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Comparative evaluation of cleaning efficacy of three rotary endodontic file systems in primary teeth

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Abstract

Objective: To compare the cleaning efficacy of different rotary instrumentation systems in primary root canals.

Materials and method: Thirty freshly extracted primary teeth were divided into three groups of ten each. In group I, root canals were instrumented with Protaper; group II with K3 and group III with Hero 642 rotary file systems. After canal preparation, the teeth were sectioned longitudinally and visualized under Scanning Electron Microscope at coronal, middle and apical thirds. Debris and smear layer removal efficacy was evaluated and the data obtained were subjected to Kruskal wallis ANOVA test and Mann- Whitney – U test.

Results: In all the three groups the debris scores are less in the apical third when compared to middle and coronal third which is statistically significant. Smear layer removal efficacy in apical third was superior in group I and II; middle third in the group III and no significant difference in the coronal third between the three groups.

Conclusion: All the tested file systems showed better debris and smear layer removing efficacy. However, Protaper and K3 rotary files showed significantly better

cleaning efficacy at the apical third when compared to Hero 642 rotary files.

Keywords: Debris removal, Hero 642, K3 files, Protaper, Rotary files, Smear layer.

Introduction

Treating decayed teeth in children is challenging because of the complexity and ribbon shaped canals, fins and isthmuses in primary teeth that need thorough cleaning, and lack of patient co-operation. As the length of the appointment is strongly associated with the child's behavior, a time effective and thorough chemo-mechanical preparation is essential for effective canal debridement that contributes to the success of the endodontic procedure. [1] Conventionally hand files are used for cleaning and shaping which are time consuming and may lead to iatrogenic errors such as ledging, zipping, canal transportation. With the advent of Ni Ti rotary files a smooth, predetermined funnel shaped canals can be prepared with minimal risks that results in consistently uniform and predictable obturation, reduces working time, less operator fatigue, better child co-operation and parental satisfaction.[2]

Even though the principle behind the cleaning and shaping of root canals are analogous for both primary and permanent teeth, careful handling is required for narrow and fine canals of primary teeth. [3] In the present era, several rotary nickel-titanium (NiTi) endodontic systems have been familiarized into the market. The selection of rotary system should be of the right choice as the individual designs and features affect the performance of the rotary instruments. [4]

Smear layer is formed on the walls of the root canal during biomechanical preparation, which is composed of inorganic and organic particles, bacteria and tissue remnants. The successful endodontic treatment aims at the removal of debris and smear layer from the root canal system. If not done appropriately and the smear layer removal is left incomplete, the antimicrobial agents are prevented from gaining access to the infected dentinal tubules. Till date ample studies were carried out on permanent dentition to evaluate the cleaning efficacy of these rotary file systems. However, studies regarding their usage in primary teeth are sparse. [1,3] So, the aim of the present *In Vitro* study was to compare the cleaning efficacy of three commercially available rotary file systems in deciduous teeth at coronal, middle and apical thirds in terms of debris and smear layer removal using scanning electron microscope.

Materials and method

After obtaining the patient informed consent, thirty freshly extracted human primary posterior teeth without any root resorption were selected for the study. Teeth with no evident of developmental defects / anomalous morphology were included in the study. These teeth were extracted from healthy children as they were retained beyond the normal time of exfoliation.Whereas the teeth showing radiographic evidence of internal resorption or root canal obliteration were excluded from the study.

After attaining the institutional ethical committee approval [Pr.34/IEC/SIBAR/2015] regarding the study design the selected teeth were divided into three groups of 10 teeth each according to the file systems used. Group I - ProTaper (Dentsply-Maillefer, Asia); group II- K3 (SybronEndo, Mexico) and group III - Hero Shapers (MicroMega, France) respectively.

The selected teeth were mounted vertically in impression compound upto the cervical region. The coronal access cavity was prepared using a round diamond bur and canal patency was evaluated using #15 hand K file. Working length was determined using radiovisiography for individual teeth.

In Group I, samples were instrumented with Protaper in the following sequence: Sx – For coronal flaring; S1, S2 – shaping the canals upto the estimated working length and finishing with F1 file. Group II samples were instrumented with K3 SX files in the following sequence: 0.10 – orifice shaper, 0.08 – 1/3rd of working length and 0.06 file upto the estimated working length. Whereas in group III samples, Hero Shaper 642 file systems were used in the following sequence: 0.06 – 20 for coronal enlargement, 0.04 – 20 upto 2/3rd of working length and 0.06 – 25 upto the predetermined working length.

Biomechanical preparation was done with predetermined rotary file systems with EDTA gel lubrication following the manufacturer's instructions for each file system in crown down technique. Irrigation of the canals was done with copious amount of saline and 5.25% of NaOCl following the use of each file and finally dried with paper points. Further these teeth were decoronated and the roots were split longitudinally using a diamond disc. The separated sections were air dried in a desiccator at room temperature and attached to coded metal stubs and sputter with 10 nm/m gold-palladium alloy. These sections were further examined under scanning electron microscope and photomicrographs were taken at 200x and 2000 x magnification at the coronal, middle and apical thirds. The geometric center of each third was observed and separate evaluations were recorded for debris and smear layer removal by means of numerical evaluation scale which was put forth by Hulsmann *et al*1997(Figure 1,2).[5]

The whole procedure and scoring was performed by a single operator. To ensure intra examiner consistency, the photo micrographs were randomly evaluated by a second investigator who was blinded to the groups and was trained prior to the recording. As there was no statistically significant variation in the values between the two examiners (P<0.05), the scores recorded by the first operator were only considered and the values obtained were tabulated and statistically analyzed using SPSS (version 18). Kruskal wallis ANOVA test and Mann-Whitney – U test.

Results

Results revealed that less amount of debris scores were detected at the apical third of root canals in all three groups compared to coronal and middle thirds, which is highly significant (P<0.01)(Table-1). Group I and II showed less debris scores at apical third of root canals which was statistically significant (p<0.05) when compared to group III samples (Table-2).

In terms of smear layer removal efficacy, no significant difference (p=0.19) was apparent in coronal, middle and apical third in group I samples, but statistically significant difference (p<0.05) was noted in group II & III (Table-3). Smear layer removal efficacy at the apical third of root canal was superior in group I and II compared to group III samples, which was statistically significant. In middle third Hero 642 showed lesser smear layer score (2.0) when compared to group I and II which is highly statistically significant (p<0.01) whereas no significant difference was noted between the three groups in coronal third (Table -4).

Discussion

The foremost objective of any endodontic treatment is to achieve optimal cleaning and shaping of the root canal. It aims to prepare the canal space to facilitate disinfection by irrigants and medicaments.

The usage of rotary files in primary teeth was first reported by Barr et al in 1999. Literature available on the use of rotary files in primary teeth has principally evaluated cutting efficiency, instrumentation time and shape of the prepared canals. Barr et al. (2000) concluded that the use of Ni–Ti rotary files for root canal preparation in primary teeth was cost effective, faster, and resulted in consistently uniform and predictable fillings. [3]

Vaudt *et al* [6] reviewed that individual design features affect the performance of Ni Ti rotary instruments. Various instrument designs with noncutting tips, different cross sections, radial lands, and tapers are now available to improve the working efficiency.[7]Among them ProTaper, Hero shaper and K3 system have been selected for this study because they have different cross-sectional configuration, variable cutting efficiency and all the three systems were made of same material (Ni-Ti).

For the preparation of root canal, crown down technique was used as it reduces friction between instruments and forms a smooth funnel shape that allows deeper penetration of irrigating solutions during instrumentation eliminates extrusion of debris and minimizes the risk of instrument separation. [8]

All endodontic instruments create dentine debris and a smear layer as a consequence of their action on root canal walls.[9],[10] Debris is demarcated as dentine chips and the residual vital or necrotic pulp tissue attached to the root canal wall is infected in most of the cases. Therefore the risk for bacterial contamination increases due to presence of debris that ultimately leads to endodontic failure.[11]Smear layer is a thick surface film of 1 to 2 µm containing dentin debris, bacteria and residual pulp tissue that remains on the dentinal walls during root canal instrumentation.Complete removal of smear layer and debris facilitates the diffusion of the irrigants/medications to the root canal system, thereby improving the adaptation of the filling materials to the root canal dentine.[12]

To assess the debris scores the samples were examined under scanning electron microscope at 200X magnification as it offers wider view to detect larger fragments. Whereas 2000× magnification was used for scoring the smear layer as higher magnification covers very small surface and gives accurate information, it also allows proper visualization of the dentinal tubule openings. [13]

It was observed that irrespective of the file system used for instrumentation, the prepared root canals exhibited maximum debris and smear layer (score 5) in few examined areas, indicating that cleanliness was not thorough due to self-centering and super-elasticity of rotary instruments. Thus it can be assumed that the instrument remains in the center of the canal due to its rotating movement, and all the areas of the root canal system are not being instrumented uniformly. [14,15]

Comparatively less debris scores were observed at the apical third of prepared root canal with the three selected systems of rotary files compared to coronal and middle third. Taha *et al.*[16], Rahimi[17]&Junior *et al*[18] also reported less debris scores at the apical third of root canals. The probable explanation for this could be the oval shape of the root canal in the coronal, middle third and a round shape as it proceeds apically.[19]The dentine particles removed from the canal walls are carried coronally by flutes of the file, due to use of rotary files with round cross section. This removal was apparently less effective when the canal is oval shape and the working surface of the file is not in contact with all the surfaces of root dentin. In such conditions, the debris that is carried coronally or being contained and packed in the file's flute space, gets packed actively into the area with the least resistance. It is conceivable to hypothesize that dentine particles were actively packed into soft tissue remnants in unprepared areas that are usually resistant to the irrigation.[4]In contrary to the present study previous SEM studies reported that the amount of smear layer and debris are greater at the apical third when compared to the middle and coronal thirds of the canals.[20] Kadhom TH[19] reported that Protaper rotary file system shaped a clean canal at the coronal and middle thirds, but were

incapable of removing the debris at the similar rate in the apical third. However, studies that are correlated to primary teeth found no significant difference in the cleaning capacity of rotary instrumentation techniques at all the three areas of root canal based on dye penetration method. [20, 21]The difference in the outcome among various studies could be due to the difference in tooth selection, rotary instruments used, technique followed, irrigation solutions used and the operator's performance.[21]

Pertaining to the smear layer removal efficacy, the present study showed significant difference in the middle third between the three groups. The reasons for removal of more amount of smear layer with Hero 642 is due to its a triangular blade design in cross-section with a positive rake angle, sharper cutting edge, and usage of more number of instruments with chelator (EDTA) for canal preparation.[22]

At apical third significant difference was observed between the three groups. Protaper and K3 showed significant increase in cleaning efficacy both in terms of smear layer and debris removal when compared to Hero 642. This might be attributed to cross sectional design with a slight positive rake angle and increased helical angle from tip to handle in K3 file system. [22]Protaper instruments exhibit a unique variable taper design with a triangular cross section and reduced radial lands that might allow the file to move freely within the canal. [22]

On contrary, study conducted by Suresh chandra[23] showed that K3 instruments left more debris and smear layer compared to Hero 642 instruments. The explanations for the result might be due to individual variations within the instruments and 'to the core' adherence with manufacturer's instructions.

The factors to be considered while selecting appropriate rotary file systems for primary teeth include type of material used to manfacture, taper, cross section, and optimum cutting efficiency. However proper removal of smear layer and debris depends upon shape of the root canal,file system used, root canal irrigation protocol followed and most importantly a thorough knowledge and clinical expertise of the rotary system is essential.

Conclusion

All the three file systems showed comparatively less debris scores at the apical third of root canal when compared to middle and coronal third. However, Protaper and K3 file systems showed better debris removal compared to Hero 642 at the apical third.

- Smear layer removal efficacy in all the three groups were similar in the coronal third; Hero 642 showed superior efficacy in the middle third whereas in the apical third Protaper and K3 file systems were effective.
- Protaper and K3 files exhibited significantly better cleaning efficacy in terms of smear layer and debris removal in the apical third when compared to Hero 642 rotary file system.

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Legend Tables and Figures

Table 1: Intra group comparison of mean debris scores at coronal, middle and apical third.

Groups	Parameter	Mean	SD	P-value	Inference
I	Coronal 1/3rd	4.80	0.42	<0.01	HS
	Middle 1/3rd	3.80	0.63		
	Apical 1/3rd	2.60	0.52		
II	Coronal 1/3rd	4.20	1.14	<0.01	HS
	Middle 1/3rd	3.50	0.71		
	Apical 1/3rd	2.70	1.06		
III	Coronal 1/3rd	4.60	0.70	<0.01	HS
	Middle 1/3rd	4.20	0.63		
	Apical 1/3rd	3.60	0.84		

SD- standard deviation, P value < 0.01 highly significant (HS).

Table 2: Inter group comparison of mean debris score at coronal, middle and apical third.

Parameter	Groups	Mean	SD	P-value	Inference
Coronal 1/3rd	I	4.80	0.42	0.26	NS
	II	4.20	1.14		
	III	4.60	0.70		
Middle 1/3rd	I	3.80	0.63	0.08	NS
	II	3.50	0.71		
	III	4.20	0.63		
Apical 1/3rd	I	2.60	0.52	**<0.05**	S
	II	2.70	1.06		
	III	3.60	0.84		

SD- standard deviation, P value**:** <0.05 statistically significant (S), P>0.05 not significant (NS)

Table 3: Intra group comparison of mean smear layer removal scores at three different areas of the root canal.

Groups	Parameter	Mean	SD	P-value	Inference
I	Coronal 1/3rd	3.70	1.25	0.19	NS
	Middle 1/3rd	4.40	0.97		
	Apical 1/3rd	3.70	0.48		
II	Coronal 1/3rd	3.30	0.48	<0.05	S
	Middle 1/3rd	2.60	0.52		
	Apical 1/3rd	3.70	1.25		
III	Coronal 1/3rd	3.00	0.00	<0.05	S
	Middle 1/3rd	2.00	0.00		
	Apical 1/3rd	5.00	0.00		

SD- standard deviation, P value:<0.05 statistically significant (S), p>0.05 not significant (NS)

Table 4: Intergroup comparison of mean smear layer removal scores at coronal, middle and apical third.

Parameter	Groups	Mean	SD	P-value	Inference
Coronal 1/3rd	I	3.70	1.25	0.15	NS
	II	3.30	0.48		
	III	3.00	0.00		
Middle 1/3rd	I	4.40	0.97	<0.01	HS
	II	2.60	0.52		
	III	2.00	0.00		
Apical 1/3rd	I	3.70	0.48	<0.01	HS
	II	3.70	1.25		
	III	5.00	0.00		

SD- standard deviation, P value :< 0.01 highly significant (HS), p>0.05 not significant (NS).

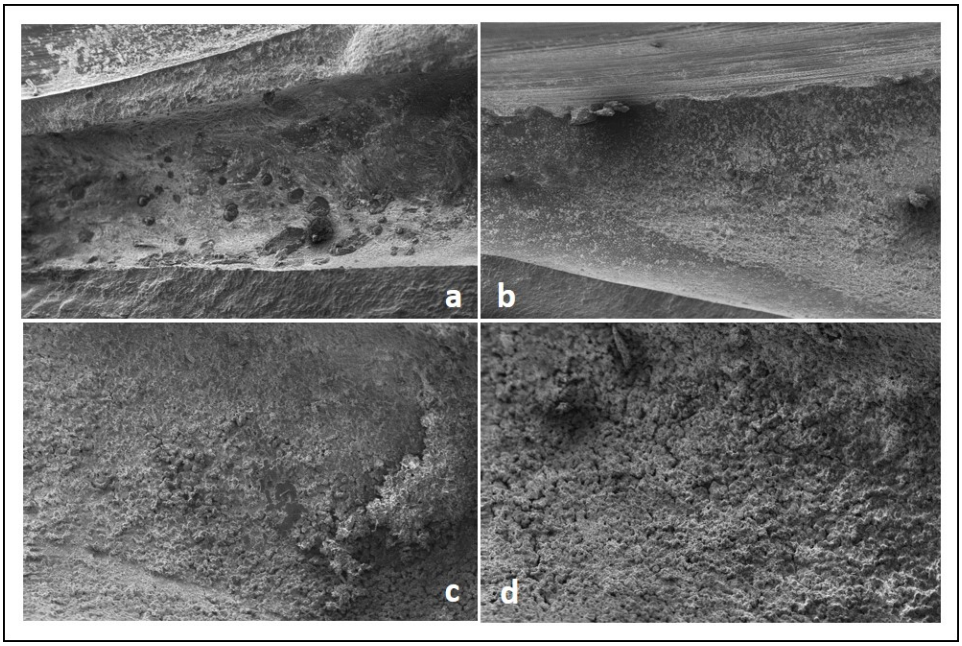

Figure 1: Debris scores

1a: score 2; 1b: score-3; 1c: score-4;1d: score-5

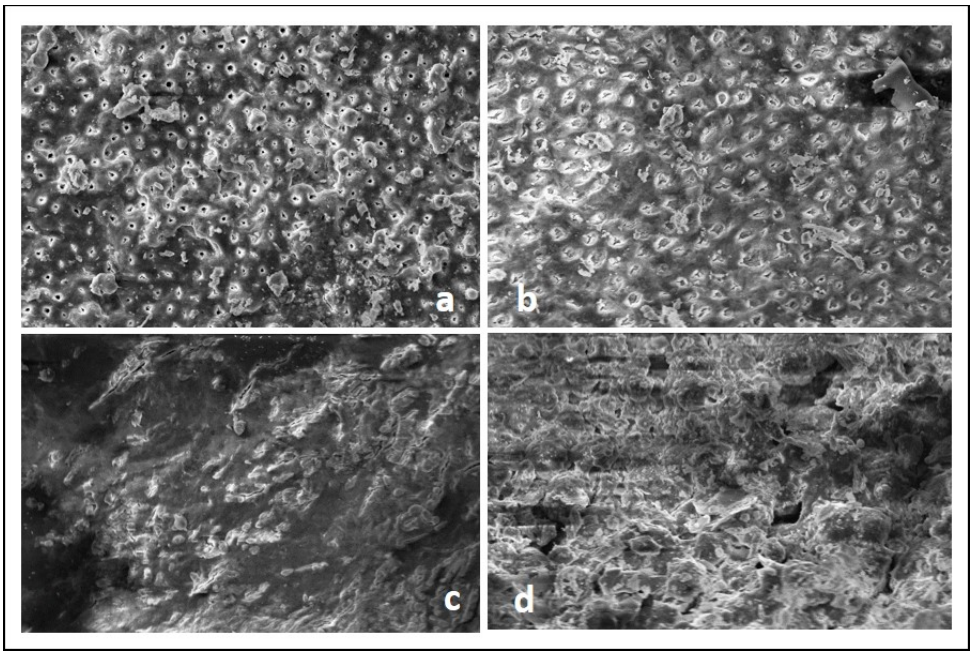

Figure 2: Smear layer scores

2a: score-2; 2b: score-3;2c: score-4; 2d: score-5