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COMPARISON OF ROOT CANAL TRANSPORTATION, CANAL CENTRING ABILITY, MAINTENANCE OF CANAL CURVATURE AND ALTERATION IN WORKING LENGTH USING CONE BEAM COMPUTED TOMOGRAPHY AND APEX ID APEX LOCATOR IN MESIOBUCCAL CANALS OF MOLARS- AN IN-VITRO AND IN-VIVO STUDY

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ABSTRACT:

Aim: The aim of this study was to compare the canal transportation, canal centering ability, change in curvature and loss of working length after instrumentation with Revo S and K3XF file system by using cone beam computed tomography (CBCT).

Materials and Methods: Hundred mesiobuccal canals of first and second molars with an angle of curvature ranging from 15 to 45 degrees were divided according to the instrument used in canal preparation into two groups of fifty samples each: Revo S (group I) and K3XF (group II). The teeth were instrumented according to manufacturer's guidelines, with all groups being prepared to size 25, 0.06 taper master apical file. Canals were scanned using CBCT scanner before and after preparation to evaluate the transportation, centering ratio at 3 mm, 6mm and 9 mm from the apex and change in canal curvature. The change in working length was measured with Apex ID (Sybron Endo) apex locator in thirty patients after instrumentation with Revo S (group III) and K3XF (group IV) file system. The data collected were evaluated using student 't' and Mann-whitney test.

Results: K3XF file system showed less mean canal transportation, better canal centering ability values and maintained the original canal curvature well as compared to Revo S file system but the results were statistically insignificant ($p > 0.05$). There was no significant difference between two groups regarding change in working length after instrumentation.

Conclusion: Although the canal transportation, centring ability, change in canal curvature and loss of working length was less for K3XF file system but the results were statistically insignificant.

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INTRODUCTION

Thorough cleaning and shaping of the root canal is a prime criterion for successful endodontics. Variations of canal sections, canal irregularities and associated curvature diversity render procedure failures almost inevitable. The goal of instrumentation is to produce a continuously tapered preparation that maintains the canal anatomy without any deviation from original canal curvature.[1]

The mechanical preparation of curved canals remains a challenge for both novices and skilled clinicians. The Glossary of Endodontic Terms of American Association of Endodontists defines transportation as "the removal of canal wall structure on the outside curve in the apical half of the canal due to tendency of files to restore themselves to their original linear shape during canal preparation."[2]

Canal centring ability is defined as the ability of the instrument to stay centred in the canal. Various parameters that affect the canal centring ability include the alloys used in manufacturing instruments and instrument design which further include cross-section, taper and tip of instrument.[3]

The advent of nickel-titanium rotary file system has revolutionized root canal treatment by reducing time required to finish preparation and other procedural errors associated with root canal instrumentation. Revo-S (Micromega, Besancon, France) is one such recently introduced rotary file system. These files have asymmetrical

TABLE I shows the statistical analysis of intergroup comparison of canal transportation.

Canal Transportation	Group I Mean ± SD	Group II Mean ± SD	Z value[#]	P value[#]	't' value[$]	P value[$]
At 3 mm	0.054 ± 0.155	0.014 ± 0.109	1.555	0.120[NS]	1.491	0.139[NS]
At 6 mm	0.042 ± 0.149	0.034 ± 0.167	0.215	0.945[NS]	0.247	0.806[NS]
At 9 mm	0.022 ± 0.153	0.010 ± 0.202	0.346	0.729[NS]	0.335	0.739[NS]

#Mann-Whitney test; $ Student 't' test; NS; p > 0.05; Not Significant; *p < 0.05; Significant

TABLE II shows the statistical analysis of intergroup comparison of canal centring ability.

Canal Centring Ratio	Group I Mean ± SD	Group II Mean ± SD	Z value[#]	P value[#]	't' value[$]	P value[$]
At 3 mm	1.3332 ± 0.758	1.2826 ± 0.705	0.242	0.809[NS]	0.346	0.730[NS]
At 6 mm	1.5280 ± 0.806	1.4052 ± 0.979	0.945	0.345[NS]	0.685	0.495[NS]
At 9 mm	1.3592 ± 0.749	1.2452 ± 0.765	0.346	0.729[NS]	0.753	0.453[NS]

#Mann-Whitney test; $ Student 't' test; NS; p > 0.05; Not Significant; *p < 0.05; Significant

TABLE III shows statistical analysis of intergroup comparison of change in canal curvature

Group	Change in Canal Curvature Mean ± SD	Z value[#]	P value[#]	't' value[$]	P value[$]
Group I	2.320 ± 1.203	0.463	0.643[NS]	0.487	0.627[NS]
Group II	2.200 ± 1.262				

#Mann-Whitney test; $ Student 't' test; NS; p > 0.05; Not Significant; *p < 0.05; Significant

TABLE IV shows statistical analysis of intergroup comparison of loss of working length

Group	Loss of Working Length Mean ± SD	Z value#	P value#	't' value$	P value$
Group III	-0.1933 ± 0.171	1.245	0.213NS	0.545	0.590NS
Group IV	-0.1667 ± 0.082				

#Mann-Whitney test; $ Student 't' test; NS; p > 0.05; Not Significant; *p < 0.05; Significant

cross section with three sharp cutting edges.The K3XF rotary file system has been developed in 2011 by Sybron Endo (Orange, CA). These files were designed with a wide radial land to make the instrument more resistant to torsional stresses.

Several methodologies have been used to evaluate the efficacy of nickel-titanium instruments in remaining centred during preparation. These include radiographic imaging, cross-sectioning, longitudinal cleavage of teeth. More recently the use of cone beam computed tomography has been suggested for this purpose with good results because it is a non-destructive method.[2]

The aim of this study was to evaluate the efficacy of two new nickel-titanium rotary instruments in maintaining canal centring ability, root canal transportation and canal curvature in mesiobuccal canals of extracted molars with the help of cone beam computed tomography and to evaluate change in working length by using apex locator in patients undergoing root canal treatment.

MATERIALS AND METHODS:

In vitro study:

The in-vitro study was conducted on freshly extracted one hundred molars collected from the Department of Oral and Maxillofacial Surgery, Sri Guru Ram Das Institute of Dental Sciences and Research, Sri Amritsar. The selected teeth were cleaned and washed off all debris and were stored in 10% formalin.

Occlusal surfaces of all the teeth were flattened upto roof of pulp chamber using diamond disc and straight handpiece (NSK, Japan). The selected teeth had root curvatures between 15 degree to 45 degree. In case of maxillary molars distobuccal and palatal roots and in mandibular molars distal roots were sectioned at furcation level and discarded. The specimen were embedded in acylic. Cone Beam Computed Tomographic (CBCT) images for all prepared teeth were obtained before instrumentation, with CS9300 equipment (Carestream Healthcare India (P) Ltd) in the high resolution dental mode at 84 kV, 5mA and 20s. Image assessment was performed by a using the CBCT software tools (DICOM software).

The coronal access was made using round bur under water spray cooling high speed handpiece (NSK, Japan) followed by the straight line access of the walls with an Endo-Z bur (Dentsply Maillefer, Switzerland). The working length was determined by inserting #10 K file (Dentsply Maillefer, Switzerland) in mesiobuccal canal until it was visible through apical foramen and then 1mm was subtracted from the recorded length. Sample of hundred teeth were randomly divided into two groups with fifty teeth in each group:

Group I: Fifty teeth were instrumented using Revo-S (MicroMega, Besancon, France) rotary file system in the sequence of: SC1 (25/0.06) was taken into canal upto 2/3rd of working length, SC2 (25/0.04) and SU (25/0.06) was taken up to working length.

Group II: Fifty teeth were instrumented using K3XF (SybronEndo, Orange, CA) rotary file system in a given sequence: # 25/0.12 followed by # 25/0.10 and # 25/0.08 was taken into canal until resistance and # 25/0.06 was taken upto working length.

All the mesiobuccal canals were instrumented with crown down technique at a speed of 350rpm and a torque control level of 2.5Ncm by using 16:1 reduction handpiece powered by an endodontic motor (Endo-Mate DT; NSK, Japan). After the use of each file the root canals was irrigated with 5% sodium hypochlorite.

The postoperative scan was done using same parameters as in preoperative scan. Canal curvature was evaluated by using Schneider's technique and the comparison was made between canal curvature before and after instrumentation with two different rotary file systems. Canal centring ability and canal transportation was evaluated at three sections of root canal: at 3mm (apical third), 6mm (middle third), 9mm (coronal third) from the root apex.

The following formula was used for the calculation of canal transportation:

$[(M1 – M2) - (D1 – D2)]$

And centring ability was calculated by using following ratio:

$(M1 – M2) / (D1 – D2)$ or $(D1 – D2) / (M1 – M2)$.

where, M1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, D1 is the shortest distance from distal edge of the root to the distal edge of the uninstrumented canal, M2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, D2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal.

According to this formula, a result other than 0 indicates that transportation has occurred in the canal. According to this formula, a result of 1 indicates perfect centralization capacity and closer the result to zero the worse the ability of the instrument to keep itself in the canal central axis.

In vivo study:

The in-vivo part of study was conducted on patients visiting the Department of Conservative Dentistry and Endodontics of Sri Guru Ram Das Institute of Dental Sciences and Research, Sri Amritsar for root canal treatment of molars. The study was undertaken to further evaluate change in working length with Apex ID apex locator (SybronEndo) in clinical conditions. The coronal access was made under local anesthesia with rubber dam isolation using round bur under water spray cooling high speed handpiece followed by the straight line access of the walls with an Endo-Z bur (Dentsply Maillefer, Switzerland). Before instrumentation working length was taken with #10 K file (Dentsply Maillefer, Switzerland) using Apex ID (SybronEndo) apex locator. According to rotary file system used two groups were taken with fifteen teeth in each group:

Group III: Fifteen teeth were instrumented using Revo-S (MicroMega, Besancon, France) rotary file system in the sequence of: SC1 (25/0.06) was taken into canal upto 2/3rd of working length, SC2 (25/0.04) and SU (25/0.06) was taken to working length.

Group IV: Fifteen teeth were instrumented using K3XF (SybronEndo, Orange, CA) rotary file system in a given sequence: # 25/0.12 followed by # 25/0.10 and # 25/0.08 was taken into canal until resistance and # 25/0.06 was taken upto working length.

Canals were prepared with rotary file systems using crown down technique at a speed of 350rpm and a torque control level of 2.5Ncm by using 16:1 reduction handpiece powered by an endodontic motor (Endo-Mate DT; NSK, Japan). After the use of each file the root canals were irrigated with 5% sodium hypochlorite.The second measurement of working length was recorded and difference between it and the initial measurement was calculated.

RESULTS:

The mean value of canal transportation was greater for group I than that in group II as summarized in table I but the results were statistically insignificant (p>0.05). The mean centring ability of group II was better than group I as shown in table II but the results were statistically insignificant (p>0.05). The mean value of change in canal curvature as tabulated in table III was more for group I than group II but insignificant results were found. The mean value of loss of working length was less for group IV than group III as summarized in table IV but the results were statistically insignificant (p>0.05).

DISCUSSION:

Successful endodontic therapy is based on the classical triad of diagnosis, adequate biomechanical preparation and obturation. The second stage of the endodontic triad, i.e. biomechanical preparation, is one of the most important aspects of endodontics. In straight root canals, it is relatively simple to achieve this but in curved canals, maintaining the original canal anatomy constitutes a great challenge, especially with traditional hand instruments made of stainless steel. Studies have shown that nickel–titanium instruments have two to three times higher elastic flexibility, shape memory property as compared to conventional stainless steel instruments.[4]

Table 1 shows the statistical analysis of intergroup comparison of canal transportation. The findings of present study are in concurrence to Hashem AA, et al.[10] (2012) who found that the mean value canal transportation of Revo S at apical third was 0.044 ± 0.015mm which is almost similar to the findings of present study. The results of present study are in contrary to Jain D, et al.[18] (2015) who reported that the mean canal transportation value of Revo S at apical third was 0.024mm which is less as compared to present study (0.054mm). This could be attributed to the reason that the instruments of this system except SC2 has asymmetrical cutting edges thus providing more flexibility through decreasing core diameter and thus working by fitting to the original canal.

According to present study the mean value of apical transportation for K3XF (group II) was 0.014 ± 0.109mm which was less than the Revo S (group I), although the results were statistically insignificant. This was in concurrence with the study by Maitin N, et al.[12] (2013) who reported that the mean value of canal transportation by K3 rotary file system at apical level was less than other instruments used for preparation in their study. This may be related to fact that K3XF is manufactured using R-phase technology. The manufacturer states that the R-phase heat treatment improves the flexibility and cyclic fatigue resistance of K3XF instruments.

Although the mean canal transportation at middle third was more for Revo S but the results were non significant (p>0.05). The findings of present study are contrary to Jain D, et al.[18] (2015) who found that the mean value of canal transportation of Revo S file at middle third was 0.022mm which is less as compared to the findings of present study . This could be attributed to the fact that Revo S file has asymmetrical cross section which increases its flexibility.

The mean canal transportation at cervical third was more for Revo S but the result was statistically non significant (p>0.05). The findings of present study are in concurrence with study by Elsherief SM, et al.[11] (2013) who concluded that the canal transportation was more for Revo S file system when compared with individual file systems. In present study, the mean canal transportation at cervical third was less for K3XF file system (0.010 ± 0.202mm). The results are in concurrence with Maitin N, et al.[12] (2013) who reported that the mean value of canal transportation by K3 rotary file system at coronal level was less than the other instruments used for preparation in their study. The results of present study are in contrary to Zhao D, et al.[13] (2013) who reported that the mean value of canal transportation by K3 at cervical third was more (0.056 ± 0.055mm) in comparison to our findings (0.010 ± 0.202mm).

TABLE II shows the statistical analysis of intergroup comparison of canal centring ability. The centring ability is less for Revo S group than for K3XF but the results were statistically non significant (p>0.05). The above findings are in concurrence with Aguiar CM, et al.[8] (2012) who reported similar value of centring ratio for Revo S at apical third as in present study. The results are contrary to Fayyad DM, et al.[9] (2012) who found that the centring ability of Revo S was better than the other file system with which it was compared.

The mean centring ability of Revo S is less than K3XF (1.4052± 0.979). The findings of present study are in concurrence with Arora A, et al.[14] (2014) who found that the centring ability of Revo S at 6mm was less than other file systems used for instrumentation in their study. The results are not in concurrence with Jain D, et al.[18] (2015) who reported that the centring ability of Revo S file system at middle third was best when compared to individual file systems. This could be attributed to the fact that Revo S has the progressive pitch which avoids screwing effects while working in canal as stated by manufacturers.

The mean value of centring ratio for Revo S at 9mm was 1.3592 ± 0.749 and for K3XF was 1.2452 ± 0.765. The above findings are in concurrence with Aguiar CM, et al.[8] (2012) who reported almost same value of centring ratio for Revo S at cervical third as in present study. Observing the results of present study, the centring ability of K3XF file system was better as compared to other system. These results are in concurrence with Al-Sudani D and Al-Shahrani S.[5] (2006) who found that the centring ability of K3 was more as compared to individual file systems of their study. This could be attributed to the fact that K3 has three radial lands. The third radial land helps to prevent instrument from threading itself into the canal.

TABLE III shows statistical analysis of intergroup comparison of change in canal curvature. K3XF maintained canal curvature well as compared to Revo S but the results were statistically insignificant (p>0.05). The findings of present study are in concurrence with Cai HX, et al.[16] (2014) who compared the root canal shaping ability of K3 with other file system. The above findings are contrary to Batouty KM and Elmallah WE.[7] (2011) who evaluated that K3 showed higher value of mean change in canal curvature than Twisted file. This may be related to the fact that K3 has 45 degree rake angle. Because dentin is a dense and resilient material, instrument having a positive rake angle actually works like a shaver on dentin surface.

The findings of present study are in concurrence with Burklein S, et al.[15] (2014) who found that Revo S showed highest mean value of canal straightening after instrumentation in comparison with other two file systems. This could be attributed to the fact that Revo S file has extended cutting part in coronal region. The results are contrary to Jain D, et al.[18] (2015) who evaluated that mean change in canal curvature with Revo S was 1.68 ± 0.53 degrees which is less as compared to present study.

TABLE IV shows statistical analysis of intergroup comparison of loss of working length.

The mean loss of working length was less for K3XF file system in comparison to Revo S file system but the results are statistically non significant (p>0.05). This may be related to fact that K3XF is manufactured using R- phase technology. The findings of present study are in concurrence with Martin-Mico M, et al.[6] (2009) who found that the mean loss of working length after preparation with K3 was significantly less when compared with ProTaper, Mtwo and RaCe file systems. The results are contrary to Olivieri JG, et al.[17] (2014) who evaluated that the mean change of working length with K3XF file system was zero. This could be attributed to the fact that in above study, they evaluated working length change in manikin model using digital radiography.The results of present study are accordingly to Burklein S, et al.[15] (2014) who found that Revo S showed significantly more loss of working length than Hyflex CM. The findings of present study are in contrary to Celik D, et al.[1] (2013) who reported that the mean loss of working length by Revo S was 0.142 ± 0.077mm which is less as compared to present study (0.1933 ± 0.171mm). This finding might be attributed to the difference of methodology, especially evaluation technique.

CONCLUSION:

Within the limitation of the present study, the following conclusions can be drawn:

Both K3XF and Revo S file systems showed canal transportation. Although the mean value of canal transportation by K3XF file system was less as compared to Revo S but the result was statistically insignificant.

The centring ability of K3XF file system was better than Revo S file system but the difference was statistically insignificant.

K3XF file system maintained the original canal curvature well as compared to Revo S file system but insignificant results were found.

Although the mean value of loss of working length after instrumentation with K3XF file system was less as compared to Revo S file system but the results were statistically insignificant.

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