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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF THE AXIS MODIFICATION, CENTERING ABILITY AND APICAL DEBRIS EXTRUSION USING SINGLE-FILE RECIPROCATING AND CONTINUOUS ROTARY INSTRUMENTATION SYSTEMS IN CURVED ROOT CANALS– IN VITRO STUDY.

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Abstract

Aim- The purpose of this study was to study the amount of apically extruded debris, axis modification and centering ability using CBCT in relatively curved root canals with WaveOne and One Shape single file systems. Method -Forty extracted human adult teeth with curvatures were selected. Experimental study groups were divided as Group I-WaveOne (n=20) and Group II-One Shape (n=20). To evaluate the axis modification and centering ability, pre and post- operative views were analyzed in longitudinal and axial sections which were taken using RVG and CBCT respectively. For evaluating the amount of debris extrusion, the difference between the pre-instrumentation and post-instrumentation weight of eppendorf tubes were calculated. For inter-group comparison, ANOVA followed by Post- Hoc test were used. Results- WaveOne and One Shape single file systems showed statistically non- significant modification of root canal axis and centering ability. WaveOne single file system non-significantly generated more debris as compared to One Shape. Conclusion- It was concluded that WaveOne single file reciprocating systems demonstrated better centering ability as compared to OneShape single file rotary systems in curved root canals.

Introduction:-

One of the most important aspects of endodontic treatment is the cleaning and shaping of the root canals.However, the preparation of curved root canals presents one of the greatest challenges in endodontics. Maintaining the original canal shape is associated with better endodontic outcomes.[1]

By far, the greatest number of commercially available files utilized to shape root canals are mechanically driven in continuous rotation.[2]On the other hand, reciprocation, defined as any repetitive back-and-forth motion, has been clinically utilized to drive stainless steel files since 1958.

The WaveOneNiTi file systemfrom DENTSPLY Maillefer, are capable of moving in a back and forth “reciprocating” motion.

One Shape (by Micro Méga, Besançon, France) in contrast to WaveOne file system are used in continuous rotation, as known from many former multiple file rotary NiTi systems for rootcanalpreparation.[3]

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The extrusion of debris during cleaning and shaping of root canal has a deleterious effect and potentially causes post-operative complications like Endodontic Flare-up.The differences in the amount of debris extruded among various file systems depends on various factorslike the preparation technique, the different tapers and the cross-sectional design of the instruments.[4]

Hence the purpose of this study was to evaluate the axis modification, centering ability and debris extrusion using CBCTin relatively curved root canals using WaveOne and One Shape single file systems.

Materials and method:-

Forty extracted human adult teeth with curvatures were selected for the study in accordance with the inclusion and exclusion criteria.Digital radiographic images of all extracted teeth were taken.

Forty teeth were divided into 2 experimental groups.Access cavities were prepared and working lengths were determined.
Teeth were de-coronated perpendicular to the long axis of the tooth at 18 mm to assure standardization of root length.

For determing the centering ability, preoperative scans were taken using CBCT. With the help of software, measurements of the dentin thickness were made in cross sectional (Axial) view at 3mm, 5mm and 8 mm from the apex. Following formula was used for calculation of centering ability:

(X1 - X2) – (Y1 - Y2) where X1 was the shortest distance from the mesial edge of the root to the mesial edge of the un- instrumented canal and Y1 was the shortest distance from distal edge of the root to the distal edge of the un-instrumented canal. X2 was the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal and Y2 was shortest distance from distal edge of the root to the distal edge of the instrumented canal. (Figure no.1) A result of 0 would indicate no canal transportation i.e. perfect centered root canal preparation.

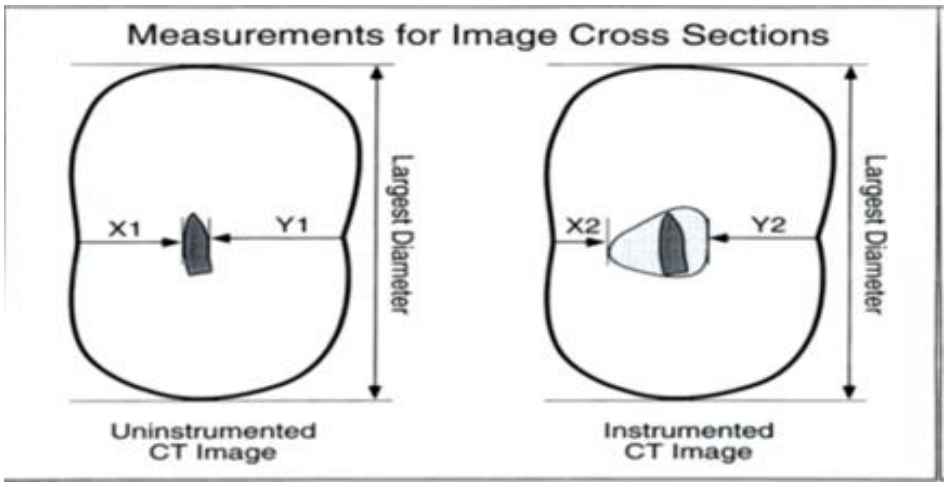

Figure no 1:-Measurement of cross section for centering ability

For axis modification, longitudinal sections (Sagittal plane) were taken using RVG and viewed for evaluating the pre- operative axis of un- instrumented curved root canals using Schneider's method and they were compared with instrumented views. (post- operative)

For evaluating debris extrusion, eppendorf tubes (2ml) were taken and pre- operative weight of the tubes were noted on an electronic weighing scale. The tooth specimen was fitted into an Eppendorf tube and stabilized using silicone putty impression material. Purpose of the Eppendorf tube was to collect the debris which would flow out of the apex during the instrumentation and irrigation procedure. A glass vial with a rubber cap was taken and a hole was created in the rubber cork with a heated instrument. The Eppendorf tube with the tooth was then pushed through the hole in

the glass vial for the purpose of stabilization. A bent 27-gauge needle was forced alongside the stopper to equalize the internal and external pressure (Figure no.2).

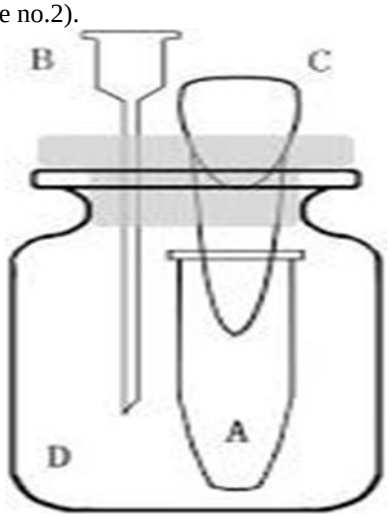

Figure no 2:- shows a) Eppendorf tube b) Needle to equalize the pressure. c)Tooth specimen. d) Vial with a rubber cork

Once the apparatus was fixed, instrumentation was done with either WaveOne or OneShape root canal instruments. Standardized amount of 17 % EDTA gel was used as a lubricating agent during instrumentation.

During the entire cleaning and shaping procedure with both WaveOne and OneShape files, the files were removed regularly, wiped clean of clogged debris. Irrigation was performed with 2ml distilled water, followed by a final rinse of root apex with distilled water externally.The specimens were then detached from the apparatus and the tube was incubated at 37 degree Celsius for 15 days to evaporate the solution. The tube again was measured on an electronic weighing scale.The difference between the pre-instrumentation and post-instrumentation weight of the Eppendorf tube was calculated for evaluating the amount of extruded debris.The tooth specimens were removed from the Eppendorf's tube and placed again in the acrylic blocks for post- operative scans using CBCT.

Results:-

Mean axis modification value for WaveOne(Group I) was 0.2±0.41and One Shape (Group II) was 0.25±0.44 and the difference was not statistically significant (Table 1).

	Group I (WaveOne)	**Group II (One Shape)**	**Student's Unpaired 't' test value**	**Result**
	Mean ± SD	**Mean ± SD**		
Difference in axis modification (in degrees)	0.2±0.41	0.25±0.44	0.54	p > 0.05 not significant

Table No. 1:- Comparison of mean and SD values of axis modification in WaveOne (Group I)and One Shape (Group II)

Mean value of centering ability at 3mm for WaveOne (Group I) was 0.05±0.06 whereas for One Shape (Group II) was 0.06±0.031 which was not statistically significant (Table 2, 3).Mean value of centering ability at 5mm for WaveOne (Group I) was 0.07±0.028 whereas for One Shape (Group II) was 0.08±0.054 which was not statistically significant (Table 2, 3).Mean value of centering ability at 8mm for WaveOne (Group I) was 0.125±0.07 whereas for One Shape (Group II) was 0.15±0.049 which was not statistically significant (Table 2, 3).

Centering ability	Group I Wave One (n=20)	Group II One shape (n=20)
	Mean ± SD	**Mean ± SD**
3mm	0.05±0.06	0.06±0.031

5mm	0.07±0.028	0.08±0.054
8mm	0.125±0.07	0.15±0.049

Table No.2:- Distribution of mean and SD values of centering ability at 3mm, 5mm and 8 mm in Experimental groups WaveOne(Group I) and One Shape(Group II)

Centering ability	**Group I WaveOne (n=20)**	**Group II One Shape (n=20)**	**Student's Unpaired 't' test value**	**'p' value and significance**
	Mean ± SD	**Mean ± SD**		
3mm	0.05±0.06	0.06±0.031	1.44	p>0.05 not significant
5mm	0.07±0.028	0.08±0.054	1.37	p>0.05 not significant
8mm	0.125±0.07	0.15±0.049	1.28	p>0.05 not significant

Table No.3:-Comparison of mean and SD values of centering ability at 3mm, 5mm and 8 mm in Experimental groups Wave One(Group I) and One shape(Group II)

Mean debris extrusion for WaveOne (Group I) was 0.01955±0.009 and One Shape (Group II) was 0.0170±0.004 and the difference was not statistically significant. (Table 4)

	Group I WaveOne (n=20)	**Group II One Shape (n=20)**	**Student's Unpaired 't' test value**	**'p' value and significance**
	Mean ± SD	**Mean ± SD**		
Debris extrusion	0.01955±0.009	0.0170±0.004	1.29	p>0.05 not significant

Table No.4:- Comparison of mean and SD values of debris extrusion in Experimental groups WaveOne(Group I) and One Shape (Group II)

Results of the study can be summarized as follows:

1. WaveOne and One Shape single file systems showed statistically non- significant modification of root canal axis after instrumentation.
2. Both WaveOne and One Shape single file systems showed non- significant differences in centering ability after instrumentation at 3mm, 5mm and 8mm from root apex.
3. Centering ability of WaveOne single file system was marginally better at 3mm, 5mm and 8mm from the root apex as compared to One Shape. This was statistically not significant.
4. There was deviation of the instrumented root canal at 3mm, 5mm and maximum at 8mm with One Shape single file system as compared to WaveOne. However this was statistically not significant.
5. Both WaveOne and One Shape single file systems generated apical debris after root canal instrumentation.
6. WaveOne single file system generated more debris as compared to One Shape, but with no statistical difference.

Discussion:-

The Glossary of Endodontic Terms of the American Association of Endodontist defines transportation as 'the 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.[5]

Deviation from the original canal curvature can lead to: 1) Excessive and inappropriate dentin removal.[6] 2) Straightening of the canal and creation of a ledge in the dentinal wall.[7] 3) A biochemical defect known as an elbow which forms coronal to the elliptical-shaped apical seal.[8] 4) Canals with hourglass appearance in cross-section.5) Overpreparation that weakens the tooth, resulting in fracture of the root.[6]

Wu et al. stated that apical transportation of more than 300 μm has the capability of negatively affecting the sealing of the obturation.[9]

The determination of extent of canal transportation was done with a formula given by Gambill et al, 1996.
CBCT scanning is an efficient method for the assessment of root canal instrumentation techniques for its accuracy and also because it does not require the destruction of the specimen and is reproducible. The advantages of CBCT

include three-dimensional rendition, geometrically precise images, increased sensitivity and specificity for caries, periodontal and periapical lesions, patient comfort, no intra-oral placement of film or sensor and soft tissue interpretation.[10,11,12]

In this study 2 commonly used single file sytemsie. WaveOne and One Shape file systems. Less transportation occurred with WaveOne may be because of the following reasons:

1. WaveOne file system has unique design characterics; they have a reverse helix and 2 distinct cross section along the length of their active portions (Figure no 3). From D1-D8, the WaveOne files have a modified convex triangular cross section, whereas from D9-D16, these files have a convex triangular cross section.[6]
2. The design of the WaveOne cross section is further enhanced by a changing pitch and helical angle along their active portions. This design is thought to reduce the core diameter and increase the flexibility, which may eliminate threading, and bending during preparation.[13]
3. The reciprocating motion has been significantly correlated to a more centered preparation compared with continuous rotating motion (Figure no 4). The advantages of reciprocating motion is based on physical law of action and reaction applied on the root canal instrumentation which result in a balanced force as theorized by Roane et al. (1985).[14] Moreover, the reciprocating movement minimizes the torsional and flexural stress.[15,16]
4. Waveone files are manufactured with the M-wire NiTi alloy which is more flexible than the conventional NiTi alloy. It maintains the tortional properties and enhances the centering ability with less transportation.

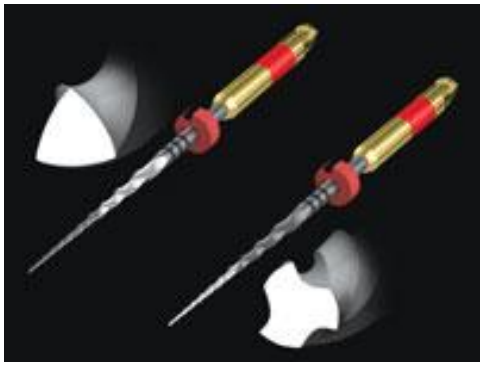

Figure no 3:- Image depicting two different cross sections along the length of WaveOne file

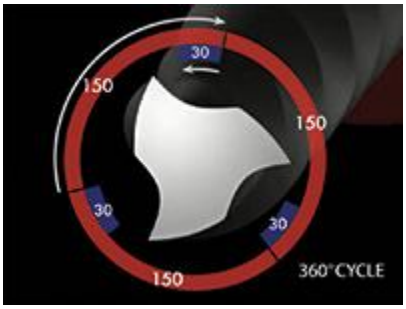

Figure no 4:- Image depicting reciprocal movement of WaveOne file

The screw-in effect of continuous rotation with One Shape file could be one reason for the transportation to occur more with One Shape single file system. It occurs frequently with active files that rotate under continuous rotation motion and results in overinstrumentation beyond the apical foramen during canal preparation.[17]

For both WaveOne and One Shape single file systems, maximum deviation from the center occurred at 8mm probably because of the greater taper of these files towards the shaft of the instrument.

VarshaHarshalTambe et al (2014) compared the canal transportation and centering ability of rotary ProTaper, One Shape and WaveOne systems using cone beam computed tomography (CBCT) in curved root canals to evaluate better instrumentation technique for maintaining root canal geometry. The canal preparation with WaveOne files showed lesser transportation and better centering ability than One Shape and ProTaper.[18]

In a study conducted by Dhingra*et al* (2014), the canal curvature modification after instrumentation with One Shape rotary file and WaveOne primary reciprocating file was compared, and it was concluded that canal prepared with WaveOne file preserved canal shape, respected the anatomical J-shape and produced a continuously tapered funnel.[19]

However McRay et al (2014) in their study based on microCT imaging reported no statistically significant difference in the canal centering ability of WaveOne and ProTaper systems.[20]

Similarly Rolly S. Agarwal et al (2015) compared the canal transportation, centering ability, and time taken for preparation of curved root canals after instrumentation with single file systems, One Shape (OS) and WaveOne (WO), using cone-beam computed tomography (CBCT). Their research showed that there was minor difference between the tested groups. Single file systems demonstrated average canal transportation and centering ability comparable to full sequence ProTaper system in curved root canals.[21]

Complete preparation of the root canal space is one of the most important stages in root canal preparation. Despite strict length control of the endodontic instruments during root canal preparation, the dentinal filings, pulp tissue fragments, necrotic tissue, microorganisms, and the intracanalirrigant may be extruded from the apical foramen into the periradicular region.[22]

The system that has received the most attention and has been adopted by most studies pertaining to apical extrusion of debris is the one described by Myers & Montgomery (1991).

Mangalam S et al and Reddy and Hicks have reported that the difference in the root canal preparation techniques and the instrument design are the major causes for variations in the apical extrusion of the debris by different instrumentation techniques.[23, 24]

Debris extrusion with WaveOne could be more because of the following reasons.

1. Guidelines for use state thatWaveOne files should be used with a progressive up and down movement no more than three to four times. A pumping action with a reciprocating motion has a tendency to pack debris beyond the tip and favors blockage and pressure leading to aberrations.[25]
2. WaveOnefileworks in a reciprocating mode, which means that it continuously changes its rotating direction during the shaping procedure. A large rotating angle in the cutting direction provides high efficiency which could lead to generation of debris and its subsequent extrusion from the apex.
3. Presence of radial lands with a neutral rake angle in WaveOne files also could have contributed to less debris extrusion.[26]

Whereas, the One Shape instrument system-

1. Has a safety tip and is 25 at the tip with a .06 taper. And they have an asymmetrical cross-section (Figure no 5) and longer pitch which increase the available volume for upward debris elimination.[3]

2. One Shape instrument works at 400 RPM, 4 N/Cm2 torque.Compared to reciprocation, continuous rotation utilizing well-designed active NiTi files requires less inward pressure and improves hauling capacity auguring debris out of a canal.

Figure no 5:- Image depicting three cross-sectional zones of One Shape file.

Jayaprada Reddy Surakanti (2014) assessed the amount of apically extruded debris during the root canal preparation using rotary and reciprocating nickel-titanium instrumentation systems. They concluded that full-sequence rotary

instrumentation was associated with less debris extrusion compared with the use of reciprocating single-file systems.[27]

Giselle Nevares (2015) analysed and compared apical extrusion of debris in canals instrumented with Reciproc (REC), WaveOne (WO), and HyFlex CM (HYF) file systems.

The HyFlex CM multiple-file system (ColteneWhaledent, Cuyahoga Falls, OH, USA) was used in continuous rotation while Reciproc and Waveone file systems in reciprocating motion. Both systems ie.Reciproc and WaveOne produced a greater apical extrusion of debris than HyFlex CM. They concluded that cross section and motion influenced the results, despite tip standardization.[28]

Bürklein S et al (2012) analyzed debris extrusion using 2 reciprocating single-file systems Reciproc (VDW) and WaveOne (Dentsply) and the 2 full-sequence rotary Mtwo (VDW) and ProTaper (Dentsply) instruments. The reciprocating files produced significantly more debris compared with both rotary systems.[25]

Emmanuel JoãoNogueira Leal Silva et al (2014**)** evaluated the amount of apically extruded debris by comparing the ProTaper Universal Retreatment system (Dentsply) with two reciprocating single-file systems (Reciproc (VDW) and WaveOne (Dentsply) during endodontic retreatment. The ProTaper Universal Retreatment system produced significantly more debris compared with the Reciproc and WaveOne systems.[29]

Yan Lu (2015) studied two reciprocating single-file systems, Reciproc and WaveOne, and two full-sequence rotary BLX and ProTaper instruments. Reciproc and WaveOne instruments produced significantly less debris than BLX and ProTaper instruments.[30]

However, more research is required in these important aspects of endodontic instrumentation using single file systems.

The limitations of this study are:
1) This experimental in vitro study needs to be carried in vivo, under clinical scenario.
2) Larger sample size may be needed for statistical significance of this research.

Conclusion:-

1. In conclusion, this study showed that WaveOne files have better centering ability at 3mm, 5mm and 8mm than OneShape files but there was no appreciable significance between the two groups.
2. OneShape files modified the axis of the curved root canals more than WaveOne files but there was no appreciable significance between the two groups.
3. WaveOne files produced less debris extrusion than One Shape files but there was no appreciable significance between the two groups.

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