ORIGINAL RESEARCH

Comparative Evaluation of Instrumentation Time and Quality of Obturation amongst Pediatric Rotary Endodontic System: An *In Vivo* Study

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Abstract

Aim: This study assesses the instrumentation time and quality of obturation of three pediatric rotary endodontic systems—GT nickel-titanium (NiTi) (Prime Pedo), controlled memory (CM) NiTi (Pro-AF-Baby Gold) and NiTi-titanium oxide (NiTi-TiO) (Kedo SG Blue).

Materials and methods: A total of 60 children aged 4–8 were chosen at random for the study based on inclusion criteria that required pulpectomy in any of the primary molars and were separated into three groups of 20 samples, each based on the file system employed. The instrumentation time during the preparation of the canal is recorded using a stopwatch. An expert dentist was blinded to the instrumentation type and showed the periapical radiograph, which he or she graded depending on the quality of the obturation by categorizing it as underfill, optimal fill, or overfill. The observations were then recorded, tabulated, and statistically analyzed for the results.

Results: The least amount of instrumentation time was needed for NiTi-TiO (group III) files, followed by NiTi-CM (group II) and NiTi-GT (group I). NiTi-TiO (group III) has the most optimally filled and least underfilled obturations among the three rotary endodontic systems mentioned. Also, NiTi-TiO (group III) and NiTi-CM (group II) have the least similar overfilled obturations when compared with NiTi-GT (Group I).

Conclusion: We conclude that NiTi-TiO needed the least amount of instrumentation time and generated the maximum optimally filled obturations based on our observations.

Clinical significance: Pediatric rotary endodontic systems are more convenient to use and reduce chairside time; thus, their use in children with behavior control issues might be more suitable.

Keywords: Kedo-SG blue, Pediatric rotary endodontic systems, Primary molars, Prime pedo, Pro-AF baby gold, Pulpectomy.

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Introduction

"Deciduous teeth" comes from the Latin phrase "*decidere*," which means "to fall out." Exfoliation occurs when teeth get soft and fall off, replacing them with permanent dentition, similar to how flower petals and leaves do.[1]

The most critical issue in pediatric dentistry is the early loss of primary molars that are necrotic due to caries or other factors, including trauma. The dentofacial skeletal complex is adversely affected in terms of soft tissue support, occlusion, full dentition development, and esthetics.[2] Also, the most unpleasant consequence of untreated dental caries in children is pulp involvement. Hence, for maintaining such teeth with irreversible pulpitis, pulpectomy is the preferable therapeutic choice.[3] Hand instrumentation is a conventional approach that may lead to canal perforations, inadequate cleaning and shaping, instrument failure, and increased chair time for children.[4] Because the duration of an appointment has a considerable impact on a child's behavior, rotary has improved workability by having fewer appointments.[5–7] As a result, more and more professionals are investigating the advantages of rotary endodontics in contemporary practice.[8]

In the realm of endodontics, rotary instrumentation has made a substantial rise. The first study to illustrate the use of NiTi rotary files in primary molars was conducted by Barr et al. They proposed the same biomechanical preparation concepts for permanent teeth.[9] The application of rotary endodontics in primary teeth was, however, constrained by the peculiar root canal shape and thinner dentine thickness.[9,10] Several modified techniques have been devised to get over these obstacles and avoid any unfavorable side effects.[11–13] Exclusive pediatric rotary files with further modifications, such as heat-treated files with a TiO coating, gold-treated files, and files with CM, are now readily accessible for use in primary teeth and range in length from 16 to 18 mm. Therefore, this *in vivo* study was created to assess and compare the instrumentation time and quality of obturation utilizing three distinct pediatric rotary endodontic systems.

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Materials and Methods

Source of Data

This *in vivo* study was conducted in the Department of Pediatric and Preventive Dentistry at Rama Dental College, Hospital and Research Centre, Kanpur, Uttar Pradesh, India, with permission from the Scientific and Ethics committee (02/IEC/RDCHRC/2019-20), in accordance with the Helsinki Declaration (1964) and its subsequent amendments. After meeting the eligibility requirements and obtaining duly signed informed consent, 60 kids between the ages of 4 and 8 were selected from the outpatient department to take part in this clinical study.

Criteria For Patient Selection

Inclusion Criteria

- The child should be in good health with no history of major systemic illness or allergies.
- Patient should be between 4 and 8 years of age.
- Patients exhibiting Frankl's behavior rating scale score of 3 (positive (+)) and 4 (definitely positive (++)).
- Vital or nonvital primary molars with deep caries and without sinus tract.
- Absence of internal or cervical pathologic root resorption.
- A minimum of two-thirds of the remaining root length
- A tooth structure strong enough to hold a rubber dam.

Exclusion Criteria

- Children with special health care needs and underlying systemic diseases.
- Children lacking the cooperative ability.
- Teeth with aberrant pathologic mobility and preshedding.
- Teeth with internal or external root resorption.
- Teeth exhibiting pulpal floor perforation.
- Gross bone loss at the furcation area or apex of primary mandibular teeth.
- Periradicular involvement, with the potential of irreversible tooth bud injury.
- Patient/guardian not ready to give consent.

Distribution of Groups

On the basis of the pediatric rotary endodontic system employed for biomechanical preparation, A total of 60 participants were then separated randomly into three groups of 20 each:

- Group I (n = 20) = NiTi-GT (Prime Pedo), (Sky International Enterprises, Navi Mumbai, Maharashtra, India).
- Group II (n = 20) = NiTi-CM (Pro-AF Baby Gold files), (Dentobizz, Yavatmal, Maharashtra, India).
- Group III (n = 20) = NiTi-TiO (Kedo-SG Blue), (Reeganz Dental Care Pvt. Ltd., Chennai, Tamil Nadu, India).

Treatment Procedure

A single operator performed all of the clinical procedures in this investigation. The treatment was aided by a well-trained dental assistant, who also kept track of the instrumentation time with a stopwatch. Oral prophylaxis was performed in every case during the first session. For all cases, pulpectomy was performed under rubber dam isolation after local anesthetic was administered. After obturation, intraoral periapical radiographs (IOPA) of all teeth were obtained.

Access Cavity Preparation

The air-rotor handpiece (NSK PANA AIR M B2) and a round diamond bur (BR-46; Mani Inc., Japan) were used to access the cavity, and the Endo Z bur (DenstsplyMaillefer, Ballaigues, Switzerland) was employed for additional deroofing. Coronal pulp amputation was performed with a spoon excavator, followed by an examination of canal orifices by the use of a DG 16 endodontic explorer (Hu-Friedy Mfg. Co. LLC). Pulp extirpation was carried out with a size #20 barbed broach (Dentsply, Maillefer, Oklahoma, United States of America). The working length was determined by measuring the radiograph from the points of the mesial or distal cusps to 2 mm short of the apex. The pulp chamber was copiously irrigated with 2.5% sodium hypochlorite and 0.9% normal saline.

Working Length Determination

Initial patency was achieved by the insertion of no.15 K-file (Dentsply Maillefer, Oklahoma, United States of America) with simultaneous irrigation of the pulp chamber. The radiographic working length was kept 1 mm short of the radiographic apex using the standard Ingle's approach.

Biomechanical Preparation

Endo motor (Coltene/Whaledent Inc. Cuyahoga Falls, Ohio, United States-Canal Pro CL2) was used to carry out rotary preparation with the respective manufacturer's instructions in relation to speed and torque. While using the rotary file, the canal was properly irrigated and lubricated with 17% ethylenediaminetetraacetic acid gel (RC Help, Prime dental products, Pvt. Ltd. India).

- Group I: Instrumentation was done with Prime Pedo™ rotary files at a speed of 300 rpm and a torque of 2.4 N/cm. The Starter (8% taper, 16 mm) was used for orifice enlargement, P1 (#15, 6% taper, 18 mm) in narrower canals, P2 (#25, 6% taper, 18 mm) in wider canals and endosonic file (2% taper, 18 mm) for apical preparation.[14] These file systems were used with the Crown down approach of instrumentation. Each canal was irrigated with 2.5% sodium hypochlorite intermittently.
- Group II: Instrumentation was performed with a CM NiTi file-Pro-AF Baby Gold files at 300 rpm and 2 N/cm torque. It is a five-file system with a continual taper of 4–6%. It has a one-of-a-kind orifice opener (B0). The following files were used in the same order to file each canal one at a time: B0 (#20/04), B1 (#25/04), and B2 (#25/06).[14] In wider canals, File B3 (#30/04) was employed. Irrigation with 2.5% sodium hypochlorite was done intermittently.
- Group III: Instrumentation was done using NiTi Heat Treated, and TiO Coated files- Kedo-SG Blue at 300 rpm and 2 N/cm torque. D1 (0.25 mm tip diameter) was used to shape the narrower molar canal, and E1 (0.30 mm tip diameter) for the wider molar canal until the working length was reached. U1 file was not used here as it is used for anterior teeth. Sodium hypochlorite (2.5%) was used intermittently to irrigate each canal.[15]
- The files were destroyed when unwinding or distortion of the flute was discovered. After using it in eight teeth, the file was discarded.

Obturation

Following biomechanical preparation, temporary restoration was placed in the access cavity, and the patient was summoned back 3 days later.

The tooth was carefully assessed for eventual obturation at the next session. Paper points were used to dry up each canal

after removing the temporary restoration. The canals were then filled with zinc oxide eugenol cement with the help of a plugger. Wet cotton pellets were used to compress the material into the root canals and achieve final compaction. After that, an intermediate restorative material was used to restore the tooth.

Assessment of Teeth

Instrumentation Time

Using a digital stopwatch, the instrumentation time was calculated from the start of the biomechanical preparation of the root canals until the last rotary file was introduced into the system.

Obturation Quality

After the procedure, immediate postoperative radiographs of all the patients were taken and then examined to determine the grade of obturation (Fig. 1). The quality of obturation was evaluated using a modified version of Coll and Sadrian's criterion.[16] When assessing the obturation, the investigators were blinded to the group allocation and obturation technique. In cases of disagreement, the lower score was selected.

- Underfilling (score 1): Canal filled >2 mm short of the apex.
- Optimum filling (score 2): Canal filled up to 2 mm short of the apex.
- Overfilling (score 3): Any canal with filling that extends beyond the root apex.

Results

The obtained data were entered into an MS Office Excel worksheet and delivered to a statistician for analysis. The mean and standard deviation were computed. Analysis of variance (ANOVA) and the *post hoc* Tuckey's test was used for statistical analysis. A *p*-value of <0.05 was deemed statistically significant.

Instrumentation Time

For all three groups, instrumentation time was recorded in minutes. (Fig. 2). The mean time required for the instrumentation of canals in GT NiTi (group I) was 4.48 minutes, for CM NiTi (group II) was 4.14 minutes, and for NiTi-TiO (group III) was 3.87 minutes. The results showed that NiTi-TiO rotary system required lesser time for bio-mechanical preparation as compared with the other two systems. ANOVA one-way test was used for the statistical analysis of the mean comparison, and $p < 0.05$ was considered statistically significant.

Analysis of variance (ANOVA) with *post hoc* Tukey's test was applied to check the difference between instrumentation times in three groups (Table 1). Instrumentation time showed no statistically significant difference ($p > 0.05$) when compared between GT NiTi and CM NiTi (groups I and II) ($p = 0.580$), GT NiTi and NiTi-TiO (groups I and III) ($p = 0.184$), and CM NiTi and NiTi-TiO (groups II and III) ($p = 0.713$).

Obturation Quality

The radiographic quality of obturation was assessed by using a modified version of Coll and Sadrian's criterion. The obturation quality of the three groups was compared using the Chi-squared test (Fig. 3). In the first group, GT NiTi, the radiographic quality of the obturation following instrumentation revealed that 55% of the obturations were filled to the greatest extent possible, while 30% of the obturations were overfilled and 15% of the obturations were underfilled. The second group, that is, CM NiTi, showed that 60% of the obturations were optimally filled while 20% of the obturations were overfilled, and 20% of the obturations were underfilled. In the third group, that is, NiTi-TiO showed that 75% of the obturations were optimally filled while 20% of the obturations were overfilled, and 5% of the obturations were underfilled.

With reference to Table 2, obturation quality analyzed by the Chi-squared test showed no statistically significant difference ($p > 0.05$) when compared between GT NiTi and CM NiTi ($p = 0.746$), GT NiTi and NiTi-TiO ($p = 0.365$), CM NiTi and NiTi-TiO ($p = 0.344$). Thus, there was no statistically significant difference ($p > 0.05$) in the quality of obturation when done with GT NiTi, CM NiTi, or NiTi-TiO.

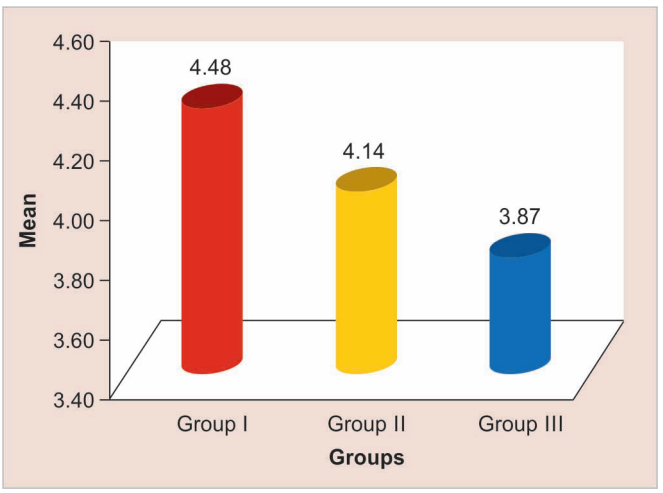

Fig. 2: Mean comparison of instrumentation time (in minutes) among the groups

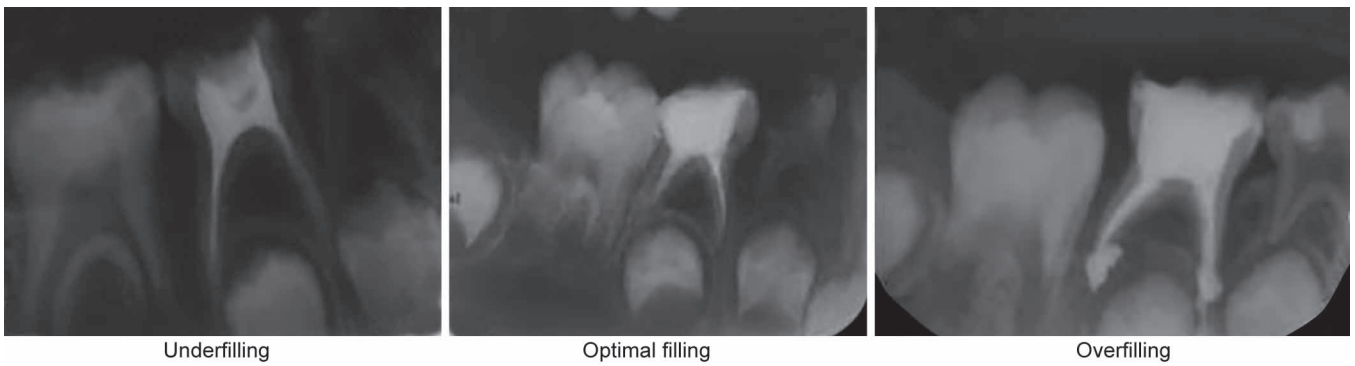

Fig. 1: Immediate postoperative IOPA radiograph depicting different levels of quality of obturation according to Coll and Sadrian criteria

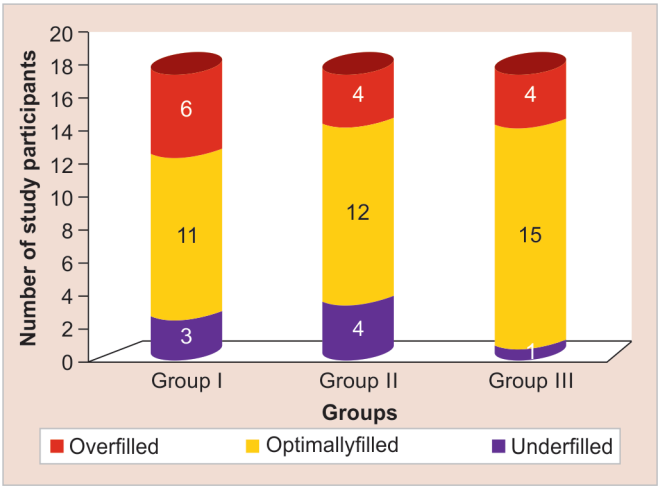

Fig. 3: Comparison of quality of obturation among three study groups

Table 1: *Post hoc* Tukey's test within-group comparison of instrumentation time (in minutes)

Group	*Mean*	*Standard deviation*	*Mean difference*	*p-value*
Group I	4.48	1.19	0.34	0.580 Not significant
Group II	4.14	0.95		
Group I	4.48	1.19	0.61	0.184 Not significant
Group III	3.87	1.08		
Group II	4.14	0.95	0.27	0.713 Not significant
Group III	3.87	1.08		

Table 2: Intergroup comparison of the quality of the obturation among three groups

Quality of obturation	*Group I (n = 20)*		*Group II (n = 20)*		*p-value*
	n	*%*	*n*	*%*	
Underfilled	3	15.0	4	20.0	0.746 Not significant
Optimally filled	11	55.0	12	60.0	
Overfilled	6	30.0	4	20.0	
Quality of obturation	*Group I (n = 20)*		*Group III (n = 20)*		*p-value*
	n	*%*	*n*	*%*	
Underfilled	3	15.0	1	5.0	0.365 Not significant
Optimally filled	11	55.0	15	75.0	
Overfilled	6	30.0	4	20.0	
Quality of obturation	*Group II (n = 20)*		*Group III (n = 20)*		*p-value*
	n	*%*	*n*	*%*	
Underfilled	4	20.0	1	5.0	0.344 Not significant
Optimally filled	12	60.0	15	75.0	
Overfilled	4	20.0	4	20.0	

Discussion

The aim of root canal therapy is to completely seal a cleaned and sterilized root canal system. In order to preserve function and aesthetics, pulpectomy is preferred over extraction for primary teeth that can be restored but have infected pulpal tissue and signs of furcation and periapical involvement. The biomechanical preparation phase is the most important one in any pulp therapy.

The use of rotary files in permanent dentition has been well-established and approved for a long time. Due to their ease of use, time efficiency, and never-ending exhaustion for both the dentist and the patient, rotary files have recently gained exceptional favor in primary dentition as well. Some dentists still believe there aren't enough grounds to utilize rotary files in primary teeth.

As a result, the goal of our research was to assess all of these issues about the use of rotary files in primary teeth. The clinical evaluation was done by a single examiner only at the end of the process, and each case had a code that was only known by the operator. All of the procedures were completed by a single operator, who also coded each sample. A single examiner who was blinded to the pulpectomy technique reviewed every case coded after the operative procedure for biomechanical preparation and obturation. This removed any potential for bias in the study.

The age range of 4–8 years was chosen to rule out the presence of under-developed or resorbed roots. Also, studies show that young children are more susceptible to unpleasant stimuli and have negative behavior than older children.[17,18]

The most prevalent method of instrumentation is still manual instrumentation using stainless steel files. They were created in the year 1960. They cause root canal transportation due to their inherent stiffness.[19] As a result, NiTi instruments were developed to prevent the undesired shaping effects of stainless-steel alloys, which are particularly problematic in curved canals. Due to characteristics like superelasticity, shape memory, and strength, many procedural errors are also reduced.[20,21] NiTi ProFile 0.04 taper rotary files were employed by Barr et al. during pulpectomy procedures, and they came to the conclusion that doing so produced a predictable and uniform root canal filling.[9] NiTi rotary files were proven to be superior in terms of instrumentation time and obturation quality despite the fact that K-files and H-files have been employed for hand instrumentation in multiple *in vivo* comparative studies in primary teeth.[5,22–24]

In this study, we compared the mean instrumentation time of all three rotary filing systems used in the study. The mean instrumentation time was significantly less in the case of NiTi-TiO, which at 3.87 minutes was around than GT NiTi at 4.48 minutes and CM NiTi at 4.14 minutes. Although the data was clinically significant, the data was statistically insignificant.

Primary teeth have a ribbon-shaped morphology and concise, slender, curled roots when compared to permanent teeth.[25] Existing rotary files meant for permanent teeth cannot be used because of certain design specifications. Lateral perforation is a major disadvantage of using permanent rotary files contraindicated for use in deciduous curved canals.[26] According to Kuo et al., new NiTi rotary files created specifically for primary teeth would be more favorable.[27] The coronal expansion and straight-line access are made simpler by the NiTi-TiO pediatrics rotary files' constant taper. This gradual taper also helps to prepare the canals optimally and avoids over-instrumenting the inner wall of the root surface.

The primary molar canals are thoroughly cleaned by the clockwise rotation of the Kedo-SG Blue rotary file, which also removes pulpal tissue and dentin from the canal. A variably variable taper feature that is unique to this system files the canals in a manner similar to primary canal morphology. An additional feature of 16 mm file length and 12 mm active length also increases its efficiency.[28] Children, on the other hand, have limited mouth opening, and the longer length of an adult rotary file makes it difficult to use them. Pro-AF Baby Gold files are heat-treated files that adhere to the root canal's inherent morphology and are less

likely to twist, increasing their fatigue resistance and minimizing breakage.[29] Their file length is 17 mm, while the active length is 13 mm. Prime Pedo files have CM that can be manipulated. They can be centered in the curved canals of primary molars due to this CM.[30]

A pediatric-specific rotary file was required by 66% of dentists, according to a 2017 survey, for easier accessibility and quicker preparation.[31] Additionally, a higher degree of instrument separation has been observed in deciduous teeth when using the available rotational systems.[32]

Some studies have found that manual instruments outperform rotational instruments in root canal wall preparation, particularly for debris.[33,34] According to Madan et al. research, Profiles provided superior cleaning in the apical third.[35] However, research by Moghaddam et al. demonstrated that hand instrumentation cleans the coronal third better than rotational instrumentation.[36] Many studies have compared the hand filing approach to the rotary filing system, but none have compared different rotary filing systems in pulpectomy. As a result, this is the first study of its sort to examine three Indian rotary filing systems.

Cleaning the mandibular mesial canals with a rotary has virtually always been very smooth and almost accomplished in one instrumentation stroke. The distal canals, on the other hand, were a significant issue in some situations. This could be due to the more ribbon-shaped distal canal structure, as well as anatomic variances such as canal bifurcations, where one canal is always thin. These considerations make distal canal preparation more difficult than mesial canal preparation. In his research, Abbas–Makaram discovered that because mesial canals are often tiny, preparing them with hand equipment is more challenging. Their findings revealed that rotary provided much better results in mesial canals and that there was no difference in distal canals between hand and rotary use.[37]

Rotary files are utilized to promote consistent canal preparation, which leads to better obturation quality. In a recent study, Bergmans et al. found that progressive taper resulted in more cervical expansion and restricted apical preparation than fixed taper.[38] Hence, progressive taper rotary files obturate better than fixed taper Hand files. Another cause for greater obturation quality could be the usage of NiTi material, which increases file flexibility.[39] Rather than enhanced zipping and transit as in hand instrumentation, this aids in the adaption of files to the principal canal curvature.[38] Another feature is the larger cervical enlargement and more conical preparation, which benefits in ease of obturation when compared to manual files that have less conical preparation.[40] The findings were comparable to those of a study conducted by Makarem et al. in 2014 and Ochoa–Romero et al. in 2011, which found a statistically significant difference in obturation quality.[2,37]

A variety of factors influence the result of pulpectomy. One of the most important considerations is the length of the root canal filling. In a 1996 study, Coll and Sadrian found that overfilled teeth had a much lower success rate than teeth that were filled all the way to the apex or just short of the apex.[15] According to Yacobi et al., underfilled canals in essential teeth fail substantially more frequently than those that are entirely filled.[41] Hence, appropriate canal filling ensures a higher success rate for pulpectomy. As a result, this study evaluated the obturation's quality.

In our study, a comparison between the obturation quality of the three pediatric rotary filing systems was done by using the Chi-square test. Though the quality of obturation is also dependent on the operators skill and experience, statistically, the comparison shows that NiTi-TiO has the greatest number of optimally filled obturations than the other two rotary filing systems. Overfilled obturations were the least in NiTi-TiO and CM NiTi when compared to GT NiTi. Out of the three systems, NiTi-TiO showed minimal underfilled obturations when compared to CM NiTi and GT NiTi. In the latest study published in 2021, Sruthi et al. compared the obturation quality of the Kedo-SG blue, Kedo-SH, and reciprocating hand K-files in primary mandibular molars. Kedo-SG Blue was discovered to provide improved obturation quality with less instrumentation time.[28]

However, when all three were compared in our study, there was no statistical difference. As a result, there was no statistically significant difference in obturation quality between NiTi-TiO, CM NiTi, and GT NiTi ($p > 0.05$).

Conclusion

According to the findings of this study, NiTi-TiO (Kedo SG Blue) had the shortest mean instrumentation time (3.87 minutes). Moreover, among the three pediatric rotary endodontic systems, Kedo-SG Blue files had the highest number of optimum obturations (75%) and the lowest number of underfilled obturations (5%).

Despite the fact that the instrumentation time and obturation quality were clinically significant, the data were statistically inconsequential. As a result, further research of this nature will be required in the future.

Clinical Significance

Previous papers have focused on different rotational systems that have been utilized in permanent dentition for root canal cleaning and shaping. However, with advancements in this field, rotary instrumentation in primary dentition is in an infant stage that has not been rigorously practiced in clinical trials. Therefore, this research will add to the current literature.

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