Evaluation of the Effect of Different Root Canal Preparation Techniques in Primary Teeth Using CBCT

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Objectives*: The purpose of this in vitro study was to compare and evaluate the cleaning and shaping efficiency of the rotary Ni-Ti, sonic and conventional file systems for root canal preparation in primary teeth under CBCT.* ***Study Design:*** *Seventy five maxillary and mandibular first and second primary molars were divided into three groups of 25 teeth each, according to the canal preparation technique: Group I Rotary file system, Group II Sonic file system, Group III Conventional K files. Canals were scanned using an i-CAT CBCT scanner before and after preparation to evaluate their shaping efficiency. Root canal transportation and centering ratio were evaluated at coronal, middle and apical thirds. The cleaning efficiency was evaluated by the extent of India ink removal from the canal walls under stereomicroscope. The collected data was subjected to statistical analysis.* ***Results:*** *Nickel–Titanium (Ni-Ti) rotary system caused less canal transportation and had better centering ability. Sonic system showed better shaping at the apex, and wider at coronal end. Conventional K-files removed more dentin at coronal than in middle and apex and efficiently cleaned the root canals. There were no significant difference in cleaning and shaping efficiency between Rotary system, Sonic system & Conventional K file system.* ***Conclusion:*** *Rotary instrumentations could be considered as an efficient alternative to conventional hand preparation as it respects the original canal anatomy with no aberrations or resulting failures.*

Key words: *Rotary file, Sonic files, Transportation, Cleaning efficiency, CBCT endodontics*

INTRODUCTION

The success of root canal treatment depends on complete debridement, chemico-mechanical preparation and three dimensional seal. Root canal system is a highly complex entity and rarely contains a single canal.[1] Endodontic instruments play a major role in the success of endodontic treatment starting from the preparation of the access cavity to the final obturation of the root canal space. [2] To improve the speed and efficacy of root canal treatment, the role of rotary instruments have been of great value.[3]

The variety of rotary instruments for endodontic treatment is staggering. There has been a constant quest for quicker, safer and effective instruments for the treatment protocol.[4]

Rotary instruments were introduced in pediatric endodontics by Barr et al in 1999 and have undergone several changes since then.[4,5] The Revo-S (SU) Ni-Ti rotary instrument has been recently introduced with an innovative feature of asymmetric cross-sectional geometry intended to decrease the stress during root canal preparation. This design facilitates penetration by a "snake-like" movement and offers a root canal shaping adapted to the biological and ergonomic imperatives.[6]

Ultrasonic devices for the biomechanical preparation were mainly used by Martin and Cunningham in the year 1970.They named this technique as 'endosonics'[3]. The MM1500 sonic air handpiece has shown safe and effective root canal preparation since many years in permanent teeth endodontics. However there is no study evaluating the efficiency and applicability of sonic handpieces for cleaning and shaping in primary teeth.[7]

A non invasive method to evaluate changes of root canal geometry is Cone Beam Computed Tomography (CBCT). This system has been designed for imaging of hard tissues of the maxillofacial region. CBCT is capable of providing sub-millimeter resolution in images of high diagnostic quality, with short scanning times (10-70 seconds) and radiation dosages reportedly up to 15 times lower than those of conventional scans. [8]

This study is one of the first in its kind to evaluate the cleaning and shaping efficiency of the Rotary Ni-Ti (Revo-S NiTi instrument system, Micro-Mega, Besancon, France), Sonic (MM1500, Micro Mega, Product, Geneva, Switzerland) and conventional method manual K- files *(Mani* Co*, Tokyo, Japan)* in root canal preparation of primary teeth using CBCT.

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MATERIALS AND METHOD

The study was conducted on seventy five primary molar root canals in teeth that had at least two third roots remaining. Each group (n = 3) contained 25 teeth chosen at random. A custom made wax sheet (modeling wax) was constructed with the dimension of 13 x 14 x 5 cm, which exactly matched the FOV (field of view) of CBCT machine. The palatal roots of the maxillary teeth and distal roots of the mandibular teeth were placed mesially for standardization.

The three groups were assigned for preparation by Ni- Ti (Revo-S NiTi instrument system, Micro-Mega, Besancon, France), sonic files (MM1500, Micro Mega, Product, Geneva, Switzerland) and manual K- files (*Mani* Co, *Tokyo*, *Japan*) Coronal access cavity was prepared with a large round bur (Diaburs, Prime Dental Products, Mumbai, India). As the pulp chamber was reached, roof of the pulp chamber was removed to gain access to the root canals. All the overlying dentin was removed with tapered bur to achieve a straight line access into the root canals. The first CBCT (uninstrumented canals) was done at this stage. India ink was inserted into each root canal before biomechanical preparation was performed.

In the group I, Rotary system (Revo-S NiTi instrument system, Micro-Mega, Besancon, France) was used according to the manufacturers' instructions. All the instruments were rotated in a 16:1 speed – reduction headpiece powered by a high torque electronic motor (X-smart Dentsply) and the flutes were cleaned of debris after each insertion. Each file was used to prepare five canals and was then discarded. Revo-S instruments were used at a speed of 250-400 rpm with a torque value of 0.8 N cm.

In group II, Sonic (MM1500, Micro Mega, Product, Geneva, Switzerland) shaper files, were used according to the manufacturers' instructions. All the instruments were oscillated in MM 1500 Micro Mega, Product, Geneva, Switzerland and the flutes were cleaned of debris after each insertion. Each file was used to prepare five canals and was then discarded.

In group III, manual K- files were used in step back technique. An ISO 10 stainless steel K file was used during the preparation to recapitulate till the working length before moving to the next file. Each file was used in the same manner and the canal was enlarged until 25 number file.

i-CAT imaging software was used for the quantitative assessment of the image. The apical tip was determined, and from this point downwards, three slices were chosen. Each cross-sectional slice was 2.0 mm apical to the previous slice. The last slice measured was at the apical tip of the root. Cross-sectional slices of the teeth at the three levels were used to evaluate transportation and centering ratio in one canal which was instrumented in all specimens. Data were arranged into three groups; coronal, middle and apical (Fig: 1).

To compare the degree of canal transportation, a technique developed by Gambill *et al* [9] was used. The amount of transportation was determined by measuring the shortest distance from the edge of the un-instrumented canal to the periphery of the root, in both a mesial and distal direction, and then comparing this with the same measurements obtained from the instrumented images (Fig:2).

The following formula was used for the calculation of transportation: [(X1-X2)-(Y1-Y2)], where X1 represents the shortest distance from the outside of the curved root to the periphery of the un instrumented canal, Y1 represents the shortest distance from the inside (furcation) of the curved root to the periphery of the un instrumented canal, X2 represents the shortest distance from the outside of the curved root to the periphery of the instrumented canal, and Y2 represents the shortest distance from the inside of the curved root to the periphery of the instrumented canal.

According to this formula, a result of '0' indicates no canal transportation. A result other than '0' means that transportation has occurred in the canal.

According to Gambill *et al* [9], the mean centering ratio indicates the ability of the instrument to stay centered in the canal. This ratio was calculated for Revo-S NiTi instrument system, sonic file and manual K- files at three levels using the following formula:

[(X1-X2)/ (Y1-Y2)] or [(Y1-Y2)/(X1-X2)]

According to this formula, a result of '1' indicates perfect centering

After instrumentation, teeth were analyzed for the cleaning capacity using 10% nitric acid. The teeth were kept in acid till they were completely decalcified. Acid was renewed every 24 hours to maintain its efficiency in decalcifying the teeth. Once the teeth become completely decalcified, they were washed under running water for eight hours to completely remove the acid from the tooth surface. Teeth were immersed in ascending order of alcohol (70% alcohol for 16 hours, 80% for 8 hours and 90% for 8 hours) for dehydration. Following decalcification and dehydration, teeth were immersed in methyl salicylate till they appear clear.

Teeth were examined with the aid of a stereomicroscope at 4X magnification, by two observers, who were previously trained and calibrated. The following scoring criteria was used:

Score 0: Total cleaning (No ink remaining in any part of root canal)

Score 1: Almost complete ink removal (Traces of ink found in some areas)

Score 2: Partial ink removal (Ink found on some walls in some areas)

Score 3: No ink removal (Appreciable amount of ink present)

RESULTS

Table 1 shows inter-group (different filing systems) comparison of transportation at different levels using One way Analysis of Variance test. At coronal root level, mean transportation was found to be maximum in Hand filing system followed by Sonic and Rotary filing systems. But this difference was not found to be statistically significant ($p>0.05$). Similarly, at middle root level also, mean transportation was found to be maximum in Hand filing system followed by Sonic & Rotary filing systems but this difference failed to reach the level of significance ($p>0.05$). At apical level, the highest mean transportation was found in Hand filing system followed by Rotary and Sonic filing systems but the difference was not statistically significant ($p>0.05$).

Table 2 shows inter-group (different filing systems) comparison of centric ratio at different levels using One way Analysis of Variance test. At coronal root level, mean centric ratio was found to be maximal in Rotary filing system followed by Sonic and Hand filing systems; but this difference was not statistically significant ($p>0.05$). Similarly, at middle root level also, mean centric ratio was

Figure-1: CBCT scan with measurements

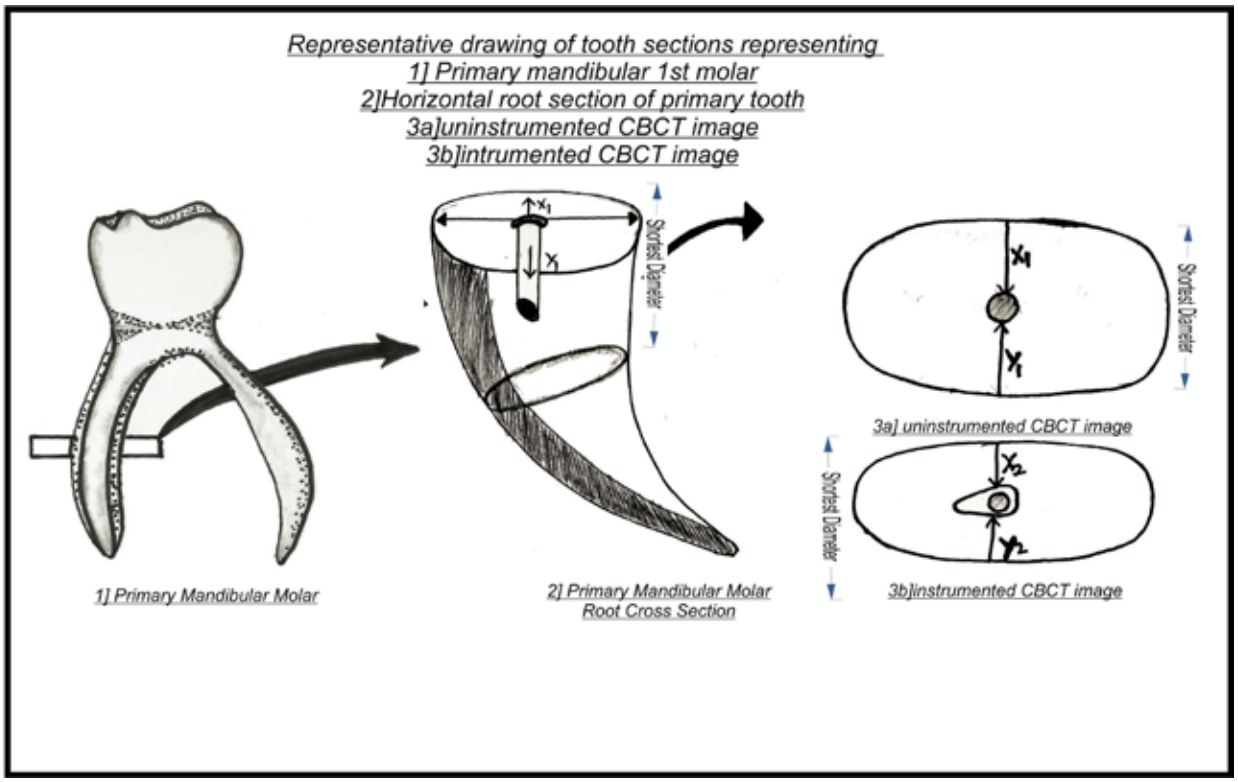
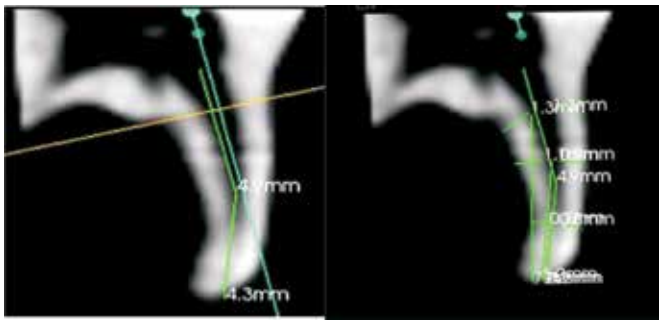


Figure-2: Diagrammatic presentation of X_1,Y_1



found to be maximum in Rotary filing system followed by Sonic & Hand filing systems but again this difference failed to reach the level of significance (p>0.05). At apical level, the highest mean centric ratio was found in Sonic filing system followed by Rotary and Hand filing systems but the difference was not statistically significant (p>0.05).

When mean decalcification scores were compared among three filing systems (Table 3) using One way Analysis of Variance test, then it was revealed that it was more in Sonic & Hand filing systems i.e. 1.36 (0.64) and 1.36 (0.49) respectively as compared to Rotary system in which it was found to be 1.20 (0.41). But again, this difference failed to reach the level of statistical significance (p>0.05).

Table 1: Transportation (Mm) Across Root Levels For All Three Systems

SYSTEM	Coronal		Middle		Apical	
	Mean	SD	Mean	SD	Mean	SD
Rotary system(RE-VO-S)	0.03	0.30	-0.02	0.23	0.02	0.23
SONIC	0.09	0.63	0.06	0.44	-0.13	0.35
HAND FILES	0.34	0.25	0.25	0.21	0.27	0.21
P* value, Significance	0.806, NS		0.392, NS		0.222, NS	

*One way Analysis of Variance

Table 2: Centric Ratio (Mm) Across Root Levels For All Three Systems

SYSTEM	Coronal		Middle		Apical	
	Mean	SD	Mean	SD	Mean	SD
Rotary system (REVO-S)	0.47	0.34	0.40	0.34	0.38	0.39
SONIC system	0.42	0.31	0.39	0.39	0.43	0.39
HAND FILES	0.34	0.25	0.31	0.29	0.20	0.28
P* value, Significance	0.27, NS		0.57, NS		0.06, NS	

*One way Analysis of Variance

Table 3: Cleaning efficiency scores for all the three groups

SYSTEM	Cleaning efficiency scores	
	Mean	SD
Rotary system (REVO-S)	1.20	0.41
SONIC system	1.36	0.64
HAND FILES	1.36	0.49
P* value, Significance	0.59, NS	

*One way Analysis of Variance

DISCUSSION

A tooth root rarely contains a single simple root canal. Primary teeth possess tortuous geometrical anatomy of root canals and pulp chamber, which is different from that found in permanent teeth. Accessory canals, lateral canals, fins, anastomoses between canals and an apical delta, all contribute to the root canal system which makes the primary teeth vulnerable to endodontic treatment failure.[10, 11]The majority of these anatomical features are not accessible to conventional instrumentation.[10] The European Society of Endodontology has defined the biological objectives of canal preparation as the removal of remaining pulp tissue, elimination of microorganisms and removal of debris (ESE, 2006).[12]

Teeth with at least 2/3rd roots remaining were included in the study. The rationale behind this was to assess the cleaning and shaping ability of different root canal instrumentation technique till the apical third where maximum amount of bacteria are present. This is in accordance with the study conducted by Silva *et al* in 2004.[13] The primary teeth are always under a constant stage of dynamism. Two third working length of root canal is essential for standardization of specimens. Numerous studies have quoted the same inclusion. [14, 15, 16]

The gold standard for endodontic files has long been the traditional, manual stainless steel hand files.[17] Selvakumar *et al* in 2016 compared the preparation time, the risk of lateral perforation and dentin removal by the stainless steel K file and K3 rotary instrumentation in primary teeth and found that significantly less amount of dentin was removed by K3 rotary files (.02 taper) as compared to the stainless steel K file.[18]

Ultrasonic devices were first introduced in Endodontics by Richman (1957)[19]. Ultrasonically activated files have the potential to prepare and debride root canals mechanically. The files are driven to oscillate at ultrasonic frequencies of 25–30 kHz that are beyond the limit of human hearing. The files operate in a transverse vibration, setting up a characteristic pattern of nodes and anti-nodes along their length. In this study, shaper sonic files were used for instrumentation. Lumley PJ in 1996 [20] investigated the factors affecting the wear and cutting ability of sonic files. Variables evaluated were file type; Heliosonic, Rispisonic or Shaper, load; 25, 50 or 100 grams and length of time in use; new, 30 or 60 seconds. The Rispisonic file was most susceptible to wear during use especially at higher loads and the Heliosonic file cut least. The study concluded that the Shaper file had better design out of the three with respect to cutting ability and wear with use. The use of ultrasonic device is widely accepted in dentistry because of its advantages like constant irrigation, better bactericidal action and reduced operator/ patient time [21]. However there is a tendency with sonic system to create hour glass pattern in root canals which hinder obturation.[7]

In recent years, the use of nickel–titanium (Ni-Ti) rotary files and automated root canal devices has increased in endodontic treatments. The advantages of rotary Ni-Ti instruments over hand instruments include facilitating canal preparation, preserving the shape of curved canals and producing smooth surfaces in lesser time and rate of tapering for use in endodontic treatment. Efforts have focused on increasing the cleaning efficacy of the root canal as well as reducing the time spent on preparation—an especially important factor in primary teeth.[16] Several studies have compared the effectiveness of rotary NiTi and hand instruments in cleaning root canals.

Most studies have confirmed that NiTi rotary systems are faster than hand instruments, eliminate problems during the preparation of curved root canals and result in better conservation of the tooth structure. With regard to the cleaning ability in permanent root canals, rotary NiTi instruments were better than hand files or yielded the same results. However the disadvantages of using NiTi rotary instruments are absence of simultaneous irrigation, high cost of files and the training of operator.[13, 16] George *et al* in his extensive review done in 2016 recommends the use of rotary instruments for pulpectomy in primary teeth.[22]

The ink penetration and clearing technique is useful for studying the cleaning ability of the instrumentation and the morphology of human teeth as it makes the teeth transparent so that the pulp cavity and root canal walls can be diagnosed. Clearing is a simple and inexpensive technique that provides three-dimensional visualization of teeth and preserves the original form of the root canal system. Numerous studies have used the method of clearing and dye penetration for evaluating the efficiency of cleaning and shaping through various root canal preparation techniques.[13,14]

I-CAT CBCT was used in the present study to evaluate the changes in dentinal thickness before and after instrumentation using all three system of shaping. Fayyad *et al* [23] performed similar study for evaluating shaping ability of Hero Shaper and Revo-S by using computed tomography.

Fayyad *et al* [23] in 2012 found similar results while comparing the apical transportation, centering ability, percentage of straightening and change in canal volume with Hero Shaper and Revo-S NiTi (Micro Méga) rotary systems. Findings from their study revealed highest canal transportation in the coronal region (0.08±0.078), followed by middle third region (0.08±0.51) and lowest in the apical region (0.07±0.48) which is in accordance with our study. However, results from both the studies failed to reach the level of significance (p>0.05). Musale *et al* in 2014 while evaluating the efficacy of rotary PROFILE, ProTaper, Hero Shaper, and K file with respect to their shaping ability, cleaning efficacy, preparation time and instrument distortion in primary molars found similar results. Their study indicated that rotary files produced significantly better taper in primary molars as compared to K-files.[24]

Elsherief *et al* in 2013[25] compared the effects of 3 different NiTi rotary instruments on final shape of the curved canals on total amount of root canal transportation by using cone-beam computed tomography and highlighted that all instruments maintained the original canal curvature well and were safe to use.

In the present study, lowest value of canal transportation was seen in apical region (0.02±0.23). This difference can be attributed to the fact that more calcified dentine is present in permanent teeth which gives more resistance while shaping the canal. However, primary teeth are always in a dynamic stage of resorption which in

turn results in softer dentin at apex , therefore equal shaping of canal is achieved and hence less transportation towards the curvature. Another possible explanation could be the tendency of the operator to perform more intensive instrumentation at the side opposite to the most favorable support. Although the difference in the mean of both the studies failed to reach the level of significance ($p>0.05$), the results of the study still highlights the trend of transportation by rotary files.

A study done by Selvakumar *et al* [26] in 2014 evaluated canal transportation and centering ability of K 3 (0.02%) and K 3 (0.04%) with hand K files in primary teeth using spiral computed tomography. The study showed that k-file produced highest centering ratio at coronal region (0.45±0.16mm) than the middle region, k-file showed lower value of centering ratio (0.24±0.04mm) and little higher value at apical region of (0.36±0.10mm). This is in accordance with the present study where we found similar results in coronal and middle third, the highest canal centering ratio was in coronal region (0.34±0.25mm) followed by middle third region (0.31±0.29mm) and then in apical region (0.20±0.28mm).

Numerous other studies support the present result. Silva *et al* [13], Schäfer and Zapke [17] reported that the manual and rotary instruments yielded similar degree of cleanliness. To correctly evaluate the cleaning and shaping efficiency of all the systems in primary molars, *in vivo* studies need to be done, which will include the comparison under exact clinical scenario in pediatric patients.

CONCLUSION

With the given data and observations, following conclusions can be derived:

- Rotary system (Revo-S) could be considered as an efficient system that respects the original canal anatomy, with no aberrations or resulting failures.
- Sonic system (MM1500 Air) showed better shaping at the apex and wider at coronal end.
- Conventional K-files removed more dentin at coronal than in middle and least at the apex and efficiently cleaned the root canals.
- There is no statistically significant difference in cleaning and shaping efficiency of Rotary system, Sonic system and Conventional k-files in root canals of primary teeth.

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