameters as in pre instrumentation scan and measurements were taken in the similar way like in pre instrumentation measurements.

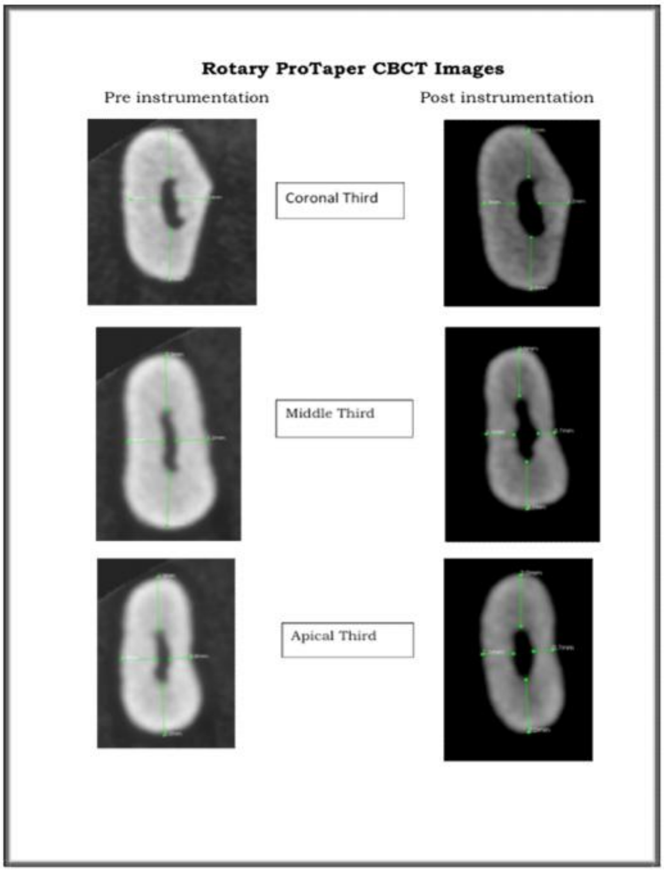
Statistical Analysis

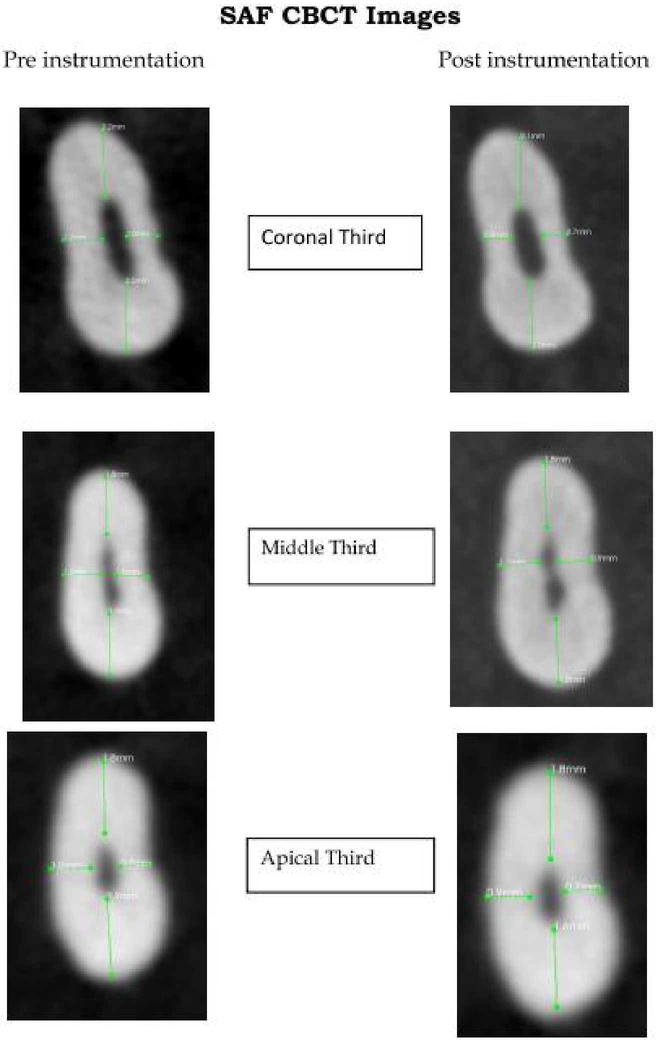
The values of pre- and post- instrumentation measurements were subjected to the statistical analysis by independent student t-test. The prepared and unprepared surfaces were obtained by Chi-square test and the ratios of means of the differences were subjected to statistical analysis by using student t-test.

CBCT Machine

Template fitted on a Fox Scale





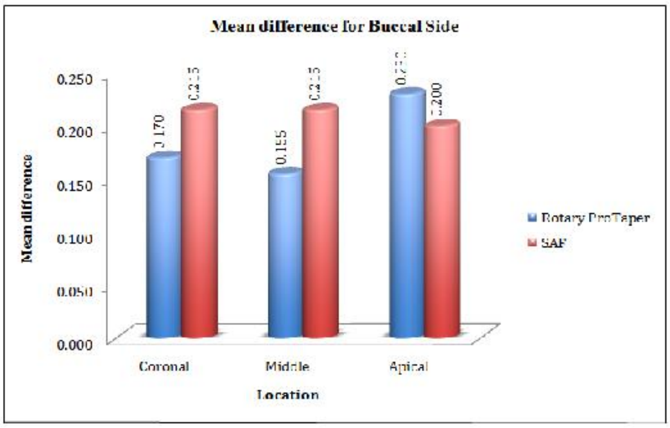


RESULTS

Comparison of mean difference (Pre and post) between Rotary ProTaper and SAF for coronal, Middle and Apical location for Buccal side.

Difference (Pre -Post)	Rotary ProTaper (n=20)		SAF (n=20)		p-value
	Mean	SD	Mean	SD	
Coronal	0.170	0.138	0.215	0.131	0.297
Middle	0.155	0.136	0.215	0.131	0.163
Apical	0.230	0.130	0.200	0.156	0.513

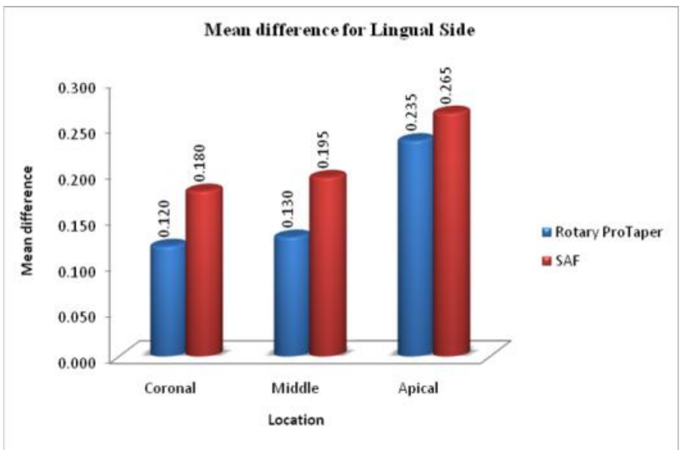
Conclusion: By using 2 independent sample t-test p-value > 0.05 therefore there is no significant difference between mean difference between Rotary ProTaper and SAF with respect to coronal, Middle and Apical location for Buccal side.



Comparison of mean difference (pre and post) between Rotary ProTaper and SAF for coronal, Middle and Apical location for Lingual side.

Difference (Pre -Post)	Rotary ProTaper (n=20)		SAF (n=20)		p-value
	Mean	SD	Mean	SD	
Coronal	0.120	0.083	0.180	0.140	0.110
Middle	0.130	0.134	0.195	0.123	0.119
Apical	0.235	0.127	0.265	0.195	0.569

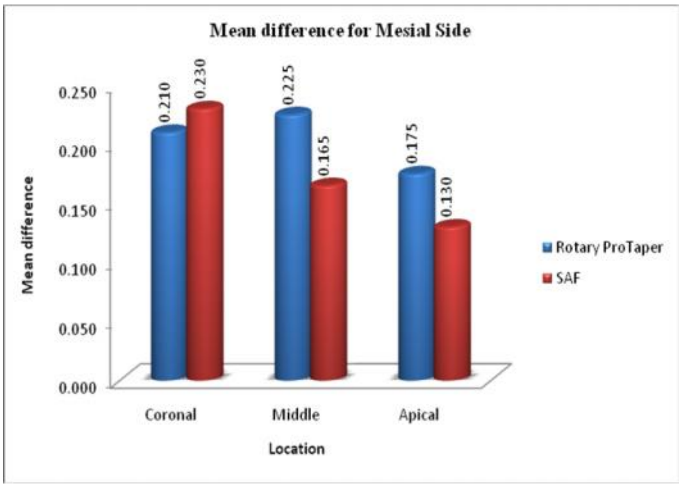
Conclusion: By using 2 independent sample t-test p-value > 0.05 therefore there is no significant difference between mean difference between Rotary ProTaper and SAF with respect to coronal, Middle and Apical location for Lingual side.



Comparison of mean difference (Pre and post) between Rotary ProTaper and SAF for coronal, Middle and Apical location for Mesial side.

Difference (Pre -Post)	Rotary ProTaper (n=20)		SAF (n=20)		p-value
	Mean	SD	Mean	SD	
Coronal	0.210	0.055	0.230	0.172	0.625
Middle	0.225	0.152	0.165	0.123	0.177
Apical	0.175	0.085	0.130	0.126	0.195

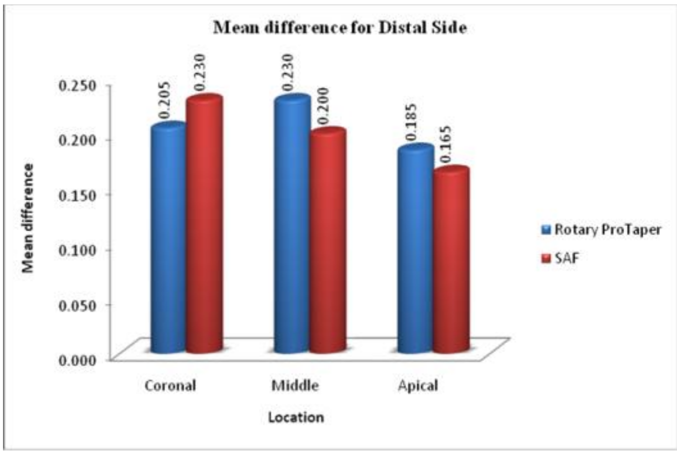
Conclusion: By using 2 independent sample t-test p-value > 0.05 therefore there is no significant difference between mean difference between Rotary ProTaper and SAF with respect to coronal, Middle and Apical location for Mesial side.



Comparison of mean difference (Pre and post) between Rotary ProTaper and SAF for coronal, Middle and Apical location for Distal side.

Difference (Pre -Post)	Rotary ProTaper (n=20)		SAF (n=20)		p-value
	Mean	SD	Mean	SD	
Coronal	0.205	0.100	0.230	0.130	0.500
Middle	0.230	0.073	0.200	0.117	0.338
Apical	0.185	0.109	0.165	0.109	0.565

Conclusion: By using 2 independent sample t-test p-value > 0.05 therefore there is no significant difference between mean difference between Rotary ProTaper and SAF with respect to coronal, Middle and Apical location for Distal side.



DISCUSSION

The intrinsic anatomy of the root canal system createschallenges, emphasizing the necessity of proper disinfection measures. Isthmuses, inter-canal communications, curvatures and oval shaped canals can make disinfection a considerable challenge (Mohammadi, 2015). The goal of cleaning and shaping may be easily and reproducibly achieved with rotary files as far as relatively straight and narrow root canals with a round cross-section are concerned. In such canals, completion of the file sequence may result in a clean canal with no tissue debris and with removal of all or most of the inner layer of the heavily contaminated dentin. Nevertheless, in flat oval-shaped root canals and in curved ones, this goal is not easily attainable (Zvi Metzger, 2010). All current rotary files have one or another type of spiral blade and helical formation that when rotating machines the root canal into a form that has a round cross-section. Substantial untouched areas may be left on the buccal and lingual sides of a flat root canal or on the side facing the isthmus in tear-shaped ones. Furthermore, such root canals may never be adequately obturated and sealed because the root canal filling or even the sealer will be separated from the canal wall by the remaining tissue and debris, providing a potential space for bacterial growth and/or future recontamination of the root canal with bacteria. Furthermore, the operator may not be aware that anything went wrong because the root canal filling may look satisfactory on the x-ray (Zvi Metzger, 2010).

To overcome the inherent problems of Rotary NiTi files like apical transportation in curved canals, straightening of the root canals at mid-root sections of curved root canal and unexpected separation of the nickel-titanium instruments, a new concept in cleaning and shaping is warranted; hence, the self-adjusting file (SAF) was developed (Zvi Metzger, 2010). The Self Adjusting File (SAF) (ReDent-Nova, Raanana, Israel) has been introduced in an effort to eliminate above mentioned limitations of NiTi instruments. It is a unique, hollow, flexible instrument designed as a compressible thin walled pointed cylinder. It is claimed that the flexibility and the compressibility allow the instrument to conform to the canal shape (both longitudinally and cross-sectionally) providing a three-dimensional adaptation. The instrumentis operated using a reciprocating, vibrating handpiece. The hollow design allows for a continuous delivery of irrigant solutions (Mohammadi, 2015). The present in-vitro study was aimed to evaluate the root canal preparation of flat-oval root-canals treated with either Rotary ProTaper Files or SAF by using CBCT analysis. Distal roots with single canal of extracted mandibular molars were used because they usually present flat-oval canals.

For CBCT imaging, a template of rubber base impression material was used to mount the specimens of each group. This template allowed accurate repositioning of the specimens and enabled us to maintain the standard pre and post instrumentation position of the specimen throughout the study. Specimens were mounted in such a way that crowns were embedded in the impression material and roots were exposed in air. This was done to reduce the structural noise created by rubber base template on the CBCT image of the roots. Keeping the roots exposed outside the template, we could achieve better contrast and roots were seen clearly. To investigate the efficiency of instruments and techniques developed for root canal preparation, a number of methods have been used to compare the canal shape before and after preparation. Various methods include radiographic evaluation, scanning electron microscopy, the Bramante method and Kuttlers endodontic cube. Various studies have shown that radiographic images provide a two dimensional image of a three dimensional object and are highly subjective, therefore results are not reliable (Sergio Kuttler, 2001). Recently, digital radiography including advanced imaging such as Computed Tomography (CT), Cone

Beam Volumetric Imaging (CBCT), and micro-CT are commonly used in endodontics. In our study, to evaluate canal preparation, specimens from both the groups were scanned before and after instrumentation, using Cone Beam Computed Tomography (CBCT). This method is noninvasive and can reconstruct 3D images of cross sections which are highly accurate and quantifiable. It has been proved that it is possible to scan teeth pre and post instrumentation without loss of specimen and compare the pre and post instrumented images of the specimen with accuracy (William C. Scarfe, 2008). From the statistical analysis, it was observed that both the groups prepared canals satisfactorily. The mean values of differences in pre and post instrumentation measurements were not statistically significant at all three levels.

Even if both the systems prepared canals satisfactorily, the main objective of the present study was to find out which instrument system prepares flat-oval shaped canals homogenously and circumferentially. For evaluation of root canal preparation, the ratio of mean of differences in pre and post instrumentation measurements at four coordinates was taken into consideration. The canal preparation was assumed to be uniform all over the circumference of the canal if the mean of ratios at four coordinates was closer to value one. The preparation of the most apical canal section remains a challenge. At this region, previous studies on root canal preparation with SAF have left uninstrumented areas ranging from 28.8%–47.4%in maxillary molar root canals.[8]In the present study the final apical preparation in the rotary group was done with size F2 Rotary ProTaper. Despite the differences in file design, it should be noted that the final apical preparation was identical to both groups, without any statistically significant difference. However, in Rotary ProTaper group the ratios of mean values of differences in pre and post instrumentations measurements was closer to the value one indicating that the canal preparation was uniform than the SAF group (Rotary ProTaper showed the ratio as 1.183 and SAF showed the ratio to be 1.323). It might be explained as root canals tend toward a rounder cross section at this region, favoring the action of rotary instruments.

The ProTaper has a cross sectional design using of a triangle with convex sides. This feature decreases the rotational friction between the blade of the file and dentin and enhances the cutting action. A unique feature of the ProTaper files is each instrument has multiple increasing percentage tapers over the length of its cutting blades. This progressively tapered design serves to significantly improve flexibility, cutting efficiency and safety. As is true with any instrument, increasing both its D_0 diameter and taper correspondingly increases its stiffness. To improve flexibility, ProTaper finishing files F2 and F3 have been machined to reduce the core. ProTaper files prepare the canal in a “crown down” technique (Clifford Ruddle, 2001& 2005). However, the rotary motion of these files tends to prepare the main root canal space into a circular shape, leaving unprepared buccal and lingual extensions, which favors the retention of tissue and bacterial remnants, especially in oval-shaped canals (James Lin, 2013). It has been shown that the amount of mechanically prepared canal surface is dependent on the geometry of the canal. Rotary NiTi instruments perform considerably poorer in long oval canals such as the distal canals of the lower molars because more than 60% of the canal surface remains untouched (James Lin, 2013).

The results of present study are in accordance with the study conducted by James Lin, YaShenet al[11]. The Rotary ProTaper group resulted in round preparations. At middle third, these instruments removed more dentin in mesial and distal directions, leaving the buccal and lingual extensions of oval canal less prepared. Although the statistical analysis of coronal, middle and apical third showed no difference between both the groups, the results clearly showed that both the instrument groups differed from each other in preparing flat-oval shaped canals. The present results suggest that SAF prepares flat-oval shaped canals homogenously at coronal and middle third, resulting in uniform, and circumferential removal of dentin. However at apical third Rotary ProTaper is more effective in canal preparation. Further studies should address clinical outcome of cases after SAF preparation.

Conclusion

In conclusion, both the instrument systems were able to prepare the canals satisfactorily and preparation of flat-oval shaped root canals with SAF was effective.

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