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Comparative evaluation of instrumentation timing and cleaning efficacy in extracted primary molars using manual and NiTi rotary technique – Invitro study

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ABSTRACT

Aim: To compare the timing of instrumentation and cleaning efficacy between manual K files and NiTi rotary files in extracted primary molars.

Study design: in-vitro study was conducted in 90 root canals of extracted primary molars which were subdivided in three groups viz. Control (No instrumentation), Manual (K files), Rotary (ProFiles) with 30 canals in each group. Mesiobuccal (MB) and Mesiolingual (ML) canals of mandibular molars, and MB and Distobuccal (DB) canals of maxillary molars were included in the test group whereas Distal canals in mandibular molars and Palatal canals in maxillary molars were included in the control group.

Method: Teeth were mounted and canals were injected with India ink to stain the canal walls. Canal preparation was done as per the group. After instrumentation, teeth were demounted, decalcified and cleared to make them transparent for scoring according to the extent of removal of India ink. Timing of instrumentation and cleaning efficacy of canals in coronal, middle and apical thirds were assessed in each sample.

Results: Mean timing of instrumentation in rotary group was 3.54 ± 1.14 min and 4.32 ± 1.04 min in manual group. Mean cleaning efficacy scores in manual and rotary groups were 2.03 and 1.66 in coronal third, 1.08 and 1.18 in middle third and 0.67 and 1.08 in apical third respectively. Inter-group comparisons showed no statistically significant difference in cleaning efficacy among test groups in all thirds of root canals.

Conclusion: NiTi rotary technique has comparable cleaning efficacy, with significantly less timing of instrumentation compared to manual K-files.

1. Introduction

One of the most important concerns in pediatric dentistry is the early loss of necrotic primary molars which has a deleterious effect on the growth of the facial skeletal complex particularly for the full development of the dental complex, its occlusion, esthetic qualities, and soft tissue support.[1] To prevent these adverse outcomes, every effort should be made to preserve the deciduous teeth until the time of eruption of the succedaneous teeth. Removal of caries and subsequent restoration is the standard treatment when the carious lesion has not reached the pulp. In cases of gross pulpal involvement, pulpectomy remains the treatment of choice. One of the most challenging and time consuming steps in endodontic treatment in primary teeth is the root canal preparation.[2] The main objectives of endodontic treatment is to shape and clean the root canal system effectively whilst maintaining the original configuration without creating any iatrogenic events.[3] Pulp Therapy of non-vital primary teeth has been proposed using various protocols with variable success rates.[4–8] Although, the morphology of root canals in primary teeth renders endodontic treatment difficult[9,10], the conventional root canal instrumentation technique for primary teeth has been hand instrumentation, which is time consuming.[11] Manual root canal preparations have been conventionally performed with burs, reamers, and files. Niti rotary instruments have gain much attention recently as most of the hand preparation techniques are time consuming and prone to iatrogenic errors like ledging, zipping, apical blockage and canal transportation.[12] The designs and high flexibility of

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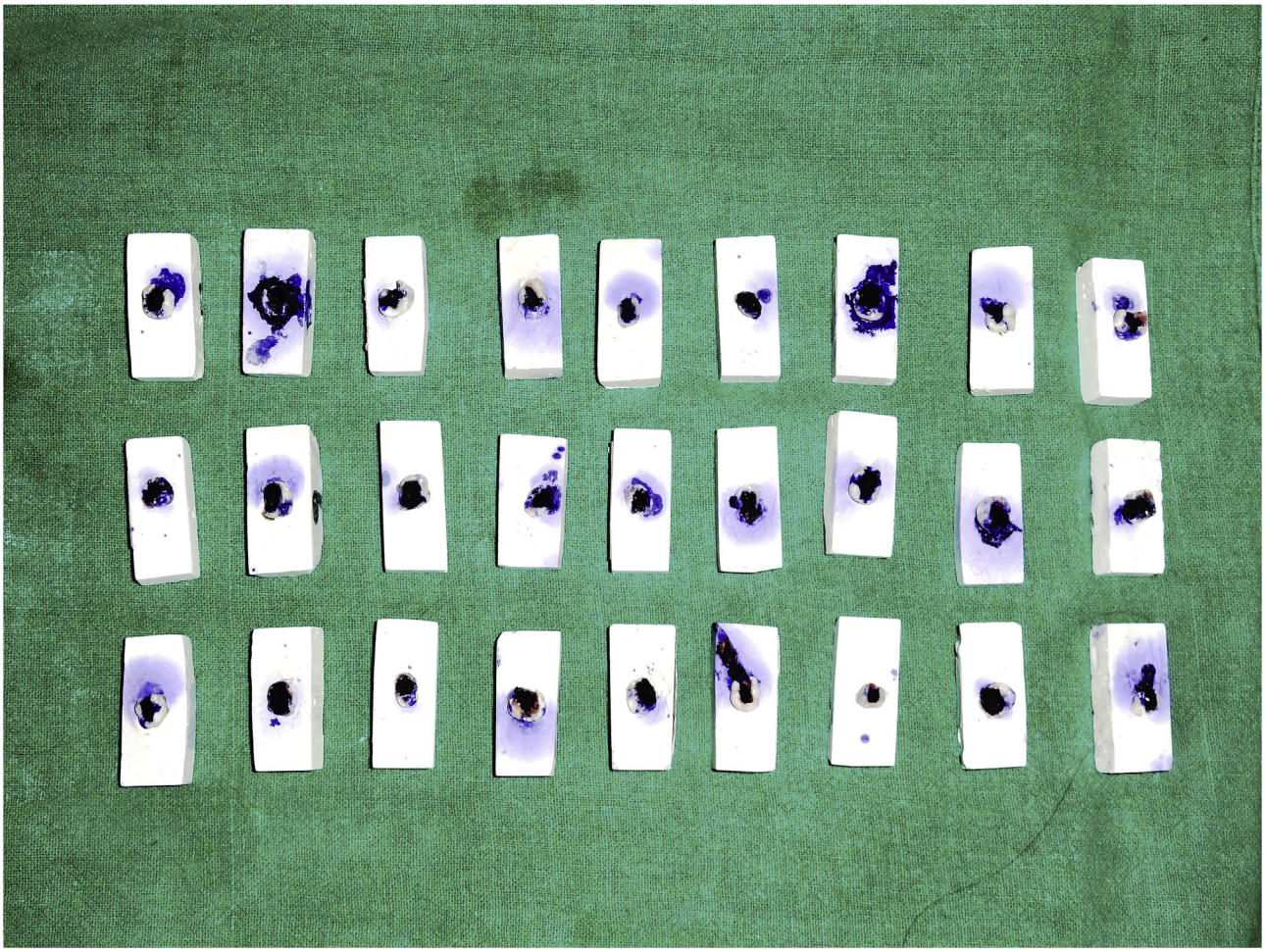

Fig. 1. Dye (India ink) injected into the samples.

NiTi files allows instruments to closely follow the original root canal path, especially in curved canals and procedural errors such as ledges, over-instrumentation and apical transportation have been greatly reduced.[13–16] Numerous studies have reported that NiTi files could efficiently create smooth, predetermined funnel form shapes with minimum risk of ledging and transportation.[14,17] Introduction of these rotary instruments has made it easier for clinicians to perform root canal therapy without too much operator fatigue, because it has been shown that shorter treatment times are required to complete the debridement procedure in the preparation of the canal walls.[18] Considering that rotary files are more convenient to use and can facilitate root canal preparation, their application may be more appropriate in children to work faster with behavior management problems. Presently, most of the current research on rotary endodontic is focused on permanent teeth with lack of enough studies regarding use of NiTi rotary endodontic files in primary teeth despite the advantages of these systems and studies performed on primary molars. Therefore, this in-vitro study was undertaken to evaluate and compare instrumentation timings and cleaning efficacy of conventional K files and NiTi rotary endodontic files in primary molars.

2. Materials and method

The present study was conducted in the Department of Pedodontics and Preventive Dentistry. Institutional ethical committee clearance was obtained before conducting the study (IRB no. 2015/2138B).

2.1. Selection of sample

Freshly extracted primary molar teeth were just procured and collected from dental colleges, hospitals and private dental clinics and the researcher was neither directly nor indirectly, responsible for the clinical judgment to extract these teeth. No tooth was extracted specially for the purpose of the study. Inclusion criteria included only those primary molars with at least 2/3rd of root present (without any perforations). Teeth with root resorption more than 1/3rd of the actual root length, grossly decayed non restorable teeth, and teeth with internal/external resorption leading to perforation of root were excluded. All specimens were washed under running water and all the soft tissue was removed from their crown and root surface with scalpel and gauze. Prepared teeth were stored in 10% formalin container as per storage protocol suggested by Rosa FM et al.[53]

The teeth that met the inclusion criteria were labeled and the canals selected in these specimens and were randomly allocated to the respective instrumentation groups. A total of 90 root canals samples were included in the study which were equally divided in three groups (30 each) namely Manual, Rotary and Control groups according to the type of instrumentation. No root canal instrumentation was done in control group. Root canals with predictable anatomic patterns i.e. Mesiobuccal (MB) and Distobuccal (DB) canals in maxillary molars, and Mesiobuccal (MB) and Mesiolingual (ML) canals in mandibular molars were included in study groups whereas Palatal and Distal canals were included in control groups owing to variation in their anatomical patterns which could affect the homogeneity of the study.

3. Methodology

Coronal access cavity was prepared with Endo access bur (Dentsply Maillefer-USA) and refinement of cavity was done with Endo Z bur (Dentsply Maillefer-USA). The pulp chamber and root canals were irrigated profusely with 1.0% sodium hypochlorite (Fisher Scientific, Fisher Scientific International, Inc.) to remove the debris. No.10 K (ISO) file (Dentsply Maillefer, Ballaigues, Switzerland) was introduced into each root canal to determine the patency of canal. The no.10 K (ISO) file that was inserted in the root canal the tip of the file was visualized through apex. The working length was established 1 mm short of this visualized length as suggested by Silva LA et al.[11] The pulp chamber and root apex of each tooth was blocked with modeling wax and sticky wax consecutively to prevent entry of dental plaster during mounting.

During mounting, all teeth were stabilized on a metal plate with sticky wax on the occlusal surface. In a jig, consisting of two open ended rectangular boxes placed over rectangular metal base having prongs to fix the rubber dam, roots of the teeth were invested in dental plaster till cementoenamel junction.

After completion of tooth mounting, wax was removed and India Ink dye (Kokoyo Camlin Ltd, India) was injected in all root canals with the help of insulin syringe (Fig. 1).

Root canal preparation was done using conventional step-back technique with sequential size enlargement from no.15K to no.40K file in hand instrumentation. Similar sequential enlargement was done in rotary instrumentation but using step-back technique as used by Madan N et al.[19]

Decalcification of each tooth was done with 5% nitric acid solution (Fisher Scientific, Fisher Scientific International, Inc., America) for 4 days where the solution was renewed every 24 h in order to maintain its efficacy. After decalcification, all teeth were dehydrated as per the technique given by Madan N et al.[19] All teeth were placed in 99% methyl salicylate (Rankem™ Chemicals, India) till they got transparent. Teeth were stored in same solution later on.

For analysis of root canals, teeth were photographed individually using a digital camera (Sony Cyber Shot, DSC-HX7V, 16.2 Megapixels, Sony Corp, Japan.) at 3X magnification and at a distance of 30 cm using a tripod, in order to standardize the dimension and magnification of all pictures after placing them against an illuminated background (Fig. 2). The pictures were projected and were then evaluated for the scoring by three independent examiners who scored the cleaning of canals in all thirds according to following scale given by Silva LA et al.[11]:

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 wall in some areas).
Score 3: No ink removal (Appreciable amount of ink present).

Mean time of instrumentation among the study groups was compared using Unpaired-t test. Inter-group comparison of mean cleaning efficacy scores in coronal, middle and apical one-third of canal was done by Mann-Whitney *U* test.

4. Results

The mean time taken for biomechanical preparation (BMP) (in minutes and seconds) was significantly more among manual group (4.32 ± 1.04 min) in comparison to rotary group (3.54 ± 1.14 min). Hence, rotary group took significantly less time for canal preparation as compared to manual group (Fig. 3).

Mean cleaning efficacy scores of coronal one-third in three groups were 2.89 ± 0.32, 2.03 ± 0.94 and 1.66 ± 0.91 in control, manual and rotary groups respectively (Fig. 4). The inter-group comparison of mean coronal third score was significantly less among manual and rotary groups in comparison to control group. No statistically significant

Fig. 2. Roots cleared of India ink.

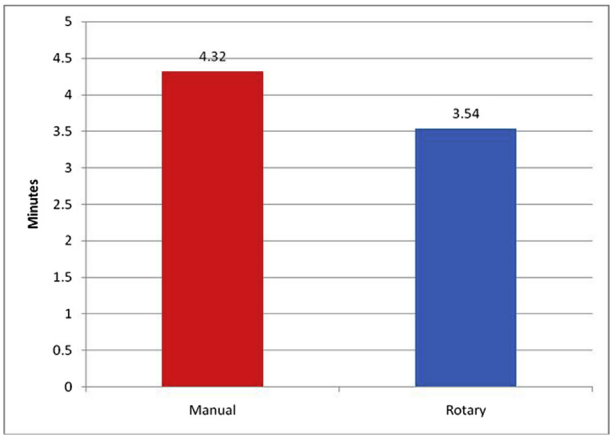

Fig. 3. Mean instrumentation timing.

difference was observed between manual and rotary groups in coronal one third scores (Table 1).

Mean cleaning efficacy scores of middle one-third of root canals were 2.75 ± 0.50, 1.08 ± 1.16 and 1.18 ± 0.98 in control, manual and rotary groups respectively (Fig. 4). The inter-group comparison revealed that the score was significantly less among manual and rotary groups in comparison to control group. However, no statistically significant difference was observed between manual and rotary group (Table 2).

Mean cleaning efficacy scores of apical one-third of root canals were 2.36 ± 1.05, 0.67 ± 1.01 and 1.08 ± 1.10 in control, manual and rotary groups (Fig. 4). The inter-group comparison score was significantly more among manual and rotary groups in comparison to control group. However, no statistically significant difference was observed between manual and rotary group (Table 3).

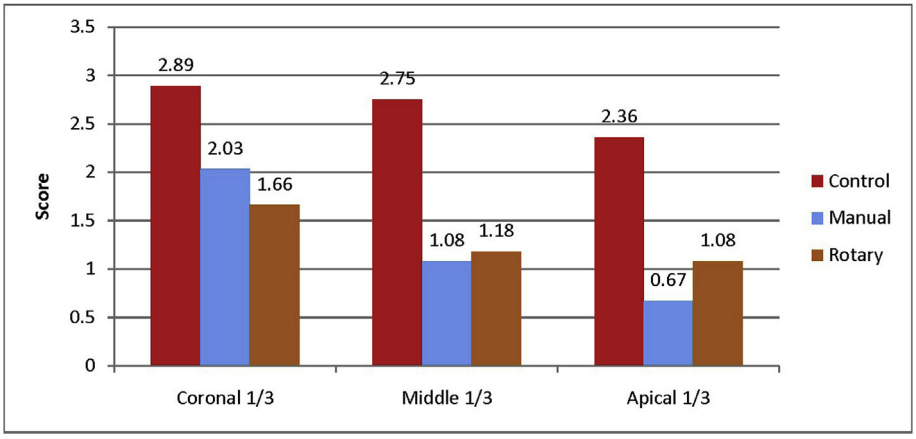

Fig. 4. Mean cleaning efficacy at Coronal, Middle and Apical thirds.

Table 1
Inter-group comparisons of mean coronal 1/3 cleaning efficacy scores.

Groups		Critical value	p-value
Control	Manual	−4.874	< 0.001[a]
Control	Rotary	−5.958	< 0.001[a]
Manual	Rotary	−1.927	0.054

[a] Statistically significant.

Table 2
Inter-group comparisons of mean middle 1/3 cleaning efficacy scores.

Groups		Critical value	p-value
Control	Manual	−5.791	< 0.001[a]
Control	Rotary	−6.127	< 0.001[a]
Manual	Rotary	−0.661	0.509

[a] Statistically significant.

Table 3
Inter-group comparisons of mean apical 1/3 cleaning efficacy scores.

Groups		Critical value	p-value
Control	Manual	−5.430	< 0.001[a]
Control	Rotary	−4.677	< 0.001[a]
Manual	Rotary	−1.701	0.089

[a] Statistically significant.

5. Discussion

Pulpectomy remains the preferred modality in pediatric dentistry for the treatment of infected pulpal tissue.[20] Before the development and introduction of Nickel-Titanium (NiTi) files in the field of dentistry, stainless steel (SS) K files used to be the choice for biomechanical preparation of the root canals. These files lacked in flexibility which created undesirable alterations in curved canals including ledges, perforations, zips and transportation.[21] This problem was overcome by NiTi files wherein the flexibility of instrument allowed it to follow the original path of root canal. The efficacy of NiTi files in debridement of permanent root canals have been shown in various studies.[22–24] NiTi alloy files used in rotary systems are composed of 56% Nickel (Ni) and 44% Titanium (Ti) and have a low elasticity modulus, high resilience, corrosion resistance, super elasticity and thermic memory of the shape. Its flexibility, which is 2 or 3 times higher than stainless steel files, allows it to maintain the same root canal shape avoiding making any canal transportation that is important in curved root canals of primary molars. There are several kinds of files that are made of NiTi alloy, some are manual and others are used with rotary systems such as GT, K3, ProTaper and ProFile etc. ProFile is the system that was chosen for this study, the characteristic features of these files are that they have a constant 4% taper in the body, inactive point and a cut zone with the shape of triple "U" with three smooth areas in contact with root canal walls that are design to brush but not cut directly the dentin.[22] Since, ProFile rotary instruments have a 4% taper which is double that of the conventional K-files, this gives a tapered shape to the canal which can easily receive an obturation paste. Usage of Rotary files have also improved patient co-operation by reducing the instrumentation time,[25] a factor that can prove vital in pediatric dentistry. Barr ES et al.[25] also recommended the use of 4% taper NiTi files for the novice clinician as they are efficient without excessive aggressiveness. Because of this, 4% taper NiTi ProFiles were used in the present study. Barr ES et al.[25] were amongst the first one to describe the technique of using rotary NiTi files (ProFiles) in primary teeth. They however mentioned that "crown-down" technique is not recommended in primary teeth as the dentin cuts more easily and extreme care must be taken to avoid over-instrumentation. Therefore in the present study step-back technique was deployed in primary molars as described by Madan N et al.[19] In order to maintain the homogeneity of preparations between the two experimental techniques, only mesial root canals in mandibular primary molars were prepared alternatively with ProFiles and K files as the distal root canals show maximum variation in the antomy.

Similarly, in maxillary primary molar only mesiobuccal and distobuccal root were instrumented alternatively with the two techniques. Palatal roots were not prepared as they are known to show variations in angulations and diameter.[24]

The palatal roots and mandibular distal roots were used as controls and injected with India ink using injection technique similar to Silva LA et al.[11]

In the present study, overall biomechanical preparation time was more (4.32 ± 1.14) in manual instrumentation group and lesser (3.54 ± 1.04) in NiTi rotary group. These results were in accordance with studies conducted by Silva LA et al.[11], Barr ES et al.[25], Moghaddam KN et al.[26] and Javadinejad S et al.[27] The justification for this variation in timing might be attributed to the higher revolutions per minute (rpm) achieved with rotary files as compared to hand files. The higher rpm leads to faster cutting of dentin and hence less time required for canal preparation. Rotary instrumentation also has an added advantage of lesser hand fatigue as compared to the manual instrumentation.

When cleaning efficacy in coronal third of root was evaluated, it was found that mean score was lowest in rotary group (1.66 ± 0.91) followed by manual group (2.03 ± 0.94). This result was in accordance with Madan N et al.[19], Silva LA et al.[11], and Schafer E and Zapke K.[28] The results were in contradiction to the findings of Moghaddam KN et al.[26] where cleaning efficacy in hand file group was found superior to

rotary instrumentation group. This might be attributed to greater percentage of taper (4%) present in ProFiles in comparison to K Files (2%). Wider diameter of ProFiles in the Coronal one third engages more dentin and thus leads to better cleaning efficacy. However, the comparable cleaning efficacy of K files could be due to their stiffer cross section through which they are able to press laterally against dentinal walls and result in efficient debridement.

On comparing cleaning efficacy in middle third of root, it was found that manual group (1.08 ± 1.16) had the lower mean score followed by rotary group (1.18 ± 0.98). This could be due to the less pressure exerted by the rotary ProFiles in the middle thirds of the root canal as increased taper keeps the ProFiles mainly supported and engaged in the coronal third resulting in lesser debridement in the middle third. This result was in accordance with results obtained by Madan N et al.[19], Silva LA et al.[11], Schafer E and Zapke K.[28]

When cleaning efficacy in apical third of root canals was compared, the lowest mean score was found in manual group (0.67 ± 1.01) followed by rotary group (1.08 ± 1.10). Despite better cleaning observed in manual group, it was not found statistically superior to the rotary instrumentation group. It has been shown that larger apical preparation sizes are necessary in many cases in order to contact as much of the circumference of the root canal as possible in the apical third of the canals to ensure optimal debridement in this critical area as suggested by Hulsmann M et al.[29]. Thus, a 4% taper file can be accepted as a valid alternative to manual files for root canal instrumentation. This result was found in accordance with study done by Silva LA et al.[11], but was contrary to the results found by Madan N et al.[19] where the manual K-file group had a statistically significant difference in cleaning efficacy than rotary group.

In the present study it was found that, on comparison of rotary group with manual group there was statistically non-significant difference in cleaning efficacy in all the thirds of the canal which was in accordance with the studies by Ahlquist M et al.[30] who also concluded that the manual technique employed in their study produced cleaner root canal walls than the rotary technique probably due to the tactile feel and the experience of the operator. However, neither of the instrumentation techniques achieved total debridement of the root canal.

In the study conducted by Silva LA et al.[11] mean score in control group was 3, which is dissimilar to our study where the mean score in control group was 2.66 probably because the ink did not fill properly in all root canals. This was further verified by progressive reduction in mean scores from coronal to apical thirds (Coronal = 2.89, Middle = 2.75, Apical = 2.36). This could be a limitation in such studies where ink penetration cannot be verified as the tooth roots are embedded in dental plaster.

6. Conclusion

Rotary instrumentation provides comparable cleaning efficacy to conventional hand files in root canal preparation of primary molars in a significantly lesser time. NiTi rotary ProFiles therefore have a potential to replace the conventional hand files for in-vivo usage in pediatric endodontics practice. Further research may be conducted using a larger sample size to obtain more detailed results. This research may also be directed in in-vivo conditions to determine the instrumentation timing and cleaning efficacy of tests groups or especially in an uncooperative child.

Conflict of interest

The authors deny any conflicts of interest related to this study.

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