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An ex vivo Evaluations of Canal Transportation and Centering Ability of Protaper Next, M-two, Revo-S, V- taper Rotary files and Stainless Steel Hand K-Files Using Computed Tomograpy.

Dental Science

Dr. Sumit Sabharwal	Sr lecturer, Dept of conservative dentistry and Endodontics Seema dental college and Hospital, Rishikesh
Dr. Azhar malik	Associate professor and head Dept of conservative and endo Indra Gandhi govt. Dental college jammu
Dr. Aina Kumar	Senior lecturer,dept of cons and endo DR B.R.Ambedkar Dental College, patna
Dr. Tazeen Rahman	BDS General clinician.
Dr. Annil Dhingra	Professor, dept of cons and endo Seema dental college and Hospital, rishikesh
Dr. Sankalp Verma	Sri Sai Hospital, Delhi Road, Moradabad

ABSTRACT

Introduction: The introduction of the Nickel Titanium (NiTi) alloy for the manufacture of endodontic instruments has been revolutionary. NiTi alloy due to their increased flexibility and shape memory, potentially allow shaping of narrow, curved root canals without causing aberrations.
Material and Methods: The present study aimed to compare canal preparation between 4 different NiTi rotary file systems (protaper next-group 1; M-two –group 2; Revo-S-group 3; V-taper files;group 4; Hand Kfiles-group 5) and one stainless steel using Computed Tomography, based on following factors: Canal transportation and Centering Ability. In all the groups, before preparation canal localization was done through CBCT measurements. Mesial and Distal distances from canal center were measured at 3 mm, 6 mm and 9 mm from coronal end.
Results: When comparing the overall canal shift, at 9 mm location, mean mesial shift ranged from 0.64±0.53 mm to 1.29±0.68 mm and statistically, there was a significant difference among groups. Post hoc test revealed that except for a significant difference between Group I and V at 9 mm location on the mesial side, none of the between group differences were significant. There was no significant difference in the overall transportation of canal in different study groups at different locations.
Conclusion: The canal transportation observed at different reference points varied significantly. At 3mm, Mtwo file system showed least canal transportation whereas at 6mm, V-Taper showed least canal transportation and at 9mm RevoS showed least canal transportation. The maximum canal transportation was observed at 3mm, 6mm and 9mm by Hand K-files. This trend clearly proved that skills of the operator and design of the cutting edge of the instrument played a pivotal role in canal transportation and centering ability.

KEYWORDS:

INTRODUCTION

Instrumentation of curved root canals is still a challenge even for skilled and experienced operators. During shaping of these canals, canal transportation, straightening, or canal deviation may occur[1].According to the Glossary of Endodontic Terms of the American Association of Endodontists, canal transportation is defined as 'Removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation; may lead to ledge formation and possible perforation.' As a result of this asymmetrical material removal during shaping, the long axis of the curved root canal will be displaced and the angle of curvature will decrease, resulting in straightening of the original curvature of the root canal[2].

Any root canal instrument tends to straighten itself inside the root canal[3-5]. Owing to the restoring forces, an uneven force distribution of the cutting edges of the instrument in certain contact areas along the root canal wall results, leading to an asymmetrical dentin removal[3,5] . In particular, the cutting edges are pressed against the outer side of the curved canal (convexity) in the apical third and against the inner side at the middle or coronal thirds (concavity). As a result, apical canal areas tend to be over prepared toward the convexity of the canal, whereas more coronally greater amounts of dentin will be removed at the concavity, leading to canal transportation or straightening of varying degrees[3,5,6]

The introduction of the Nickel Titanium (NiTi) alloy for the manufacture of endodontic instruments has been revolutionary. NiTi alloy due to their increased flexibility and shape memory, potentially allow shaping of narrow, curved root canals without causing aberrations[5]. The present study aimed to compare canal preparation between 4 different NiTi rotary file systems and one stainless steel using Computed Tomography, based on following factors: Canal transportation and Centering Ability.

MATERIALS AND METHODS

A Hundred extracted non-carious human mandibular premolars were selected for the in vitro study. All teeth were preserved in 10% formalin solution for cleaning/disinfection for 24hrs. Samples were randomly divided into five groups. Each group contained 20 extracted mandibular premolars (n=20).

An initial Radiovisiograph (SOPIX,(ACTEONsopro) scan was done to exclude any changes of the presence of calcified canals, pulp stones or abnormal root curvatures of the recriuted samples to facilitate easy instrumentation using different file system.

The total length of all the samples were 18mm, this was measured with the help of metallic scale and divider. For more uniform samples, the crown were flattened with steel disk and straight handpiece, and final dimension of 18mm working length(WL) was achieved for each tooth. After the above procedure acess opening of all the samples were prepared with air-rotor-handpiece(NSK,Japan) and using endo access bur.The next procedure a size 10 stainless steel k-file was placed into the canal until it reached the apical foramen, and the working length was established 0.5 to 1mm short of this length. Radiovisiograph (RVG) scan was done to know the working length. All the samples were embedded in the acrylic block.All samples were scanned by computed tomography (GE light speed 32 slice, Brio Ct385 series SYS#Ct99) to determine the root canal shape before instrumentation. The sections were 1 mm thick from apical to the canal orifice coronally determined by Computed tomography.

Before instrumentation cross section of all samples was done by reformat/reconstruction in CT scan, Three sections from each tooth i.e 3mm from the apical end of the root (apical level), 6mm from the apical and 9mm from the apical level (18mm from the apex) their cross-sections was stored onto a magnetic optical disk.[Figures 1,2,3]

After cross section all the samples were measured to find out canal transportation and centering ability of canal. All root canals were instrumented to the WL with sizes 10, 15, 20, K-files by using a step-

back technique to maintain the patency of the canal. Instrumentation of 4 groups were done by different NiTi file systems by crown-down technique by using X-Smart endo motor(Dentsply Mailleffer) and 1 group was done by stainless steel k file system by step back technique with the use of Glyde (Dentsply Maillefer, U.S.A.).

Group 1 Root Canal preparation of 20 teeth was done by using Protaper next (Dentsply Mailleffer) file system. Protaper next innovative off-centred rectangular cross section gives the file a snakelike "swaggering" movement as it moves through the root canal. The operating squence was as follows: a10,15,20, K-file was used to create a guide path.

- Recommended speed is 300RPM with a torque from 4-5.2Ncm ,requiring just two files for most cases, the shorter clinical sequence means that less time is spent changing instruments. The high cutting efficiency also reduces the shaping time. The shaping procedure commenced with Protaper next size 21mm X1 17 taper/ 0.04.
- The coronal one third or two thirds of the root canal was shaped if passive penetration was possible. Protaper next size 21mm X2 25 taper/.06 was inserted and used until 1mm short of WL. Apical preparation size is 25.
- GlydeTM (10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size and the canals were irrigated using 27 gauge needle with 5.25% sodium hypochlorite and normal saline for complete debridement after every instrument used.

Group 2 Root Canal preparation of 20 teeth was done by using Mtwo(VDW) file system. The cross-section shape of Mtwo is an "italic S" with two cutting blades. The operating squence was as follows: a10,15,20, K-file was used to create a guide path.

- Recommended speed range of 250-350RPM with a torque from 2-5Ncm used in a crown down manner. Mtwo (VDW Co., Munich, Germany) #10 (0.04 taper), #15 (0.05 taper), #20 (0.06 taper) and #25 (0.06 taper) were used respectively to the full length of canal, each file was rotated for 3 seconds in the canal until it reached the apical point. Apical preparation size is 25.
- GlydeTM(10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size and the canals were irrigated using 27 gauge needle with 5.25% sodium hypochlorite and normal saline for complete debridement after every instrument used.

Group 3 Root Canal preparation of 20 teeth was done by using Revo-S (MICRO MEGA) file system. The operating squence was as follows: a10,15,20, K-file was used to create a guide path.

- They were used in a crown-down manner at a speed of 350RPM with a torque 2Ncm. The operating squence was as follows: a10,15,20, K-file was used to create a guide path; a 6% taper, size-25 instrument(SC1) was used to 2/3 of the WL (18mm); a 4% taper, size 21 instrument (SC3) was used to the full WL(18mm); a 6% taper, size 25 instrument (SU) was used to the full WL (16mm). Apical preparation size is 25.
- GlydeTM(10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size and the canals were irrigated using 27 gauge needle with 5.25% sodium hypochlorite and normal saline for complete debridement after every instrument used.

Group 4 Root Canal preparation of 20 teeth was done by using V-Taper (SS WHITE) file system. They were used in a crown-down manner at a speed of 200RPM with torque 1.8 to 2.5Ncm. The operating squence was as follows: a10,15,20, K-file was used to create a guide path.

- 4% taper,size-17 instrument,21mm length was used to 2/3 of the WL(18mm); a 6% taper,size-20 instrument,21mm length was used to the full WL(18mm); a 6% taper, size 25 instrument,21mm length ws used to the full WL(18mm). Apical preparation size is 25.
- GludeTM(10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size and the canals were irrigated using 27 gauge needle with 5.25% sodium hypochlorite and normal saline for complete debridement after every instrument used.

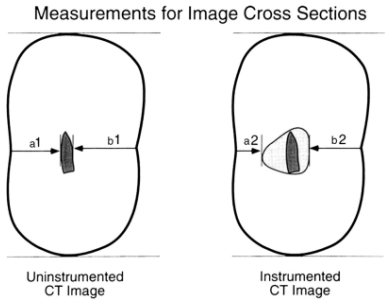
Group 5 Root Canal preparation of 20 teeth was done by using stainless steel hand K-file system (DENTSPLY Tulsa). The International Organization for Standardization (ISO) apical preparation size 25.

- Hand K filing were done by using "watch-winding" motion, 10,15,20,25,30,35, 40 number as the last file used with a step-back technique. Using 21mm length and 0.02 taper.Canal were prepared upto master apical file (MAF)size 25 with watch-winding motion.
- Then step-back in 1mm increments for three additional sizes was done to prepare middle and coronal third of the canal. Recapitulation with MAF at working length was carried out after each step-back file. GlydeTM(10% carbamide peroxide and 15% EDTA gel) was used during instrumentation with each file size and the canals were irrigated using 27 gauge needle with 5.25% sodium hypochlorite and normal saline for complete debridement after every instrument used.

After instrumentation all samples were scanned once again by Computed Tomography (GE light speed 32 slice, Brio Ct385 series SYS# Ct99) to determine the canal transportation and centering ability of canal. Cross section of all samples was done by reformat/ reconstruction in CT scan, three sections from each tooth i.e 3mm from the apical end of the root (apical level), 6mm from the apical and 9mm from the apical level (18mm from the apex) their cross-sections was stored onto a magnetic optical disk.[figure 4,5,6]

After cross section all the samples were measured to find out canal transportation and centering ability of canal. This was done by using reformat/Recontruction method in axial section. There were many scales like straight scale, cross scale, circular scale, semilunar scale, trangular scale, rectangular scale but straight scale was used for this study(Fig. 7).

The Formulae used for Canal Transportation And Centering Ability :
Distal Shift = A1-A2
Mesial Shift = B1-B2



a1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, b1 is the shortest distance from distal edge of the root to the distal edge of the uninstrumented canal, a2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, and b2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal[7].

$$\textbf{Transportation} = \sqrt{((A1 - A2) - (B1 - B2))^2}$$

Centering ability= (A1/B1) / (A2/B2) if (A1/B1)>(A2/B2)
or
(A2/B2) / (A1/B1) if (A2/B2)>(A1/B1)

ANOVA and post hoc tests were used to compare mean values with significance set at $p<0.05$.

RESULTS

Table 1 shows pre-operative measurements in mesial and distal sides at different locations in different study groups. At 9 mm, mean distance at distal side ranged from 3.14±0.57 mm (Group II) to 3.93±0.52 mm (Group I). On comparing the data statistically, intergroup differences were found to be significant ($p<0.001$). Also at 6 mm location, mean distances ranged from 3.34±0.54 (Group III) to 3.99±0.47 mm (Group II). Statistically, the intergroup differences were found to be significant ($p=0.016$).At 9 mm, mean distances ranged from 3.26±0.69 mm (Group II) to 3.82±0.58 mm (Groups IV and V). Statistically, intergroup differences were significant ($p=0.041$).

On between group comparison, at distal side, none of the between group comparisons were significant statistically at 3 mm and 6 mm locations. However, at 9 mm locations, only significant difference was observed between Groups I and II and Groups I and IV ($p=0.001$).At

mesial location, none of the between group differences were found to be significant statistically at 3 mm and 9 mm locations. At 6 mm location, a significant difference was observed between Groups II and III (p=0.006). [Table 2]

After the procedure, at distal side, at 3 mm location, distances ranged from 1.92±0.57 mm (Group III) to 2.66±0.80 mm (Group II). Statistically, intergroup differences were found to be significant (p=0.002).[table 3]. Table 4 shows the post-procedure, at 3 mm, for distal measurements, Group II had significantly higher values as compared to Groups I and III. None of the other between group differences were significant (p>0.05).

When comparing the overall canal shift, at 9 mm location, mean mesial shift ranged from 0.64±0.53 mm to 1.29±0.68 mm and statistically, there was a significant difference among groups (p=0.035).[Table 5] Post hoc test revealed that except for a significant difference between Group I and V at 9 mm location on the mesial side, none of the between group differences were significant (p>0.05).[Table 6] There was no significant difference in the overall transportation of canal in different study groups at different loc.ations.[table 7]

DISCUSSION

According to the Glossary of Endodontic Terms of the American Association of Endodontists, canal transportation is defined as follows: Removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation; may lead to ledge formation and possible perforation[2,8].

The factors associated with an increased risk of canal transportation include insufficiently designed access cavities, use of inflexible instruments, instrumentation technique, insufficient irrigation during mechanical enlargement, degree and radius of a canal curvature, unseen canal curvatures in two dimensional radiography and experience of operator[2].

Various undesirable apical preparation outcomes such as damage to the apical foramen, elbow formation, zip formation and perforation have been described as possible results of canal transportation. Perforation represents a communication between the root canal space and the external root surface, causing irritation of the periradicular tissues. Zip formation adopts an elliptical shape at the apical endpoint. Similar terms describing the shape of a zipped apical part of the root canal are an hourglass shape, a teardrop or a foraminal rip[8,9].

Apical transportation can be categorized into:
Type 1: represents a minor movement of the position of the physiologic foramen, resulting in its iatrogenic relocation[2,8].

Type II: represents a moderate movement of the physiologic position of the foramen, resulting in a considerable iatrogenic relocation on the external root surface. In this type, a larger communication with the periapical space exists, and attempt to create a more coronal shape may weaken or perforate the root[2].

Type III: represents a severe movement of the physiologic position of the canal, resulting in a significant iatrogenic relocation of the physiologic foramen[2].

Apical transportation may be because of several reasons such as the preparation technique, physical properties of alloys and design of the instrument. According to a few research groups, small degrees of transportation is associated with ability of the file to remain centered within the canal, which depends on the physical properties of used alloys as well as shape of the instrument tip[8].

Keeping these parameters in mind, the present study focused on evaluating canal transportation in the root canals in extracted human premolars.

In the present study mean canal transportation [Distal Shift(a1-a2)~Mesial Shift(b1-b2)] at 3 mm location, centering ability ranged from 0.94±0.25mm (Group IV) to 1.10±0.38mm (Group V), thus showing no significant difference among groups (p=0.268).At 6 mm, canal centering ability ranged from 0.95±0.22mm (Group IV) to 1.07±0.14mm (Group V). Statistically, the difference was not significant (p=0.170). 9 mm, canal centering ability ranged from 0.87±0.27mm (Group V) to 1.02±0.35mm (Group II). Statistically, this difference was not significant (p=0.417). Except for mesial shift in Group V, which was significantly higher as compared to Group I. None of the differences were significant statistically. No significant difference among different groups was observed with respect to centering ability.

At 3 mm, for distal measurements, Group II had significantly higher values as compared to Groups I and III. None of the other between group differences were significant (p>0.05). In mesial direction, none of the between group differences were significant at 3mm location.

According to **Elnaghy**[10], at 3mm from the apex using ProTaper Next with PathFile showed a mean canal transportation of 0.07±0.03mm (Mean±S.D), and 0.05±0.02mm using ProTaper Next with ProGlider .

According to **Gergi**[7], at apical level using Stainless Steel Hand K-file, showed a mean canal transportation of 2.39±0.43 (Mean±S.D), using Twisted file at apical level, showed a mean canal transportation 0.07±0.03, and using Pathfile-ProTaper at apical level, showed a mean canal transportation 0.72±0.42 . According to **Gharrawi**[11], at 4mm from the apex using ProTaper in group A, showed a mean canal transportation of 0.206±0.116 (Mean±S.D), using BioRace in group B, showed a mean canal transportation of 0.113±0.064, and using Self Adjusting File in group C, showed a mean canal transportation 0.173±0.149 .

At 6 mm for distal measurement, except for the difference between Groups II and V, none of the other between group differences were significant. At 6 mm, mean canal transportation was higher in Group V as compared to Group II. In mesial direction, at 6mm location Group III had significantly lower mean value asa compared to GroupI, II and IV.According to **Elnaghy**[10], at 5mm from the apex using ProTaper Next with PathFile showed a mean canal transportation of 0.09±0.05mm (Mean±S.D), and 0.07±0.03mm using ProTaper Next with ProGlider. According to **Gergi**[7], at mid-root level using Stainless Steel Hand K-file, showed a mean canal transportation of 1.78±0.57 (Mean±S.D), using Twisted file at mid-root level, showed a mean canal transportation 0.06±0.024, and using Pathfile-ProTaper at mid-root level, showed a mean canal transportation 0.74±0.49. According to **Gharrawi**[11], at 6mm from the apex using ProTaper in group A, showed a mean canal transportation of 0.207±0.127 (Mean±S.D), using BioRace in group B, showed a mean canal transportation of 0.113±0.064, and using Self Adjusting File in group C, showed a mean canal transportation 0.133±0.072.

At 9 mm, for distal measurement, Group I had significantly higher mean value as compared to all the other groups (p<0.05). None of the other differences were significant statistically (p>0.05). In mesial direction, at 9mm location, Group I has significantly higher mean value as compared to Group II ans V.According to **Elnaghy**[10], at 7mm from the apex using ProTaper Next with PathFile showed a mean canal transportation of 0.17±0.08mm (Mean±S.D), and 0.15±0.07mm using ProTaper Next with ProGlider. According to **Gergi**[7], at coronal level using Stainless Steel Hand K-file, showed a mean canal transportation of 1.16±0.315 (Mean±S.D), using Twisted file at coronal level, showed a mean canal transportation 0.049±0.02, and using Pathfile-ProTaper at coronal level, showed a mean canal transportation 0.84±0.64. According to **Gharrawi**[11], at 9mm from the apex using ProTaper in group A, showed a mean canal transportation of 0.207±0.127 (Mean±S.D), using BioRace in group B, showed a mean canal transportation of 0.113±0.064, and using Self Adjusting File in group C, showed a mean canal transportation 0.133±0.072.According to Elnaghy10, at 3mm and 5mm, ProTaper Next with ProGlider showed lower mean transportation. According to **Gergi**[7], K-file showed highest canal transportation, and Twisted file showed least canal transportation. According to **Gharrawi**[11], group B showed least canal transportation at 6mm, group C showed least canal transportation at 9mm, and group A showed least canal transportation at 4mm.

In this study, no statistical differences were found between different groups at 3mm, 6mm and 9mm for centering ability of different file systems. Therefore, the canal transportation of the different file systems could be attributed to the design of the cutting edges and technique of the operator.

CONCLUSION

Canal transportation of the root canals and centering ability of the file

systems are important virtues of the endodontic procedure. They greatly influence the prognosis of the treatment and quality of life of the patient after endodontic therapy. Hand K-files(Control Group) and various Ni-Ti systems viz. ProTaper Next(Group I), Mtwo(Group II), RevoS(Group III) and V-Taper(Group IV) have been compared in this study. No statistical difference was observed as far as centering ability was concerned. The canal transportation observed at different reference points varied significantly. At 3mm, Mtwo file system showed least canal transportation whereas at 6mm, V-Taper showed least canal transportation and at 9mm RevoS showed least canal transportation. The maximum canal transportation was observed at 3mm, 6mm and 9mm by Hand K-files. This trend clearly proved that skills of the operator and design of the cutting edge of the instrument played a pivotal role in canal transportation and centering ability.

Table 2: Between Group differences in Pre-operative Measurements in Distal side in different study groups at different locations (n=20 at each location) (Tukey HSD test)

SN	Comparison	3 mm			6 mm			9 mm		
		MD	SE	'p'	MD	SE	'p'	MD	SE	'p'
Distal										
1.	I vs II	-0.33	0.19	0.443	-0.35	0.21	0.497	0.79	0.17	<0.001
2.	I vs III	0.15	0.19	0.946	0.05	0.21	0.999	0.38	0.17	0.198
3.	I vs IV	-0.24	0.19	0.748	0.13	0.21	0.974	0.79	0.17	<0.001
4.	I vs V	-0.21	0.19	0.831	-0.35	0.21	0.497	0.39	0.17	0.166
5.	II vs III	0.48	0.19	0.115	0.40	0.21	0.345	-0.42	0.17	0.122
6.	II vs IV	0.09	0.19	0.988	0.48	0.21	0.185	-0.01	0.17	1.000
7.	II vs V	0.13	0.19	0.968	0.00	0.21	1.000	-0.40	0.17	0.147
8.	III vs IV	-0.38	0.19	0.299	0.07	0.21	0.997	0.41	0.17	0.130
9.	III vs V	-0.35	0.19	0.382	-0.40	0.21	0.345	0.01	0.17	1.000
10.	IV vs V	0.03	0.19	1.000	-0.48	0.21	0.185	-0.40	0.17	0.157
Mesial										
1.	I vs II	-0.20	0.18	0.811	-0.28	0.18	0.562	0.50	0.21	0.134
2.	I vs III	0.08	0.18	0.992	0.37	0.18	0.262	-0.02	0.21	1.000
3.	I vs IV	0.03	0.18	1.000	0.07	0.18	0.995	0.27	0.21	0.712
4.	I vs V	-0.34	0.18	0.338	-0.03	0.18	1.000	-0.06	0.21	0.998
5.	II vs III	0.28	0.18	0.540	0.65	0.18	0.006	-0.52	0.21	0.108
6.	II vs IV	0.23	0.18	0.716	0.35	0.18	0.331	-0.23	0.21	0.806
7.	II vs V	-0.14	0.18	0.935	0.24	0.18	0.684	-0.56	0.21	0.069
8.	III vs IV	-0.05	0.18	0.999	-0.30	0.18	0.475	0.28	0.21	0.653
9.	III vs V	-0.42	0.18	0.147	-0.41	0.18	0.183	-0.04	0.21	1.000
10.	IV vs V	-0.37	0.18	0.254	-0.11	0.18	0.978	-0.32	0.21	0.531

Table 4: Between Group differences in Post-operative Measur ements in Distal side in different study groups at different locations (n=20 at each location) (Tukey HSD test)

SN	Comparison	3 mm			6 mm			9 mm		
		MD	SE	'p'	MD	SE	'p'	MD	SE	'p'
Distal										
1.	I vs II	-0.58	0.18	0.016	-0.20	0.18	0.819	0.91	0.16	<0.001
2.	I vs III	0.16	0.18	0.913	0.31	0.18	0.451	0.58	0.16	0.005
3.	I vs IV	-0.18	0.18	0.871	0.21	0.18	0.775	0.76	0.16	<0.001
4.	I vs V	-0.09	0.18	0.990	-0.02	0.18	1.000	0.64	0.16	0.002
5.	II vs III	0.74	0.18	0.001	0.50	0.18	0.053	-0.33	0.16	0.261
6.	II vs IV	0.41	0.18	0.179	0.41	0.18	0.177	-0.16	0.16	0.876
7.	II vs V	0.50	0.18	0.058	0.18	0.18	0.858	-0.28	0.16	0.446
8.	III vs IV	-0.33	0.18	0.371	-0.09	0.18	0.985	0.18	0.16	0.819
9.	III vs V	-0.24	0.18	0.680	-0.32	0.18	0.401	0.06	0.16	0.997
10.	IV vs V	0.09	0.18	0.988	-0.23	0.18	0.728	-0.12	0.16	0.947
Mesial										
1.	I vs II	-0.37	0.19	0.310	-0.08	0.19	0.994	0.57	0.20	0.047
2.	I vs III	-0.03	0.19	1.000	0.64	0.19	0.012	0.32	0.20	0.518
3.	I vs IV	0.08	0.19	0.991	0.32	0.19	0.491	0.32	0.20	0.518
4.	I vs V	-0.38	0.19	0.284	0.05	0.19	0.999	0.59	0.20	0.036
5.	II vs III	0.34	0.19	0.382	0.72	0.19	0.003	-0.25	0.20	0.734
6.	II vs IV	0.45	0.19	0.131	0.39	0.19	0.261	-0.25	0.20	0.734
7.	II vs V	-0.01	0.19	1.000	0.13	0.19	0.963	0.02	0.20	1.000
8.	III vs IV	0.11	0.19	0.978	-0.33	0.19	0.459	0.00	0.20	1.000
9.	III vs V	-0.35	0.19	0.353	-0.59	0.19	0.026	0.27	0.20	0.675
10.	IV vs V	-0.46	0.19	0.117	-0.26	0.19	0.655	0.27	0.20	0.675

Table 5: Overall Canal shift in Mesial and Distal directions in different study groups at different locations (n=20 at each location)

SN	Group	3 mm	6 mm	9 mm			
		Mean	SD	Mean	SD	Mean	SD
Distal							
1	I	0.61	0.38	0.35	0.23	0.52	0.35
2	II	0.36	0.27	0.50	0.37	0.64	0.53
3	III	0.62	0.38	0.60	0.44	0.73	0.53
4	IV	0.67	0.37	0.43	0.49	0.49	0.41
5	V	0.73	0.64	0.68	0.49	0.77	0.60
ANOVA (F)		2.206		2.013		1.221	
"p"		0.074		0.099		0.307	
Mesial							
1	I	0.70	0.49	0.39	0.28	0.64	0.53
2	II	0.53	0.38	0.58	0.39	0.71	0.88
3	III	0.60	0.30	0.66	0.36	0.98	0.90
4	IV	0.76	0.50	0.63	0.48	0.69	0.62
5	V	0.66	0.42	0.47	0.22	1.29	0.68
ANOVA (F)		0.866		2.017		2.712	
"p"		0.488		0.098		0.035	

FIGURES

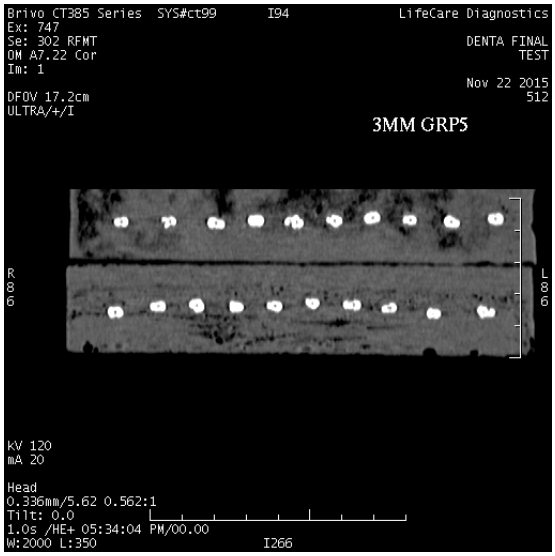


Fig.1 Sections from each tooth, i.e 3MM from the apical end of the root after instrumentation.

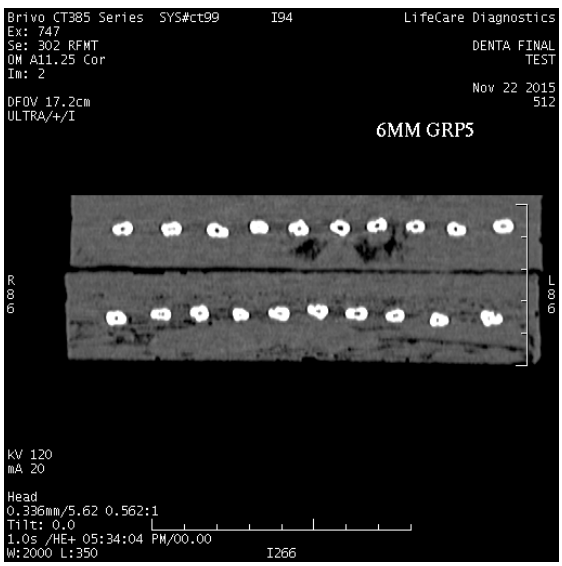


Fig. 2 Sections from Each Tooth, I.E 6MM from the Apical End of the Root After Instrumentation.

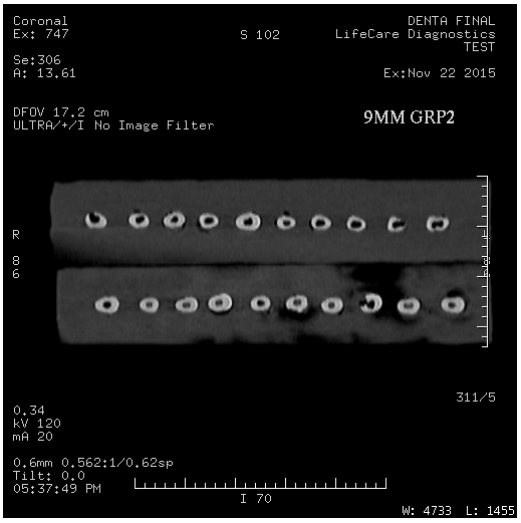


Fig.3 Sections From Each Tooth, I.E 9MM From the Apical end of the Root After Instrumentation.

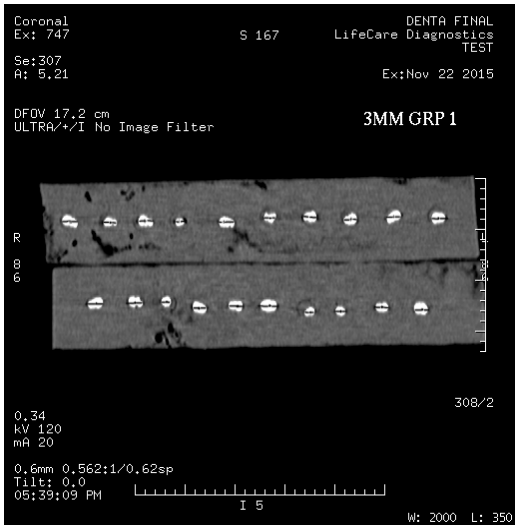


Fig. 4 Method to Measure canal Transportation and Centering Ability. Sections from each Tooth, i.e 3MM from the apical end of the Root After Instrumentation.

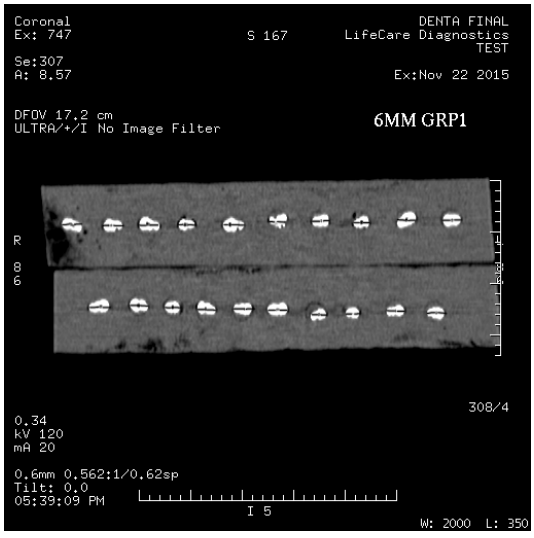


Fig. 5 Method to measure canal transportation and centering ability. Sections from each tooth, i.e 6mm from the apical end of the root after instrumentation.

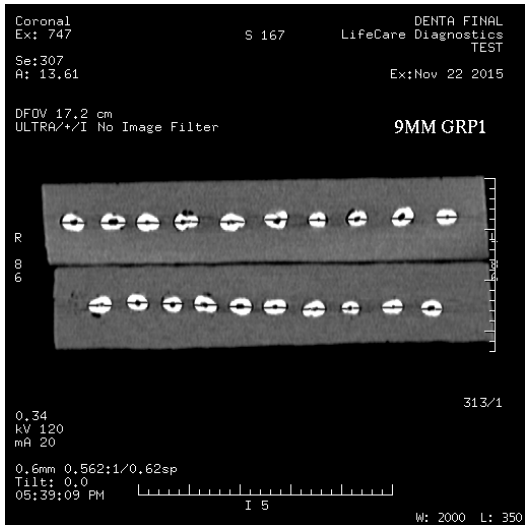


Fig. 6 Method to measure canal transportation and centering ability. Sections from each tooth, i.e 9mm from the apical end of the root after instrumentation.

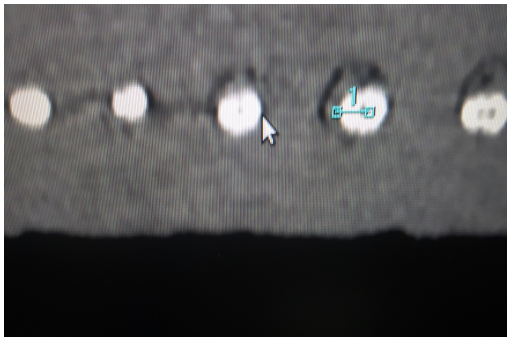


Fig. 7 Straight Scale Used for Measurement of Canal Transportation and Centering Ability Before Instrumentation

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