http://dx.doi.org/10.1590/1981-86372023001620220005

| ORIGINAL

Endodontic techniques with Nickel Titanium instruments: analysis of quality and efficiency of instrumentation in primary molars

Técnicas endodônticas com instrumentos de Níquel Titânio: análise da qualidade e eficiência da instrumentação em molares decíduos

Maria Luiza da Matta Felisberto **FERNANDES**[1] 0000-0002-5120-1449

Caroline Andrade **MAIA**[2] 0000-0002-0751-5053

Gabriele Andrade **MAIA**[3] 0000-0002-1604-3449

Alice Machado Carvalho **SANTOS**[3] 0000-0002-6864-246X

Saul Martins **PAIVA**[3] 0000-0002-3968-1638

Alexandre Moreira **FERNANDES**[4] 0000-0001-6928-2024

ABSTRACT

Objective: The purpose of the present in vitro study was to evaluate the efficiency of three different instruments in the root canals of artificial primary molars as well as the quality of the fillings. **Methods**: Sixty artificial primary molars were divided into three groups of 20 teeth. Each group was submitted to a different technique: Group 1 - conventional manual technique using Kerr files; Group 2 - manual technique with nickel-titanium files; Group 3 - NiTi rotary technique. The root canals were filled with calcium hydroxide paste. Aspects such as homogeneity of the fillings, taper and flowability of the preparations were considered comparatively to assess the quality of the instrumentations. The non-parametric Kruskal-Wallis and Mann-Whitney tests were used to compare the efficiency of the preparation of the root canal considering the preparation times of them. **Results**: All three techniques were equally effective at shaping the root canals of primary teeth. The working time was shorter with the rotary instrument (p=0.000). In the pairwise comparisons, working time was shorter with the rotary instrument compared to the manual techniques with steel files (p=0.000) and NiTi files (p=0.000). Comparing the manual techniques, the working time was shorter with NiTi files compared to steel files (p=0.011). Moreover, less variability in the preparation time was found when the rotary instrument was used. **Conclusions**: The mechanized rotary method led to a shorter operating time in comparison to the manual techniques and is therefore a preferable option for the *preparation of the root canals of primary teeth.*

Indexing terms: *Endodontics. Pediatric Dentistry. Tooth, Deciduos.*

[1] Centro Universitário Newton Paiva, Faculdade de Odontologia, Departamento de Odontopediatria. Belo Horizonte, MG, Brasil.
[2] Universidade Federal de Minas Gerais, Faculdade de Odontologia, Departamento de Odontologia Restauradora. Belo Horizonte, MG, Brasil.
[3] Universidade Federal de Minas Gerais, Faculdade de Odontologia, Departamento de Odontopediatria. Rua Prof. Moacir Gomes de Freitas, 688, Pampulha, 31270-901, Belo Horizonte, MG, Brasil. Correspondence to: <gabriele.am120@gmail.com>.
[4] Centro Universitário Newton Paiva, Faculdade de Odontologia, Departamento de Endodontia. Belo Horizonte, MG, Brasil.

How to cite this article

Fernandes MLMF, Maia CA, Maia GA, Santos AMC, Paiva SM, Fernandes AM. Endodontic techniques with Nickel Titanium instruments: analysis of quality and efficiency of instrumentation in primary molars. RGO, Rev Gaúch Odontol. 2023;71:e20230016. http://dx.doi.org/10.1590/1981-86372023001620220005

RESUMO

***Objetivo**: Avaliar a eficiência de três instrumentos diferentes nos canais radiculares de molares decíduos artificiais, bem como a qualidade das obturações.* ***Métodos**: Sessenta molares decíduos artificiais foram divididos em três grupos de 20 dentes. Cada grupo foi submetido a uma técnica diferente: Grupo 1 - técnica manual convencional com limas Kerr; Grupo 2 - técnica manual com limas de níquel-titânio; Grupo 3 - Técnica rotatória de níquel-titânio. Os canais radiculares foram preenchidos com pasta de hidróxido de cálcio. Aspectos como homogeneidade das obturações, conicidade e fluidez das preparações foram considerados comparativamente para avaliar a qualidade das instrumentações. Os testes não paramétricos de Kruskal-Wallis e Mann-Whitney foram utilizados para comparar a eficiência do preparo do canal radicular considerando os tempos de preparo dos mesmos.* ***Resultados**: Todas as três técnicas foram igualmente eficazes na modelagem dos canais radiculares. O tempo de trabalho foi menor com o instrumento rotatório (p=0,000). Nas comparações pareadas, o tempo de trabalho foi menor com o instrumento rotatório em comparação com as técnicas manuais com limas de aço (p=0,000) e limas de NiTi (p=0,000). Comparando as técnicas manuais, o tempo de trabalho foi menor com as limas de NiTi em comparação com as limas de aço (p=0,011). Além disso, foi encontrada menor variabilidade no tempo de preparo quando o instrumento rotatório foi utilizado.* ***Conclusão**: O método rotatório levou um menor tempo operatório em comparação com as técnicas manuais e, portanto, é uma opção preferível para o preparo dos canais radiculares de dentes decíduos.*

Termos de indexação: *Endodontia. Odontopediatria. Dente Decíduo.*

INTRODUCTION

The maintenance of primary teeth in the dental arch until physiological exfoliation is one of the main goals of pediatric dentistry. The premature loss of primary teeth can have negative consequences, such as an imbalance of oral functions (chewing, swallowing and speech), dental mesialization, extrusion and the loss of space in the arch for the permanent successor, and can also affect a child's oral health-related quality of life [1,2].

Endodontic treatment is a conservative option to maintain the primary tooth in the dental arch [2]. To achieve treatment success, it is extremely important to have an aseptic field, adequate mechanical-chemical preparation and the complete obturation of the root canal with filling paste [3,4]. However, the smaller opening of a child's mouth, the anatomy of primary teeth with accentuated root divergence and the occurrence of physiological root resorption are limitations that exert a negative impact of the operating time of endodontic treatment, the quality of treatment, the reduction of anxiety and the cooperation of the child during the procedure [5].

To overcome the challenges of endodontic treatment of primary teeth, novel technologies have been explored. Nickel-titanium (NiTi) rotary and manual files have been employed to reduce the operating time and improve the prognosis of treatment [6]. Therefore, studies investigating the use of these technological resources are essential to optimizing endodontic treatment of primary teeth and, consequently, contributing to the control of stress and child behavior in the dental clinic.

The aim of the present study was to analyze the instrumentation quality and operating time required in root canals of artificial primary teeth using three different instruments.

METHODS

Sixty artificial maxillary primary molars (stock teeth, Fábrica do Sorriso, Uberlândia, Brazil) were equally divided into three groups: Group 1 - conventional manual technique using Kerr files (Dentsply Maillefer, Ballaigues, Switzerland) used as the "gold standard"; Group 2 - manual technique with nickel-titanium files (Easy ProDesign M - Easy Equipamentos Odontológicos, Belo Horizonte, Brazil); and Group 3 - rotary technique with NiTi files (Easy ProDesign LOGIC- Easy Equipamentos Odontológicos, Belo Horizonte, Brazil). Each tooth was numbered and allocated to one of the experimental groups.

A single operator with experience in endodontics and the use of rotary devices performed the experimental part to ensure standardization and avoid operator-related confounding factors. An initial radiograph was taken with parallel X-rays (Spectro 70X Dabi Atlante, Ribeirão Preto, São Paulo, SP, Brazil) of each test specimen for the radiographic tooth length determination.

The teeth were then opened and the roof of the pulp chamber was removed with a high-speed n° 2 spherical bur and water cooling. Endodontic access was achieved with a nº 2 Batt bur (Dentsply Maillefer, Ballaigues, Switzerland). To standardize the preparation of each group, a vise (Morsa Linha Profissional Number 2 REF.METALSUL-TBP 057) was used to maintain the teeth in an adequate position.

After opening, odontometric analysis was performed of each canal using a K10 file in all artificial teeth and observing the passage of the file passively through the foramens. These data were filed and used for the instrumentation in the different experimental groups. The following techniques involving not only the instruments themselves but also the sequence and kinematics, were then performed:

Group 1 - Manual preparation performed with Kerr files (Dentsply Maillefer, Ballaigues, Switzerland) as the "gold standard" for the analyses. After the odontometric analysis, preparation (crown-down sequence) was initiated with the K40 file pushed passively to the point of resistance. The same procedure was performed sequentially with the 'K35, K30, K25 and K20 until the last file (K20) reached the working length. This sequence was repeated, always beginning with the K40 file and progressively with the K25, K30, K35, until the K40 reached the working length (1 mm). Irrigation with saline solution was performed with each change of file [7]

Group 2 - Manual preparation with NiTi files (Easy ProDesign M). Initial pre-enlargement was performed using the 30/05 file with a clockwise rotary movement to 3 mm from the working length. Next, apical preparation (working length - 1 mm) was performed with the 25/01 and 25/06 files. Initial apical refinement was then performed with the 35/01 file, followed by final refinement with the 35/05, both to the working length (1 mm). The following protocol was used with each file: approximately 50 360° clockwise turns simultaneously to progressive penetration of the instrument. Irrigation with saline solution was performed with each change of file.

Group 3 - Preparation with NiTi rotary files (Easy ProDesign LOGIC) and electric motor (EASY SI, Easy Equipamentos Odontológicos, Belo Horizonte, Brazil). Cervical pre-enlargement was performed with the 30/05 file (torque of 4 Ncm2 and 950 rpm) 3 mm short of the working length. Next, apical preparation was performed with the 25/01 file (torque of 1 Ncm2 and 350 rpm) 1 mm short of the working length, followed by the 25/05 file (torque of 4 Ncm2 and 950 rpm) to the same distance. Apical refinement was first performed with the 30/01 file (torque of 1 Ncm2 and 350 rpm), followed by the 30/05 file (torque of 4 Ncm2 and 950 rpm) to 1 mm from the working length. Irrigation with saline solution was performed with each change of file.

Operating time was recorded with the use of a stopwatch beginning with the insertion of the first file in the first canal of each tooth until the finalization of the root preparation of all canals. Thus, the times (in seconds) spent on the treatment of each canal were summed to determine the time spent on the total procedure in each group.

Obturation was performed with Calen paste (SS White) using the following protocol: ML endodontic syringe with screw thread embolus for application of endodontic paste; previously curved disposable 27 G-LONG needle placed into root canal to the working length; complete turn of embolus to release desired quantity of paste with back-and-forth movements until completely filling the root canal. After filling, final radiographs were taken of all teeth to verify the conformation of the preparation with the three different techniques. Aspects such as homogeneity of the fillings, taper and flowability of the preparations were considered comparatively to assess the quality of the instrumentations

Data analysis

Data analysis used descriptive statistics of the time (in seconds) spent per canal with each technique and analytical statistics. The nonparametric Mann-Whitney and Kruskal-Wallis tests were used to compare operating times (pairwise and set of three techniques). The level of statistical significance was set at 5% and 95% confidence intervals were calculated.

RESULTS

Sixty artificial primary teeth were submitted to endodontic treatment using three different instrument systems. After the opening of the canals, some stock teeth did not have three canals. Among the 20 teeth submitted to the

conventional technique with manual stainless-steel files (Group 1), 18 teeth had three canals treated and two had two canals treated (total of 58 canals). Among the 20 teeth submitted to manual NiTi files (Group 2), 12 teeth had three canals treated and eight had two canals treated (total of 52 canals). All 20 teeth submitted to rotary NiTi files (Group 3) had three canals treated (total of 60 canals). Thus, a total of 170 canals were treated in the present study.

Treatment time per canal was determined. Mean and standard deviation values for each type of instrument are displayed in table 1. The results of the comparative statistical tests are displayed in table 2.

Table 1. Descriptive statistics of time (in seconds) spent per canal with each instrument system.

Descriptive	**Instrument system (seconds - s)**		
Statistics	Conventional manual (n = 20)	Mechanized rotary (n = 20)	Manual NiTi (n = 20)
Min	263.7	152.3	242.7
Mean	383.5	202.3	307.0
Standard dev.	62.6	30.8	41.1
Median	377.6	206.3	298.0
Max	474.7	240.0	380.0

Table 2. Comparative analysis of time spent during preparation of root canals with different instrument systems.

Instrument system	**Comparative analysis**	**p-value**
Conventional manual vs Mechanized rotary vs Manual NiTi	Kruskal-Wallis test	p = 0.000 **SIG**
Conventional manual vs Mechanized rotary	Mann-Whitney test	p = 0.0003 **SIG**
Manual NiTi vs Mechanized rotary	Mann-Whitney test	p = 0.0003 **SIG**
Conventional manual vs Manual NiTi	Mann-Whitney test	p = 0.0113 **SIG**

The set of times spent on mechanized rotary preparation had the least variability, whereas the set of times spent on conventional manual preparation had the greatest variability among the three instrument systems (figure 1).

All three techniques were effective at preparing the root canals. The final radiographs revealed the complete, homogeneous filling of the root canals performed during the obturation step.

DISCUSSION

The literature describes the preparation of the root canals of primary teeth using the conventional manual method with Kerr stainless-steel files [8,9]. However, rotary instruments have been employed in endodontic therapy for primary teeth due to the shorter operating time and better preparation shape compared to Kerr files [10-12].

The use of artificial teeth in this type of study has the disadvantage of not precisely reflecting the behavior of instruments in contact with natural dentinal tissue. The use of natural teeth would certainly alter the cutting capacity and would result in different times from those found in the present study. However, natural teeth present a limitation due to the lack of standardization [13]. Differences of curvature, reabsorption, position and foramen shape can exert a decisive

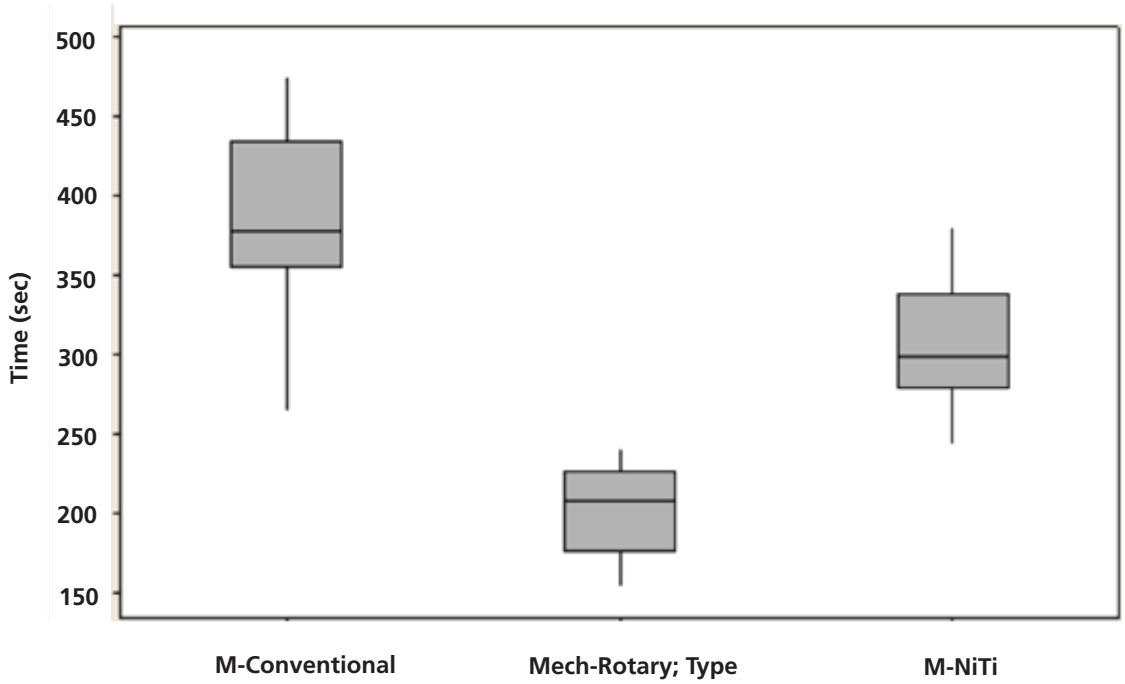

Figure 1. Variation in time (in second) spent on preparation of root canals using conventional technique with stainless-steel files, manual NiTi files and rotary NiTi instrument.

influence on operating time and constitute confounding factors that hinder the interpretation of the results. There may be considerable difficulty in obtaining a sufficient number of natural teeth for the formation of representative samples. Despite having a different consistency from dentine with regards to contact with instruments, artificial teeth offer a considerable advantage in terms of standardization and there is no restriction in obtaining samples with a sufficient number of specimens [13,14].

In the present study, operating times were compared among three different types of files: manual stainless-steel, manual NiTi and rotary NiTi. Compared to the manual stainless-steel files, the operating time with the Easy ProDesign LOGIC rotary system was significantly shorter. Silva et al. [15] described similar results in a previous in vitro study, in which the authors evaluated the cleaning capacity and time required to prepare the root canals of primary molars using manual and rotary instruments. Although no difference was found with regard to cleaning capacity, the operating time was shorter when using the rotary system. This reduction in time is clinically relevant to the endodontic treatment of primary teeth. Moreover, a systematic review showed that stainless-steel instruments have limitations, such as the longer operating time, apical transportation and the formation of undesirable edges. Stainless-steel files are also more susceptible to fracture compared to rotary instruments [16].

A Brazilian study described similar results in a study comparing the preparation of the canals of primary teeth using manual stainless-steel and rotary instruments, reporting a shorter preparation time when the rotary technique was used [17]. Others also reported a difference in operating time between the mechanized and manual techniques, making the rotary method a possible option for optimizing clinical time in the endodontic treatment of pediatric patients [18,19].

In the present study, the average operating time with the rotary technique was the shortest among all techniques tested. This finding is clinically relevant to pediatric dentistry, as the duration of the procedure is one of the factors of the successful treatment of primary teeth [9]. This protocol enables procedures of greater quality and safety and reduces fatigue in both the patient and dentist. In vitro and in vivo studies using rotary instruments on primary molars report a shorter operating time and more conical preparation of the canal, which favors obturation with better quality [9,15,16,20-23].

Some important factors may account for the shorter operating time with rotary files compared to manual files. One of the factors cited in the literature is the smaller number of instruments (four) used in each canal for efficient cleaning and modeling in comparison to the use of manual K files (1 set of K15 to K40) (six) down-scaling -1 mm for the effective preparation of the canal. Another factor cited in previous studies is that the reduction in operating time may be linked to the examiner's experience [10,24]

Operating time with the manual NiTi ProDesign M file system was longer than that required with the rotary system, but shorter in comparison to the operating time required using the Kerr stainless-steel file system. Moreover, NiTi files offer greater flexibility compared to stainless-steel files, making them better for the preparation of narrow canals in primary teeth. This greater flexibility is due to fabrication with a nickel-titanium alloy [25]. NiTi instruments (ProDesign M and ProDesign Logic) have greater cutting power than K files and are therefore more efficient during preparation, which is reflected in the shorter operating time [26]. Thus, in the comparison of the manual instruments, ProDesign M files are more efficient than K files, which are known to have a low cutting capacity. According to the manufacturer, the ProDesign LOGIC and ProDesign M files are the same instruments. The only difference is the presence of a shaft to connect to the electric motor on the Logic instruments and a finger grip shaft on the ProDesign M instruments.

Studies have shown that manual NiTi files are more effective in the preparation of the apical third, although the obturation quality is similar when compared to rotary systems. However, the operating time is shorter with rotary systems [16,27]. There is a need for more comparative studies on these two techniques.

In the comparison of the three systems analyzed herein, the shorter operating time with the rotary system may be explained by the greater number of revolutions per minute in comparison to the other techniques. The higher number of rotations provided by the electric motor translates to more efficient cutting of the dentine and, therefore, less time required for the preparation of the root canal. These results are similar to those reported in previous studies [9,28].

The present results are compatible with findings described in the literature, demonstrating a significant reduction in operating time achieved with the Easy ProDesign LOGIC rotary file system, followed by the ProDesign M manual system and, finally, the conventional K file system.

CONCLUSION

The findings of the present in vitro study revealed a statistically significant difference of operating time among the three root canal preparation methods, along with other advantages of NiTi files, for which further studies are needed. The mechanized rotary method led to a shorter operating time in comparison to the manual techniques (conventional stainless steel and NiTi files) and is therefore a preferable option for the preparation of the root canals of primary teeth.

Collaborators

ML Fernandes, conceptualization (lead), formal analysis (equal), funding acquisition (equal), methodology (equal), project administration (equal), resources (equal), supervision (lead), writing - original draft (equal) and writing - review & editing (lead). CA Maia, GA Maia and AMC Santos, data curation (equal), investigation (equal), methodology (equal), writing - original draft (equal) and writing - review & editing (equal). SM Paiva, data curation (equal), investigation (equal), supervision (equal), validation (equal), writing - review & editing (equal). AM Fernandes, conceptualization (equal), data curation (equal), formal analysis (equal), methodology (lead), project administration (equal), resources (lead), supervision (equal), writing - original draft (equal).

REFERENCES

1. López-Gómez SA, Villalobos-Rodelo JJ, Ávila-Burgos L, Casanova-Rosado JF, Vallejos-Sánchez AA, Lucas-Rincón SE et al. Relationship between premature loss of primary teeth with oral hygiene, consumption of soft drinks, dental care, and previous caries experience. Sci Rep. 2016 Feb 26;(6):21147. http://dx.doi.org/10.1038/srep21147

2. Monte-Santo AS, Viana SVC, Moreira KMS, Imparato JCP, Mendes FM, Bonini GAVC. Prevalence of early loss of primary molar and its impact in schoolchildren's quality of life. Int J Paediatr Dent. 2018;28(6):595-601. http://dx.doi.org/10.1111/ipd.12416

3. Barcelos R, Tannure PN, Gleiser R, Luiz RR, Primo LG. The influence of smear layer removal on primary tooth pulpectomy outcome: a 24-month, double-blind, randomized, and controlled clinical trial evaluation. Int J Paediatr Dent. 2012;22(5):369-381. http://dx.doi.org/10.1111/j.1365-263X.2011.01210.x

4. Divya S, Jeevanandan G, Sujatha S, Subramanian EMG, Ravindran V. Comparison of quality of obturation and post-operative pain using manual vs rotary files in primary teeth - A randomised clinical trial. Indian J Dent Res. 2019;30 (6):904-908. http://dx.doi.org/10.4103/ijdr.IJDR_37_18

5. Panchal V, Jeevanandan G, Subramanian E. Comparison of instrumentation time and obturation quality between hand K-file, H-files, and rotary Kedo-S in root canal treatment of primary teeth: A randomized controlled trial. J Indian Soc Pedod Prev Dent. 2019;37(1):75-79. http://dx.doi.org/10.4103/JISPPD.JISPPD_72_18

6. Mello-Moura ACV, Borelli T, Matos R, Bonini GC, Moura-Netto C. How can we optimize endodontics in primary teeth? a reported case. Rev Assoc Paul Cir Dent. 2012;67(1):50-55.

7. Mello Moura ACV, Mendes FM, Mori I, Silva SREP, Raggio DP, Braga MM, Imparato JCP. Desenvolvimento de modelos pedagógicos de dentes decíduos artificiais: alternativa para o treinamento e pesquisa na área de endodontia. Braz Oral Res. 2010;24:24.

8. Gomes GB, Bonow MLM, Carlotto D, Jacinto RC. In vivo Comparison of the Duration between two Endodontic Instrumentation Techniques in Deciduous Teeth. BRPDIC. 2014;14(3):199-205. http://dx.doi.org/http://dx.doi.org/10.4034/PBOCI.2014.143.04

9. George S, Anandaraj S, Issac JS, John SA, Harris A. Rotary endodontics in primary teeth: a review. Saudi Dent J. 2016;28(1):12-17. http://dx.doi.org/10.1016/j.sdentj.2015.08.004

10. Barr ES, Kleir DJ, Barr NV. Use of nickel-titanium rotary files for root canal preparation in primary teeth. Pediatr Dent. 2000;22(1):77-78.

11. Katge F, Patil D, Poojari M, Pimpale J, Shitoot A, Rusawat B. Comparison of instrumentation time and cleaning efficacy of manual instrumentation, rotary systems and reciprocating systems in primary teeth: an in vitro study. J Indian Soc Pedod Prev Dent.2014;32(4):311-316. http://dx.doi.org/10.4103/0970-4388.140957

12. Musale PK, Mujawar SAV. Evaluation of the efficacy of rotary vs. hand files in root canal preparation of primary teeth in vitro using CBCT. Eur Arch Paediatr Dent. 2014;15(2):113-120. http://dx.doi.org/10.1007/s40368-013-0072-1

13. Mello-Moura ACV, Moura Netto C, Araki AT, Guedes Pinto AC, Mendes FM. Ex vivo performance of five methods for root canal length determination in primary anterior teeth. Int Endod J. 2010;43:142-147. http://dx.doi.org/10.1111/j.1365-2591.2009.01667.x

14. Nadin G, Goel BR, Yeung CA, Glenny AM. Pulp treatment for extensive decay in primary teeth. Cochrane Database Syst Rev. 2003;1:CD003220. http://dx.doi.org/10.1002/14651858.CD003220

15. Silva LAB, Leonardo MR, Nelson-Filho P, Tanomaru JMG. Comparison of Rotary and manual instrumentation techniques on cleaning capacity and instrumentation time in deciduos molars. J Dent Child. 2004;71(1):45-47.

16. Govindaraju L, Jeevanandan G, Subramanian E. Clinical evaluation of quality of obturation and instrumentation time using two modified rotary file systems with manual instrumentation in primary teeth. J Clin Diagn Res. 2017;11(9):ZC55-ZC58. http://dx.doi.org/10.7860/JCDR/2017/30069.10602

17. Kummer TR, Calvo MC, Cordeiro MMR, Vieira RS, Rocha MJC. Ex vivo study of manual and rotary instrumentation techniques in human primary teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105(4):84-92. http://dx.doi.org/10.1016/j.tripleo.2007.12.008

18. Crespo S, Cortes O, Garcia C, Perez L. Comparison between Rotary and manual instrumentation in primary teeth. J Clin Pediatr Dent. 2008;32(4):295-298. http://dx.doi.org/10.17796/jcpd.32.4.l57l36355u606576

19. Machado MEL, Nabeshima CK, Leonardo MFP, Cardenas JEV. Analysis of workingtime of the reciprocating single file instrumentation: Wave One and Reciproc. Rev Assoc Paul Cir Dent. 2012;66:120-125.

20. Azar MR, Safi L, Nikaein A. Comparison of the cleaning capacity of Mtwo and Pro Taper rotary systems and manual instruments in primary teeth. Dent Res J. 2012;9(2):146-151. http://dx.doi.org/10.4103/1735-3327.95227

21. Vieyra JP, Enriquez FJJ. Instrumentation time effciency of rotary and hand instrumentation performed on vital and necrotic human primary teeth: a randomized clinical trial. Dent. 2014;4(4):1-5. http://dx.doi.org/10.4172/2161-1122.1000214

22. Ramezanali F, Afkhami F, Soleimani A, Kharrazifard MJ, Rafiee F. Comparison of cleaning efficacy and instrumentation time in primary molars: mtwo rotary instruments vs. Hand K-files. Iran Endod J. 2015;10(4):240-243. http://dx.doi.org/10.7508/iej.2015.04.006

23. Chauhan A, Saini S, Dua PE, Mangla R. Rotary Endodontics in Pediatric Dentistry: Embracing the New Alternative. Int J Paediatr Dent. 2019;12:460-463. http://dx.doi.org/10.7508/iej.2015.04.006

24. Priyadarshini P, Jeevanandan G, Govindaraju L, Subramanian EMG. Clinical evaluation of instrumentation time and quality of obturation using paediatric hand and rotary file systems with conventional hand K-files for pulpectomy in primary mandibular molars: a double-blinded randomized controlled trial. Eur Arch Paediatr Dent. 2020;21(6):693-701. http://dx.doi.org/10.1007/s40368-020-00518-w

25. Carvalho-Junior JRD, Oliveira LAD. Root canal preparation using a manual option of instruments manufactured with controlled memory NiTi technology: preliminar observations. Oral Sci. 2016;8(1): 22-27.

26. Pinto JC, Pivoto-João MMB, Espir CG, Ramos MLG, Guerreiro-Tanomaru JM, Tanomaru-Filho M. Micro-CT evaluation of apical enlargement of molar root canals using rotary or reciprocating heat-treated NiTi instruments. J Appl Oral Sci. 2019;27(12):2-11. http://dx.doi.org/10.1590/1678-7757-2018-0689

27. Subramaniam P, Girish Babu KL, Tabrez TA. Effectiveness of rotary endodontic instruments on smear layer removal in root canals of primary teeth: a scanning electron microscopy study. J Clin Pediatr Dent. 2016;40(2):141-146. http://dx.doi.org/10.17796/1053-4628-40.2.141

28. Jeevanandan G, Govindaraju L. Clinical comparison of Kedo-S paediatric rotary files vs manual instrumentation for root canal preparation in primary molars: a double blinded randomised clinical trial. Eur Arch Paediatr Dent. 2018;19(4):273-278. http://dx.doi.org/10.1007/s40368-018-0356-6

Received on: 29/1/2022
Approved on: 2/12/2022

Assistant editor: Luciana Butini Oliveira