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Volumetric analysis of Hand and Rotary instrumentation and Evaluation of Obturating material in Primary teeth using CBCT – A Clinical trial

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ABSTRACT

Aims & Background: The biomechanical preparation is considered a critical step in the Pulpectomy procedure. The goal is to remove the microbiological contents in the canal and protect tooth function. In-vitro studies demonstrate that the shape of the root canal is more conical, favouring higher obturation quality and thereby increasing success rate using rotary files. So, this clinical trial aims to compare the volume of root canals before and after root canal instrumentation using hand and rotary files and to evaluate the flow of obturating material using CBCT in primary molars.

Materials and Methods: This trial was conducted in 20 primary molars which were assigned to Group 1 (Hand files) and Group 2 (Rotary files). A CBCT was taken at 3 different intervals i.e., Prior to the procedure, After BMP, After the procedure. The difference between the Pre-instrumentation and Post-instrumentation CBCT images reveals the 3D volume change measured using hand and rotary files. Post-instrumentation and Post-obturation CBCT scans display the flow of root canal filling material in primary molars.

Results: There were statistically significant differences noticed within Group 1 (p value = 0.000); and pre-instrumentation and post-instrumentation, pre-instrumentation and post-obturation in Group 2 (p value = 0.000). No statistically significant difference seen between post-instrumentation and post-obturation values (p value = 0.076). Significant differences were found in post-instrumentation and post-obturation volumes between groups.

Conclusion: This trial concluded that rotary files led to a more productive funnel-shaped canal preparation that resulted in better obturation quality with minimal voids than hand files.

Clinical significance: Rotary files using 3D imaging allowed more conservative and efficient root canal preparation while maintaining anatomy, resulting in superior three-dimensional obturation than hand files.

INTRODUCTION

Dental caries is one of the utmost frequent preventable non-communicable illnesses, affecting 2.5 billion people worldwide, according to the Disease Study Global Burden, and has increased by 14.6% in the last ten years. Dental caries was found to be 46.2% and 53.8% prevalent worldwide in primary teeth and permanent teeth, respectively, with lower estimations seen in European nations and higher estimates in African nations. [(1)] Dental caries and dental trauma (TDI) are the foremost common conditions affecting young children globally, both in developed and developing nations. The outcomes exhibited that there was an inverse relation between the mean dmft index and the total OHRQoL score. [(2)]

The maintenance of the primary teeth, either naturally or through endodontic therapy, is essential for the proper growth of the jawbone and musculature, which eventually aids in the emergence of permanent teeth into the appropriate position and for functionality purposes. Premature primary tooth loss can lead to abnormal habit formation, altered phonation, and changes in the permanent tooth eruption pathway. [(3)] A pulpectomy is a procedure that restores the primary teeth and functions as a natural space maintainer.[(4)] It is considered an appropriate treatment strategy for carious primary teeth involving pulp. This treatment procedure has been performed with a variety of instrumentation methods. [(5)] The preparation of primary root canal is a tedious and lengthy stage during pulpectomy as they have untraversable root canal morphology, rendering root canal therapy a complex procedure. [(6)]

The foremost purpose of root canal therapy for both permanent and primary teeth is to remove contaminated tissues, and microorganisms from the canal, and their byproducts through chemical and mechanical cleaning, as well as debridement with the use of either hand instruments or rotary systems. [7] The efficacy of pulpectomy is entirely dependent on pristine canal preparation and impervious root canal sealing. These rotary or manual files can be used for biomechanical preparation, which is considered the pivotal phase in root canal procedures and determines its success. [8] However, automated systems have been demonstrated to substantially decrease the instrumentation time while also cleaning and shaping the root canal with a higher degree of precision and efficacy. [9]

To alleviate these constraints, Barr et al. 2000 [10] introduced Ni-Ti rotary files using Profile 0.04 taper rotary instruments in the pulpectomy of primary teeth. In comparison to stainless steel files, nickel-titanium (NiTi) files are less rigid and can retain their shape. So, during the root canal preparation process, NiTi files adhere to the original canal anatomy, producing a funnel-shaped canal preparation with a low probability of technical errors. [6] The rotary files that are used for permanent teeth caused over-instrumentation when they were used in the comparatively narrow primary root canals. Additionally, because of their limited mouth opening, adult rotary files were harder to use on pediatric patients due to their extended length. These entailed the conception of a unique pediatric rotary file system to be employed with children. [11]

In 2016, Kedo files, the rotary endodontic files, were specially designed for primary teeth; introduced by Ganesh Jeevanandhan [12], and manufactured locally by the manufacturer Kedo Dental, Chennai, Tamil Nadu, India. Kedo rotary files consist of 5 generations currently and are referred to as "Kedo-S, Kedo-SG, Kedo-SG Blue, Kedo-S Square, and Kedo-S Plus files." [13]

There is a lacunae in the existing literature regarding the volumetric analysis of root canals and flow of obturating material using hand and rotary files. Thus, the present research study aims to compare the volumetric change using hand (K files) and rotary (Kedo-S Plus files) and the flow of obturating material in root canals of primary molars.

Methods:

Teeth were selected from the patients who visited the OP of the Department of Pediatric and Preventive Dentistry. Twenty primary molars were used in this investigation, which was set up as a clinical trial with two groups of participants. The ethical clearance was obtained from Institutional Ethics Committee of our tertiary health care hospital. This research study was enrolled in Clinical trials registry - India (Trial REF/2024/05/083853). Informed agreement was acquired from the parents of the patients chosen for this study. The sample size of this study was calculated based on the available literature (Poornima et al. 2016 [14]). Using the Fishbowl method of random sampling, patients were assigned to both groups (Group 1 - Hand files and Group 2 - Rotary files). Due to the obvious nature of the treatment, neither the patient nor the operator could be blinded.

INCLUSION CRITERIA:

Age range - 4 to 8 years

An extensive carious lesion accompanied by a spontaneous pain history was noticed during clinical examination.

Teeth radiographically showing more than two-thirds of the root.

Sufficient amount of tooth structure for the placement of the rubber dam.

Primary molars, which are diagnosed as chronic irreversible pulpitis and require Pulpectomy procedure.

EXCLUSION CRITERIA:

Patients with any of the following conditions: severe systemic diseases, uncontrolled bleeding disorders, or known allergies to the materials used in the procedure.

Teeth with mobility and the presence of sinus on clinical examination.

Radiographically, teeth with more than one-third of root resorption, internal resorption and calcification of pulp were also excluded.

An overview of the methodology is presented in Figure 1 as a flow chart.

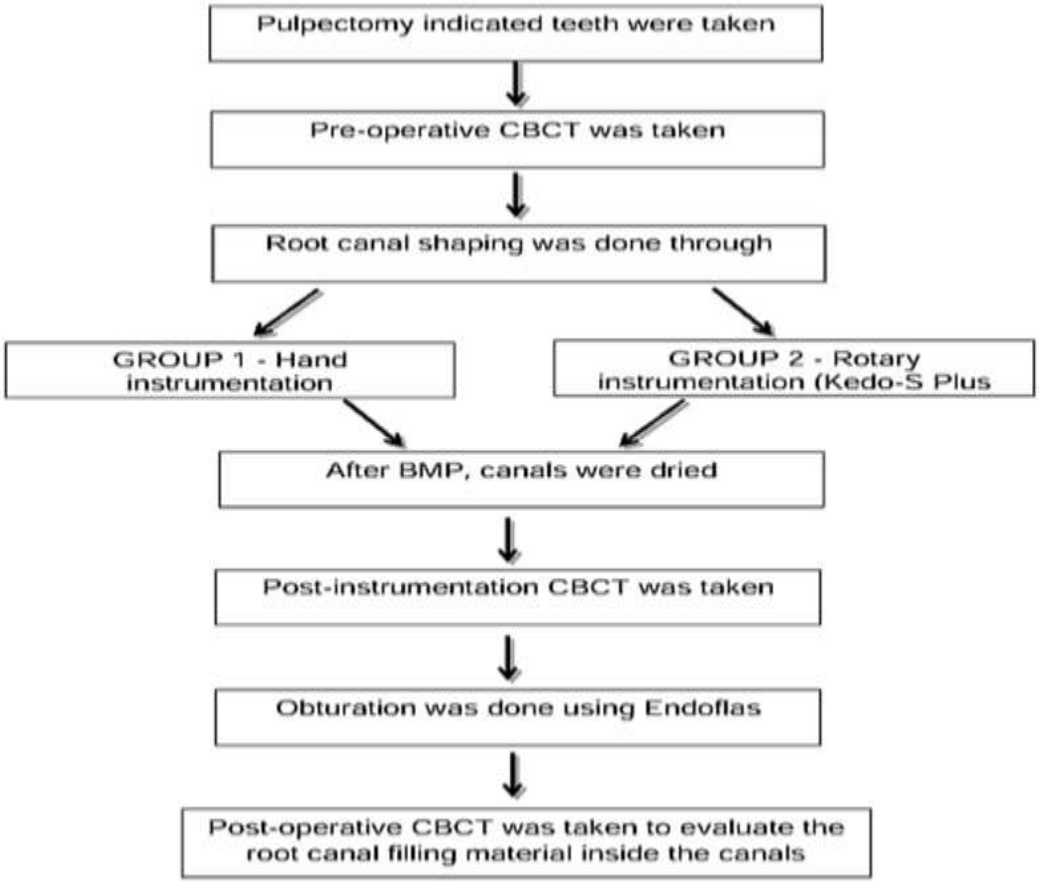


FIGURE 1: Outline of Methodology

A CBCT with a 5×5 FOV (Fig.2) was preferred for this investigation due to its minimal dose of radiation. A local anesthetic solution was injected into the targeted site following the administration of topical anesthesia, and a rubber dam was used to isolate the tooth that needed to be treated. The access cavity preparation was done with large round bur, followed by deroofing of the pulp chamber, which was finished with the non-end cutting bur; a sharp spoon excavator was used for coronal pulp amputation. After working length determination, BMP was performed in all the root canals using K-files (hand instrumentation) in Group 1, which were enlarged up to #40 size K-file with 0.02% taper using a quarter-turn and pull technique. Each instrument was utilized for 5 times and then discarded. Canals were irrigated with 2% chlorhexidine in between file instrumentation. The torque measured at 2.2N and the endodontic motor speed at precisely 250 rpm were used in conjunction with the rotary files. As advised by the manufacturer, each rotary file was used for a maximum of five teeth in order to preserve consistency throughout the canal preparation process. For BMP in Group 2 (rotary instrumentation), utilizing EDTA, Kedo-S Plus files (P1) with an endomotor were employed in brushing movement until the working length was reached for an additional 5 strokes, considering the finalization of instrumentation, as proclaimed by the manufacturer. Canals were copiously irrigated with 2% chlorhexidine, specially manufactured for endodontic purposes. The obturating material, Endoflas, was prepared by mixing a scoop of powder, two drops of liquid, and a drop of accelerator on the glass slab. Spreaders and pluggers were utilized to obturate the root canals with Endoflas, and the material was pushed inside with a wet cotton pellet. The tooth was sealed with a final restoration by means of Type-IX GIC and recalled after a week for the placement of SSC.

FIGURE 2: Pre-instrumentation CBCT, Post-instrumentation CBCT, Post-obturation CBCT

The volume of the canals was calculated with acquired CBCT data via Dolphin software, through which automatic values interpreting the volume in terms of cm3 were generated. So, the difference between the Pre-instrumentation and Post-instrumentation CBCT images reveals the main objective, which was the 3D volume change defined by using hand and rotary files. Likewise, Post-instrumentation and Post-obturation CBCT scans displays the flow of root canal filling material that were instrumented using hand and rotary files in primary molars. The obtained values were then subjected to statistical analysis.

Statistical analysis:

Descriptive statistics were expressed as mean ± SD and the acquired data was processed, tabulated, and analyzed using SPSS version 2.0 for Windows. A volumetric comparison between pre-instrumentation, post-instrumentation and post-obturation readings within the groups and in between the groups were done using Wilcoxen Signed Rank test and Mann Whitney U test respectively. To be deemed statistically significant, a p-value has to be below 0.05.

Results:

In Group 1 (hand files), the mean and standard deviation values of pre-instrumentation, post-instrumentation and post-obturation volumes were 0.32±0.06, 0.48±0.07 and 0.40±0.06 respectively (Table 1).

In Group 2 (rotary files), the mean and standard deviation values of pre-instrumentation, post-instrumentation and post-obturation volumes were 0.36±0.04, 0.67±0.06 and 0.64±0.07 respectively (Table 1).

S. No	HAND FILES (Primary tooth sample)	Pre-instrumentation volumes	Post-instrumentation volumes	Post-obturation volumes
1	Mandibular second molar	0.38 cm^3	0.50 cm^3	0.45 cm^3
2	Mandibular second molar	0.32 cm^3	0.50 cm^3	0.42 cm^3
3	Mandibular first molar	0.27 cm^3	0.42 cm^3	0.42 cm^3
4	Mandibular second molar	0.30 cm^3	0.49 cm^3	0.39 cm^3
5	Maxillary first molar	0.35 cm^3	0.49 cm^3	0.35 cm^3
6	Maxillary second molar	0.41 cm^3	0.58 cm^3	0.51 cm^3
7	Mandibular first molar	0.22 cm^3	0.35 cm^3	0.30 cm^3
8	Mandibular second molar	0.35 cm^3	0.49 cm^3	0.42 cm^3
9	Mandibular first molar	0.28 cm^3	0.40 cm^3	0.34 cm^3
10	Mandibular second molar	0.36 cm^3	0.51 cm^3	0.42 cm^3
S. No	ROTARY FILES (Primary tooth sample)	Pre-instrumentation volumes	Post-instrumentation volumes	Post-obturation volumes
1	Mandibular second molar	0.31 cm^3	0.58 cm^3	0.55 cm^3
2	Mandibular second molar	0.39 cm^3	0.67 cm^3	0.62 cm^3
3	Mandibular first molar	0.40 cm^3	0.76 cm^3	0.75 cm^3
4	Mandibular second molar	0.35 cm^3	0.69 cm^3	0.65 cm^3
5	Maxillary first molar	0.38 cm^3	0.71 cm^3	0.70 cm^3
6	Maxillary second molar	0.29 cm^3	0.57 cm^3	0.54 cm^3
7	Mandibular first molar	0.37 cm^3	0.70 cm^3	0.67 cm^3
8	Mandibular second molar	0.32 cm^3	0.63 cm^3	0.60 cm^3
9	Mandibular first molar	0.39 cm^3	0.71 cm^3	0.68 cm^3
10	Mandibular second molar	0.35 cm^3	0.70 cm^3	0.68 cm^3

TABLE 1: Volumes of Hand files (Group 1) and Rotary files (Group 2)

There were statistically significant differences noticed between pre-instrumentation and post-instrumentation, post-instrumentation and post-obturation, and pre-instrumentation and post-obturation in Group 1 (hand files), with a p value of 0.000 (Table 2).

There were statistically significant differences found between pre-instrumentation and post-instrumentation, and pre-instrumentation and post-obturation in Group 2 (rotary files), with a p value of 0.000 while there is no significant difference noticed between post-instrumentation and post-obturation values with a p value of 0.076 (Table 2).

HAND		Mean Difference (I-J)	Std. Error	Sig.[b] (p value)	95% Confidence Interval for Difference[b]		Mean and Standard deviation
					Lower Bound	Upper Bound	
Pre	Post	-.028*	.008	0.000	-.175	-.129	0.32±0.06
	Obt	-.080*	.005	.000	-.094	-.066	
Post	Pre	.152*	.008	0.000	.129	.175	0.48±0.07
	Obt	.072*	.005	.000	.057	.087	

Obt	Pre	.080*	.005	0.000	.066	.094	0.40±0.06
	Post	-.072*	.005	.000	-.087	-.057	
ROTARY		**Mean Difference (I-J)**	**Std. Error**	**Sig.[b] (p value)**	**95% Confidence Interval for Difference[b]**		**Mean and Standard deviation**
					Lower Bound	**Upper Bound**	
Pre	Post	-.317*	.010	0.000	-.346	-.228	0.36±0.04
	Obt	-.289*	.013	.000	-.326	-.252	
Post	Pre	.317*	.010	0.000	.288	.346	0.67±0.06
	Obt	.028	.004	.076	.017	.039	
Obt	Pre	.289*	.013	.000	.252	.326	0.64±0.07
	Post	-.028	.004	.076	-.039	-.017	

Statistically significant

TABLE 2: Intragroup comparisons of Hand and Rotary files, Mean and Standard deviation values of Group 1 and Group 2

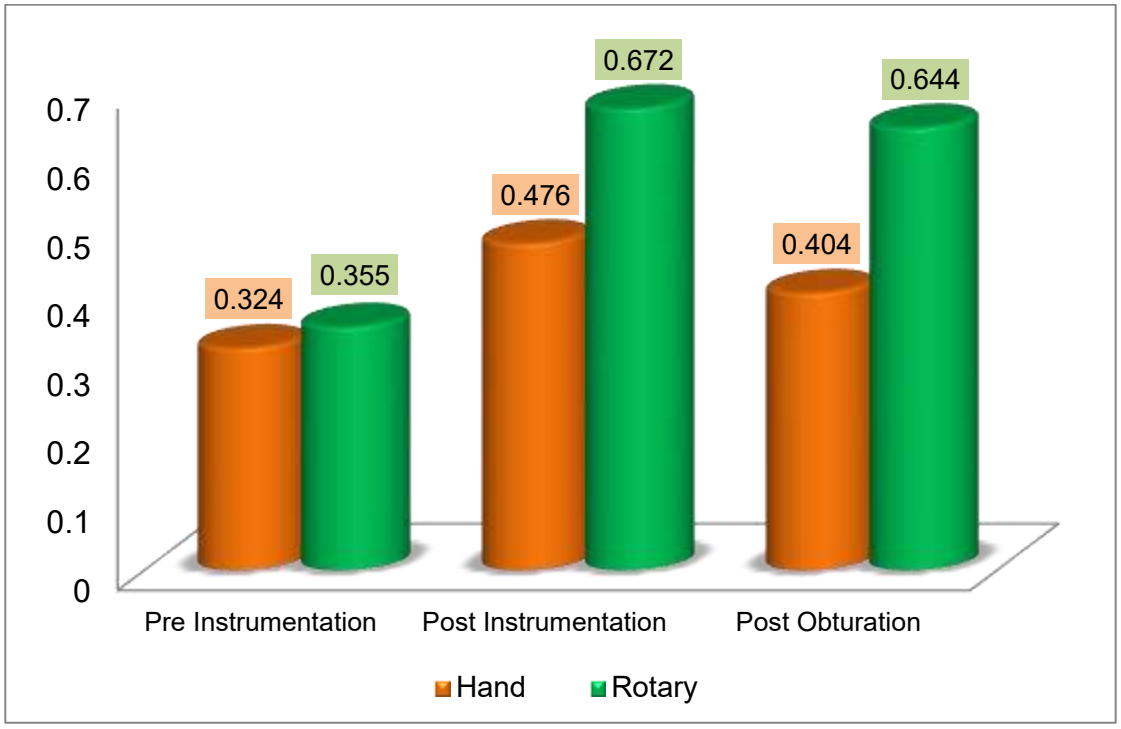
The mean and standard deviation values of post-instrumentation and post-obturation in hand group were 0.476±0.021 and 0.404±0.019 respectively, whereas in rotary group, they were 0.672±0.019 and 0.644±0.021 (Table 3 and Graph 1).

GROUPS		**Mean**	**Std. Error**	**95% Confidence Interval**	
				Lower Bound	Upper Bound
HAND	Pre-instrumentation	.324	.018	.283	.365
	Post-instrumentation	.476	.021	.428	.524
	Post-obturation	.404	.019	.360	.448
ROTARY	Pre-instrumentation	.355	.012	.328	.382
	Post-instrumentation	.672	.019	.629	.715
	Post-obturation	.644	.021	.596	.692

Statistically significant

TABLE 3: Intergroup comparison of Hand and Rotary files

When post-instrumentation volumes of Group 1 (K files) was compared with post- instrumentation volumes of Group 2 (Kedo-S Plus files), there was a statistically significant difference with a p-value of 0.000. Similarly, when post-obturation volumes of Group 1 (K files) was compared with post-obturation volumes of Group 2 (Kedo-S Plus files), there was a statistically significant difference with a p-value of 0.000 (Table 3 and Graph 1).



GRAPH 1: Bar graph showing intergroup comparison of Hand and Rotary files

DISCUSSION

Dental caries is a severe, progressive disease with substantial variances in distribution due to a wide array of factors, and a deficit of information impedes development toward the WHO's dental caries prevalence reduction goals. In primary dentition, the dmft index has 59% prevalence as a diagnostic criterion for dental caries. However, the prevalence rates of dmft/DMFT for diagnosing dental caries were 66% and 43% in mixed and permanent dentition, respectively. [15]

In order to maintain the length of the arch and direct the emergence of the underlying successors, the treatment of infected primary teeth in children has undergone a paradigmatic shift from extractions to pulpectomy, which is considered a crucial endodontic procedure. [16] The biomechanical preparation performs a pivotal role in the successful outcome of the pulpectomy procedure by facilitating the complete debridement and removal of the infected pulp tissue through comprehensive cleaning and shaping of the root canals. This permits accessibility for the irrigating solutions to reach the apical portion of the root and subsequently provides a sterile space for the obturation of the prepared canals. [17]

The most recent rotary system of Kedo brand is the Kedo-S Plus file (5th generation). It has a variety of unique characteristics, such as a patented variably variable taper, heat treated NiTi with controlled memory wiring, blue titanium oxide layer coating and cyclic fatigue resistance. The benefits include greater flexibility, simple and quicker removal of tissue and debris, easier access to all canals, no need to be precurved, following the original root canal anatomy, and funnel shaped canal preparation which eventually results in a more predictable obturation. [18]

Crespo et al. in 2008 [19], performed a comparative study on rotary and manual instrumentation using a stereomicroscope and they inevitably concluded that the use of rotary systems in primary teeth provided decreased working time, therefore contributing to patient cooperation and since the root canal shape is more conical, leading to a superior quality of the root canal filling, and increasing clinical success when compared to conventional hand files which correlates with this current study findings as well.

Poornima et al. in 2016 [14] found a significant increase in the post-instrumentation root canal volume, which ultimately led to a statistically significant root canal filling with rotary files when compared to hand files using spiral CT which is consistent with the findings in the current study.

Jeevanandan et al. in 2018 [16], Panchal et al. in 2019 [20], Priyadarshini et al. in 2020[21], Shah et al. in 2021 [22] reported that Kedo-S rotary systems led to statistically significant improvement in obturation quality in primary molars, which is in accordance with the results obtained in our study.

Contrary to the present study findings, Morankar et al. in 2019 [23] and Sruthi et al. in 2021 [24] found no significant differences in obturation quality using hand and rotary files. This may be on account of the variations in rotary file systems, radiographic scans, and operator skills in our study.

We acknowledge a few limitations of the study. So, further research using the larger sample size and different rotary file systems can be evaluated.

CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

1. Both the K files and Kedo-S plus files are good at efficiently enlarging root canals, resulting in an increase in post-instrumentation and post-obturation volumes when compared to the pre-instrumentation volumes.
2. Within Group 1 (K files), there was a statistically significant difference between the post-instrumentation and post-obturation volumes, indicating evident voids after the obturation in primary molars.
3. Within Group 2 (Kedo-S Plus files), there was a statistically significant difference between the pre-instrumentation and post-instrumentation volumes.
4. In Group 2 (Kedo-S Plus files), when the post-instrumentation volume was compared with post-obturation volume, no statistically significant difference was noticed, corresponding to a lesser number of voids.
5. In the intergroup comparison of post-instrumentation and post-obturation volumes, there were statistically significant differences.
6. Hence, it can be concluded that rotary files led to a more productive funnel-shaped canal preparation that resulted in better obturation quality with minimal voids compared to hand files.

Clinical significance:

By employing the standard, most accurate, and reliable tool of 3D analysis, this research investigation showed that the

instrumentation with rotary files led to more conservative and efficient root canal preparation while maintaining root canal anatomy, which in turn led to superior quality three-dimensional obturation in comparison to hand files.

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