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RESEARCH ARTICLE
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COMPARATIVE EVALUATION OF ROOT CANAL AREA INCREASE WITH THREE DIFFERENT ROTARY FILE SYSTEM AT THREE DIFFERENT LEVELS USING CONE BEAM COMPUTED TOMOGRAPHY:AN IN VITRO STUDY

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Background: Endodontic therapy success depends on effective cleaning and shaping of the root canal while maintaining the original anatomy. Ideally, instruments should retain the canal's natural shape during preparation to maximize cleaning efficiency and minimize unnecessary weakening of the tooth structure. Thus, the present study aims to evaluate and compare the root canal area increase achieved by three nickel-titanium (Ni-Ti) rotary file systems—XP Endoshaper, Hyflex CM, and K3 XF—at three levels of the root canal using cone beam computed tomography (CBCT).
Materials and Methods: This in vitro study was conducted at Dr. HSRSM Dental College, Hingoli involving a total of 60 freshly extracted teeth with fully formed apices, which were collected and stored in 0.1% NaOCl. The teeth were then divided into three groups: GROUP I (n=20) for XP Endoshaper, GROUP II (n=20) for Hyflex-CM, and GROUP III (n=20) for K3 XF. Canals were instrumented to a standardized size of 30/0.04 taper. Pre- and post-instrumentation CBCT scans were taken at 3 mm, 6 mm, and 9 mm from the apex.

Results: In the present study, statistical analysis showed no significant differences in root canal area increase between the groups at 3 mm and 6 mm levels. However, at the 9 mm level, XP Endoshaper demonstrated a significantly greater increase in canal area compared to both Hyflex CM and K3 XF ($p<0.05$). Hyflex CM and K3 XF also showed significant differences, with K3 XF achieving a higher increase compared to Hyflex CM ($p<0.05$).

(01-08)

Conclusion: XP Endoshaper was most effective in increasing the root canal area across all levels, indicating superior shaping ability. Hyflex CM and K3 XF showed moderate increases with distinct performance characteristics. The choice of rotary file system should consider the specific requirements of the clinical case, as XP Endoshaper may be preferable for extensive canal enlargement, while Hyflex CM and K3 XF may offer advantages in preserving canal anatomy.

Keywords: *Root Canal Area Increase, Computed Cone Beam Tomography, XP Endoshaper, Hyflex CM, K3 XF.*

INTRODUCTION

Mechanical preparation of the root canal system is considered as crucial step in root canal treatment. [1] According to the quality guidelines of the European Society of Endodontology, the main objectives of root canal instrumentation are to remove residual pulp tissue, eliminate debris, and maintain the original curvature of the canal during enlargement. [2]

Since the evaluation of the first nickel-titanium (Ni-Ti) files in 1988, various Ni-Ti instruments have been developed for both manual use and use with rotary endodontic handpieces. [3] As various Ni-Ti systems are now commercially available, a detailed investigation of their shaping effects has become increasingly important to understand how their design features impact performance. [4]

The primary issues with instruments used in continuous rotary motion are instrument separation due to cyclic fatigue and the inability to maintain canal curvature. Several rotary file systems address these challenges. The newly developed XP Endoshaper employs patented electropolishing technology to enhance cutting efficiency. Controlled memory technology in the Hyflex CM file allows it to adapt to the canal path. The K3 XF, a flexible nickel-titanium file system, is designed to resist cyclic fatigue. [5]

Radiographic examination plays a crucial role in diagnosing and planning treatments in endodontics. [6] Conventional radiographic techniques offer two-dimensional images of three-dimensional objects. [7, 8] To address the limitations of conventional radiography, advanced digital imaging technologies, such as cone-beam computed tomography (CBCT), have been introduced in dentistry.

Computed tomography was originally employed in endodontics to confirm root fractures, examine root canal walls, and assess pulp chamber anatomy. More recently, this technology has been utilized to evaluate root canal preparations. [9,10]

Therefore, recognizing the significance of preserving the remaining dentinal thickness by employing various instrument systems correctly, this study aimed to compare and assess the canal area enlargement using three different Ni-Ti rotary systems.

MATERIALS AND METHOD

This in-vitro study was conducted in the Department of Conservative Dentistry and Endodontics. A total of 60 freshly teeth were selected fulfilling the inclusion and exclusion criteria This study included mandibular premolars that exhibit an angle of curvature up to 100 degrees, as per the criteria described by Schneider (1971). Additionally, only teeth with completely formed apices were enrolled.

For the present study 60 freshly extracted teeth were selected with complete formation of apices, collected and stored in 0.1% NaOCl. The crowns were decoronated using a diamond disc at low speed

(300 rpm). Each specimen was then mounted on silicone impression material to simulate the mandibular arch shape and scanned using the Kodak CS 9300 scanner (Carestream Health Inc., NY, and USA) at 90 kV, 10 mA, with a 5 cm × 5 cm FOV, 90 µm resolutions, and an 18.6-second exposure time, using CS 3D Imaging software 3.3.11.

The sixty teeth were then randomly divided into three experimental groups containing twenty teeth each namely: GROUP-I (n=20): for XP Endoshaper, GROUP-II (n=20): for Hyflex-CM, GROUPIII (n=20): for K3 XF.

A size #15 K-file was used to establish a glide path and a size 10 K-file (Mani) was inserted for Xray imaging (0.25 sec, 60 kV). Schneider's technique measured root curvature angles, selecting teeth with up to 10° curvature. Final apical preparation was standardized to 30/0.04 taper, 21 mm size. Canals were instrumented using XP Endoshaper (1 Ncm, 800 rpm), Hyflex-CM (2.5 Ncm, 500 rpm), and K3XF (350-500 rpm). Post-instrumentation scans were analyzed by a single blinded observer.

Evaluation of Root Canal Area Increase

Pre instrumentation and post instrumentation CBCT scans of all samples in the three groups were acquired. The area of each canal was measured at 3mm, 6mm and 9mm before and after instrumentation for comparison among the three rotary systems as well as to evaluate the root canal area increase at three different levels.

For the calculation of root canal area increase at each level for all groups, formula used should be

S=ABπ, where S is area for Pre instrumentation CBCT Scans

S1=A1B1π, where S1 is area for Post instrumentation CBCT Scans

A=Major radius for Pre instrumentation CBCT Scans

B= Minor Radius for Pre instrumentation CBCT Scans

A1=Major radius for Post instrumentation CBCT Scans B1=

Minor Radius for Post instrumentation CBCT Scans

Where B≤ A.

S1-S= Increase in the root canal area.

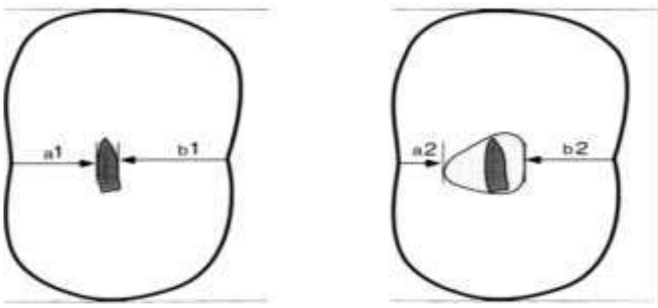


Fig No 1: a) Uninstrumented and b) Instrumented CT image

RESULTS:

Root canal area increase – (Pair wise comparison)

At 3 mm – There were no statistically significant difference seen between the groups at this level with XP Endoshaper(Group 1),Hyflex CM (Group 2),K3XF (Group 3)

At 6 mm- There were no statistically significant difference seen between the groups at this level with XP Endoshaper(Group 1),Hyflex CM (Group 2),K3XF (Group 3)

At 9 mm –There were statistically significant difference seen between the K3XF (Group 3) is compared with K3XF (Group 3)

There were statistically significant difference seen between the Hyflex CM (Group 2) and K3XF (Group 3) with high significant values in K3XF (Group 3).

There were statistically no significant difference seen when XP Endoshaper (Group 1) Hyflex CM (Group 2).

Table 1: Intergroup comparison of root canal area increase at various levels

	Groups	N	Mean	Std. Deviation	F value	P value
Area 3mm Pre	1	20	0.619365	0.4489768	0.421	.660#
	2	20	0.50083	0.2143048		
	3	20	0.603665	0.2184392		
	Total	60	0.57462	0.3073754		
	1	20	1.478155	0.567208	8.042	.002**
Area 3mm post	2	20	0.81012	0.3072283		
	3	20	0.9106	0.2605916		
	Total	60	1.066292	0.4895864		
Area 6mm Pre	1	20	1.192415	0.6270229	0.131	.878#
	2	20	1.095075	0.4934377		
	3	20	1.09586	0.2883372		
	Total	60	1.127783	0.4749103		
Area 6mm post	1	20	2.4021	0.9791789	5.374	.011*
	2	20	1.56686	0.610488		
	3	20	1.48522	0.3253054		
	Total	60	1.81806	0.789711		
Area 9mm Pre	1	20	2.379335	0.9219171	1.93	.165#
	2	20	2.21684	0.6593502		
	3	20	1.724645	0.7221151		
	Total	60	2.10694	0.8004176		
Area 9mm post	1	20	4.01135	1.2758927	8.839	.001**
	2	20	2.836205	0.6867447		
	3	20	2.26551	0.7680458		
	Total	60	3.037688	1.1752249		

Table 2: Pairwise comparison using Post Hoc Tests

Dependent Variable	Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	P value
Area 3mm Pre	1	2	0.118535	0.1402908	.679#
	1	3	0.0157	0.1402908	.993#
	2	3	-0.102835	0.1402908	.746#
Area 3mm post	1	2	.6680350*	0.1796334	.003**
	1	3	.5675550*	0.1796334	.010*
	2	3	-0.10048	0.1796334	.843#

Area 6mm Pre	1	2	0.09734	0.2190551	.897#
	1	3	0.096555	0.2190551	.899#
	2	3	-0.000785	0.2190551	1.000#
Area 6mm post	1	2	.8352400*	0.3095492	.031*
	1	3	.9168800*	0.3095492	.017*
	2	3	0.08164	0.3095492	.962#
Area 9mm Pre	1	2	0.162495	0.3469989	.887#
	1	3	0.65469	0.3469989	.162#
	2	3	0.492195	0.3469989	.346#
Area 9mm post	1	2	1.1751450*	0.4234316	.026*
	1	3	1.7458400*	0.4234316	.001**
	2	3	0.570695	0.4234316	.382#

Figure 1 : Graph showing inter group comparison of area at 3mm

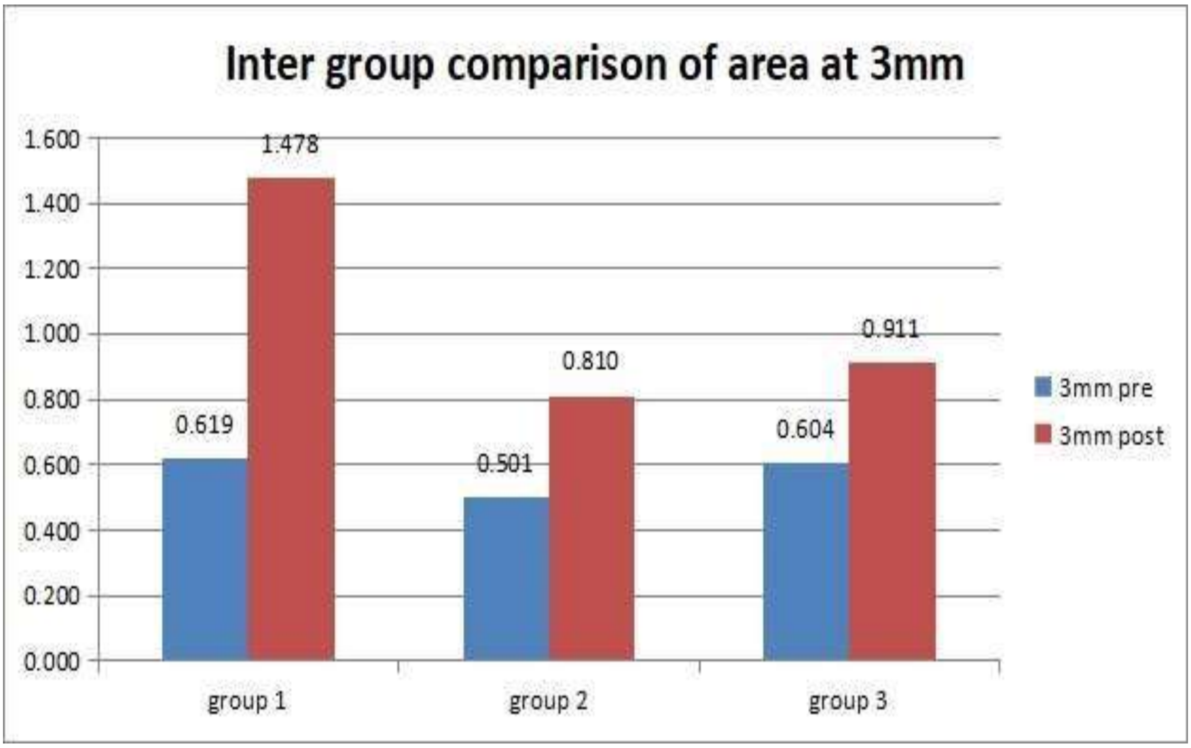


Figure 2: Inter group comparison of area at 6mm

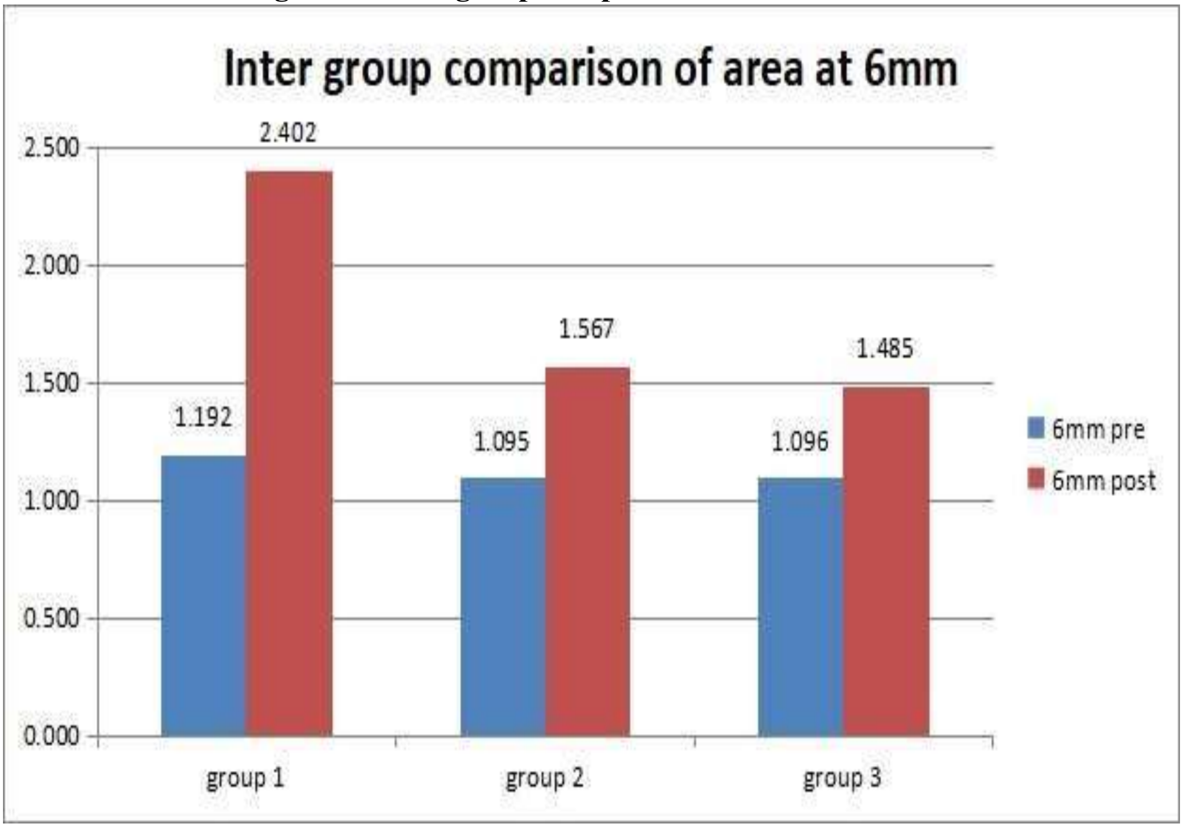


Figure 3: Inter group comparison of root canal area at 9mm

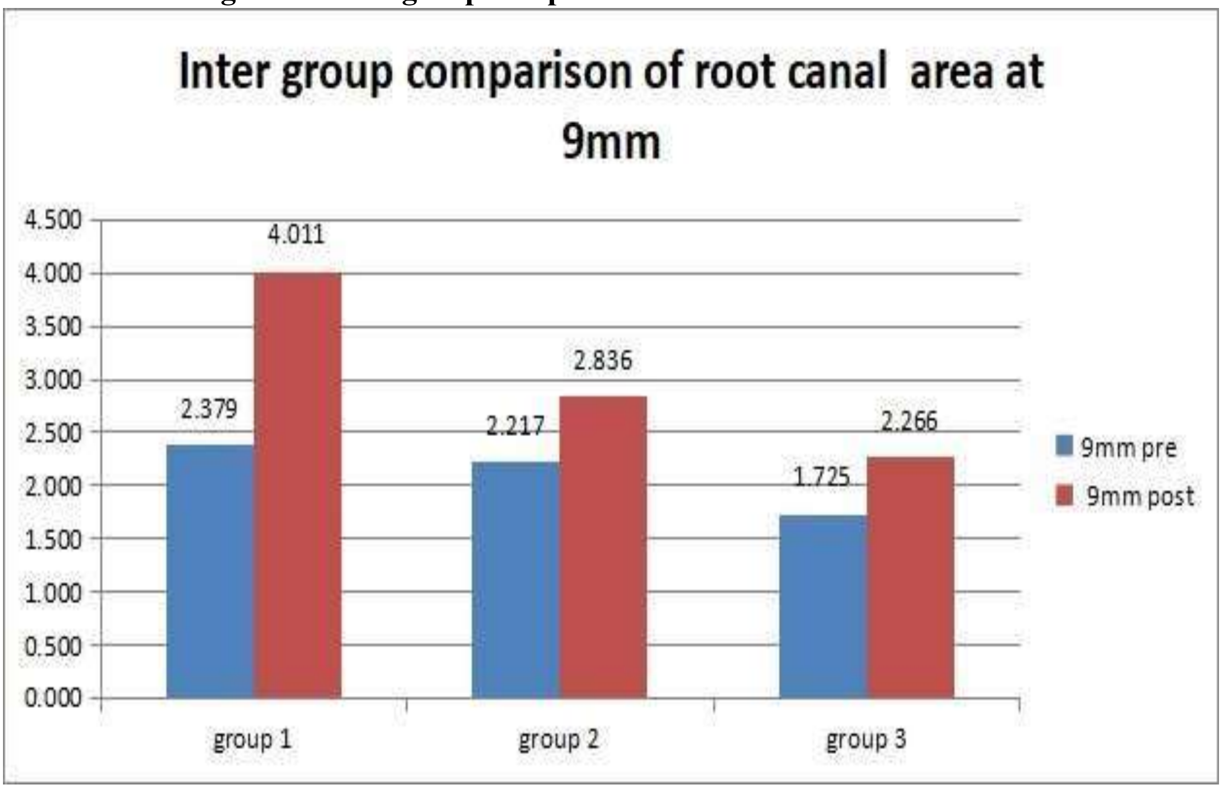


Figure 4 : Graph showing Inter group comparison of area at various levels for pre

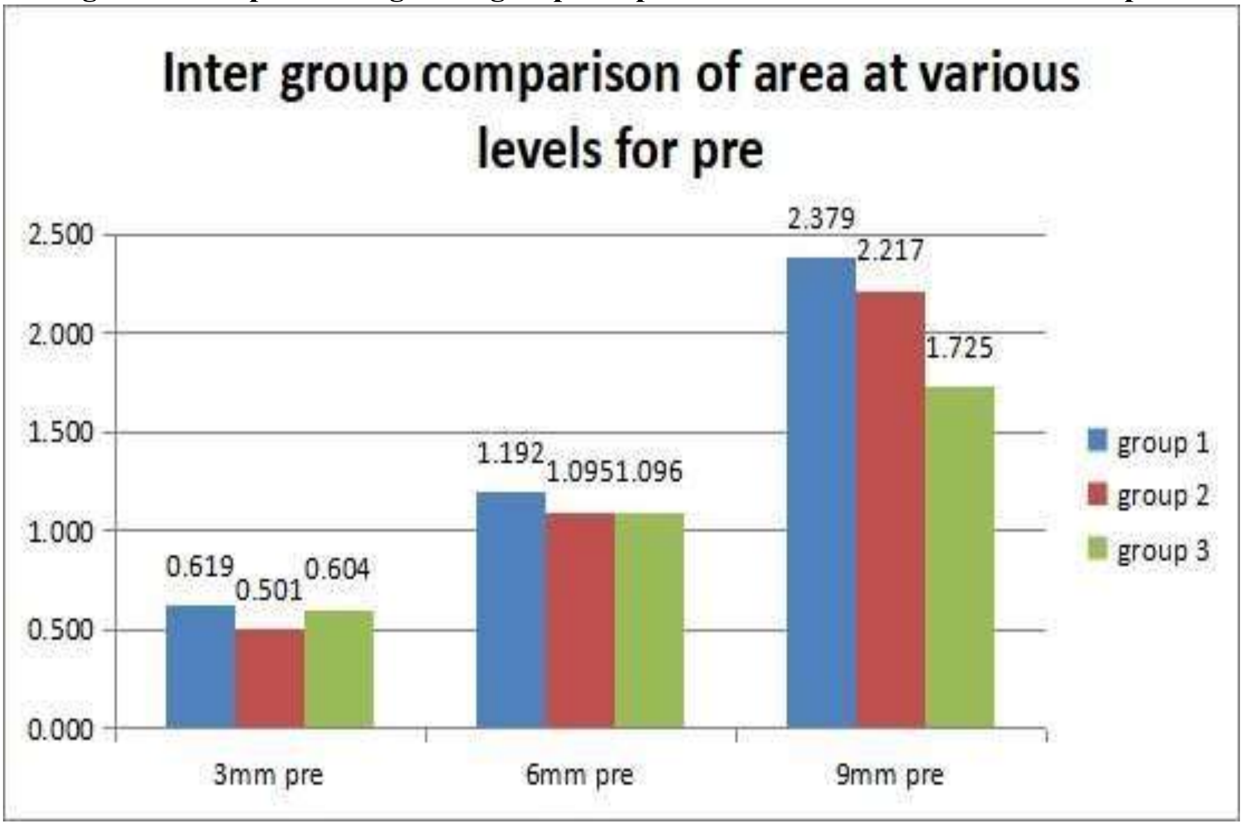
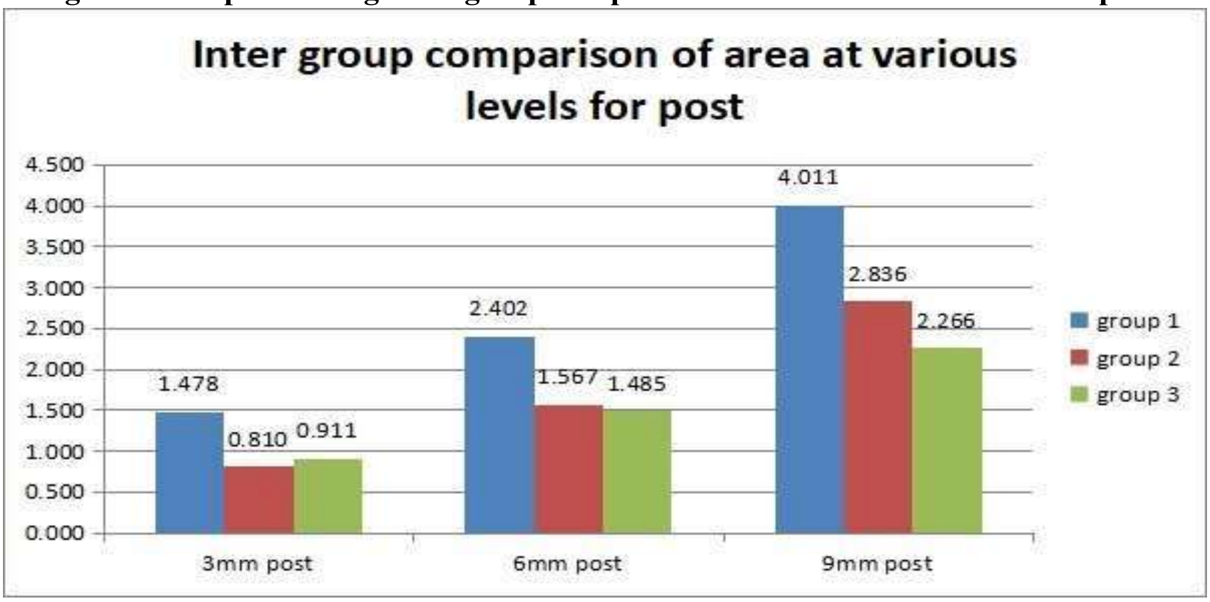


Figure 5: Graph showing Inter group comparison of area at various levels for post



DISCUSSION:

There is significant evidence indicating that reducing intracanal microorganisms is a critical objective in endodontic therapy. The primary goals for an endodontist during root canal treatment include thoroughly disinfecting the canal space, uncertain the progression of inflammation in periradicular tissues, and thereby facilitating favorable conditions for periradicular healing. Achieving these goals requires effective chemo-mechanical preparation, which is crucial for successful endodontic treatment. [11]

However, traditional hand instruments frequently fall short in achieving these goals. Since most canals are curved, endodontic instruments are typically made from straight metal blanks. This leads to uneven force distribution in specific contact areas and a tendency for the instrument to straighten within the canal. As a result, apical canal regions often become overprepared towards the outer curve or convexity of the canal, while more coronal areas may be transported towards the concavity.

Various studies have investigated the efficiency of Ni-Ti rotary instruments, but few have examined the ability to increase root canal area. [10] In the present study, three Ni-Ti rotary systems namely XP Endoshaper, Hyflex CM, K3XF were used to investigate the canal area increase before and after instrumentation.

When comparing the increase in root canal surface area among the XP Endoshaper, Hyflex CM, and K3XF groups, there was no significant difference in surface area increase among the three groups. Similar results were reported by **Prasanthi et al., [12]** where they found no significant difference between ProTaper LSX and K3XF groups.

In the present study, it was observed that the XP Endoshaper resulted in the greatest increase in root canal area during instrumentation. This is consistent with findings from a study by **Capar et al.,** [13] which demonstrated that, the XP Endoshaper's electropolishing technology and progressive taper design may remove more dentin during root canal preparation. These results further support the effectiveness of the XP Endoshaper in achieving significant canal enlargement. [14, 15]

Similarly, in a study by **Singh et al., [16]** the XP Endoshaper increased the root canal area more than the Hyflex CM and K3 XF file systems. The controlled memory technology of Hyflex CM may reduce its cutting efficiency compared to the XP Endoshaper, leading to more cautious canal preparation. The K3 XF's moderate expansion of the canal area aligns with its design, which emphasizes flexibility and resistance to cyclic fatigue over aggressive dentin removal. [17, 18]

The increasing root canal area disparities between the three file systems emphasize the importance of choosing the right rotary file system for the clinical context. XP Endoshaper may benefit from difficult canal anatomies or massive canal expansion. Hyflex CM is better for retaining canal form.

CONCLUSION

The XP Endoshaper consistently outperformed both the Hyflex CM and K3XF in increasing the root canal area at all three measured levels. This suggests that the XP Endoshaper might be the most effective system for root canal preparation. These results highlight the potential of the XP Endoshaper to improve the efficacy of root canal treatments by providing more thorough cleaning and shaping of the canal, potentially leading to better clinical outcomes. Further research and long-term clinical studies are needed to optimize the selection of rotary file systems for various endodontic situations.

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