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Influence of the method for determining working length on the obturation level of primary molars

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Abstract: Efficient working length determination is essential for a successful endodontic treatment. The purpose of the present study was to evaluate whether the method for determining the working length of root canals (radiographic or electronic) influences the obturation level of primary molars. Thus, a controlled, triple-blind, randomized clinical trial was conducted. Sixty-four children aged 6 to 9 years with an indication for primary molar pulpectomy were included. Participants were divided into two groups according to the method used to determine the working length of the root canals: (G1) radiographic and (G2) using an electronic apex locator. The study had 3 operators: #1 performed the clinical procedures, except the electronic measurement; #2 performed radiographic measurement and final evaluation of obturation level; and #3 performed eligibility criteria and electronic measurement. Adequacy of obturation level was evaluated based on the final conventional radiography and it was recorded as acceptable or unacceptable (short or overfilled). Data were analyzed with repeated measures logistic regression. There was no difference between the obturation level of primary molars measured by radiographic and electronic methods ($p > 0.05$). The other investigated variables (age, tooth type, dental arch position, last instrumentation file, and canal location) also did not influence the obturation level ($p > 0.05$). In conclusion, both measurement methods resulted in similar adequacy of obturation level in primary molars after pulpectomy.

Keywords: Pulpectomy; Tooth, Deciduous; Randomized Controlled Trial; Root Canal Obturation.

Declaration of Interests: The authors certify that they have no commercial or associative interest that represents a conflict of interest in connection with the manuscript.

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Introduction

Despite the high success rates demonstrated by previous studies,[1,2] the clinical indication of pulpectomy for primary teeth is still complex.[2,3] The complexity is related, among several factors, to the immaturity of patients to report their symptoms, the root canal anatomy, the physiological resorption process, the proximity to the permanent successor, the difficulty in obtaining good radiographic views of primary tooth apices, and difficulty in determining the working length.[4] Correct determination of the working length is important for the success of root canal treatment in primary teeth.[4,5] Underestimating

this dimension can lead to insufficient chemical-mechanical preparation of the root canal, as well as inefficient root filling.[5] Likewise, overestimating it can result in injury of the periapical tissues and the successor tooth germ, postoperative pain, and periapical inflammation.[5]

Methods to determine the working length include periapical radiographs and electronic apex locators (EALs).[5,6] Periapical radiography is essential for diagnosis and allows direct observation and study of the root canal anatomy. However, high-quality radiographs of primary teeth are difficult to obtain[7] due to superimposition of some anatomic structures, variations in the apical foramen, image distortion, and the patient's collaboration.[8,9] To overcome these difficulties, the use of EALs has become common in clinical endodontic practice.[10] EALs define the working length by measuring the impedances with different frequencies between the endodontic file and the canal fluids.[4] Its use is well established in permanent teeth, but clinical studies in primary teeth are still needed.[11]

Adequate obturation is achieved when a fluid-tight seal is obtained along the entire length of the root canal.[3,12] It should eliminate all entry ports between the periodontium and the root canal system, creating a homogeneous, hermetically sealed mass with minimal voids.[2] The success of the endodontic procedure depends not only on an effective mechanical debridement of the root canal, but also on the level and quality of the obturation,[12] which can be influenced by the type of material used, the technique applied, and by factors inherent to the preparation of the canal, such as the correct determination of the working length.[12]

There is low-quality evidence of the influence of the method used to determine the working length on the obturation level of primary teeth pulpectomies,[9,13] and no randomized clinical trial has evaluated this influence on primary molars. Therefore, the present clinical trial aimed to evaluate whether the method for working length determination (radiographic or electronic) influences the level of obturation of primary molars after pulpectomy. The null hypothesis is that the method used does not influence the obturation level of primary molars.

Methodology

Study design and ethical considerations

The study protocol of this parallel, controlled, triple-blind, randomized clinical trial was approved by the local Human Research Ethics Committee of the Federal University of Santa Catarina (#1.450.709) and it was registered in the ClinicalTrials database (Identifier: NCT03161639). Each child assented to participate, and children's parents or guardians signed an informed consent form. Only the researchers had access to participants' information. The present report followed the guidelines of the Consolidated Standards of Reporting Trials (CONSORT).[14]

Sample size calculation

Sample size estimation was performed in the Sealed Envelope software (Sealed Envelope Ltd., https://sealedenvelope.com/) considering an equivalence trial with a binary outcome. Based on data from previous studies, a success rate of 90% and an equivalence limit of 25% were considered.[15,16] A final sample of 64 primary molars was obtained, totalizing 192 root canals. The sample size was recalculated in the G-Power 3.1.9.2 software (Universität Düsseldorf, Germany), considering a significance level of 5% and a power of 80%, confirming that a sample size of 192 root canals is sensitive to detect a 2.45 difference in odds ratio.

Participants

The participants were patients enrolled in the Pediatric Dentistry Clinics of the Federal University of Santa Catarina from July 2016 to November 2017. Only one tooth per child was included.

Inclusion criteria were children aged 6 to 9 years, without systemic impairments, with a primary molar with clinical and radiographic indications of pulpectomy. The following exclusion criteria were applied: molars with previous root canal manipulation, with radiographic evidence of calcification, furcation perforation, bone resorption involving the permanent tooth crypt, and physiological or pathological internal or external root resorption exceeding a third of its length.[2,3] Molars with coronal destruction that prevented adequate

rubber dam isolation and posterior restorative procedure were excluded.

Training, calibration process, and pilot study

To ensure study blindness, three operators were trained and calibrated (when applicable) to perform data collection. Operator #1 – an MSc and specialist in pediatric dentistry – was trained to perform the pulpectomy procedures (except working length measurement). Operator #2 – a PhD and specialist in pediatric dentistry – was calibrated to perform the radiographic measurement (*Cronbach's alpha* = 0.959) and the evaluation of the obturation level (*Kappa* = 0.750). For working length measurement, ten radiographs of primary molars with indication of pulpectomy were measured twice with a seven-day interval. For the evaluation of the obturation level, other ten radiographs with filled primary molars were evaluated. All radiographs used in this process were from the university's database, and no children were submitted to unnecessary radiographs. Operator #3 was calibrated to perform the electronic measurement *(Cronbach's alpha* = 0.947*)*. For this purpose, five pulpectomies were performed on five children in two appointments with an interval of seven days.

A pilot study was conducted with five children. Five primary molar pulpectomies were performed in a single appointment to standardize the randomization, operator blindness, chair-time, pulpectomy clinical intervention (operator #1), and measurements (operators #2 and #3). No important adjustment was necessary. Children involved in both the calibration process and pilot study were not included in the final sample.

Interventions, randomization, and blinding

At the first appointment, the initial periapical radiograph was taken for the diagnosis and to verify the eligibility criteria. It was executed under 0.4 seconds of exposure time, 70 kVp, and 10 mA, with a periapical film (2x3 cm InsightR; Carestream Health, New York, USA) and a positioner (Fit Rinn; Dentisply Sirona, Ballaigues, Switzerland). The same positioner was used in all evaluations and always placed in the same position. The positioner was adjusted to the size of the child's mouth to be more comfortable.

The sequence of clinical procedures is summarized in Figure 1. Once the eligibility criteria were checked, the radiograph measurement was performed by operator #2. The distance from the cusp tip to the apex or the border of the physiological/pathological root resorption was measured with a flexible plastic ruler (the shortest part of the root was measured in cases of irregular apex resorption). After, the working length was established as 1 mm short of this measurement.[6,15,17] Measurements were performed in a dark room with an x-ray viewer and under a ×4 magnifying glass (Illuminated magnifying glass, Tokyo, Japan). The working length was recorded in a specific file.

In a second appointment, the tooth was anesthetized with 1.8 mL of 2% lidocaine HCl with epinephrine 1:100.000 (Alphacaine; DFL, Rio de Janeiro, Brazil) through the appropriate nerve block technique. The tooth was isolated with a rubber dam and the traditional root canal access was performed. Then, operator #3 performed the electronic measurement (without operator #1 in the room) and recorded it in a specific file.

Electronic measurement was done by operator #3 by inserting a 15/0.02 K-type file (Dentsply Maillefer, Baillagues, Switzerland) into the root canal until the EAL (Root ZX II; J. Morita, Tokyo, Japan) beeped and the panel indicated that the apex level had been reached. This measure was considered valid when the value remained stable for at least 5 seconds. A rubber stopper was adjusted to the reference point, the file was carefully removed from the canal, and the measurement was done with a metallic ruler. The working length was established 1 mm short of the indicated value.[6,16]

The participants were then randomly allocated (1:1) into two groups: (G1) radiographic measurement and (G2) electronic measurement, using a permuted block design of 4 and 6 patients each. The allocation concealment was secured by a computer-generated randomization list, placed in numbered opaque sealed envelopes. The working length was then informed to operator #1, who was blinded. All root canals were chemo-mechanically prepared, dried

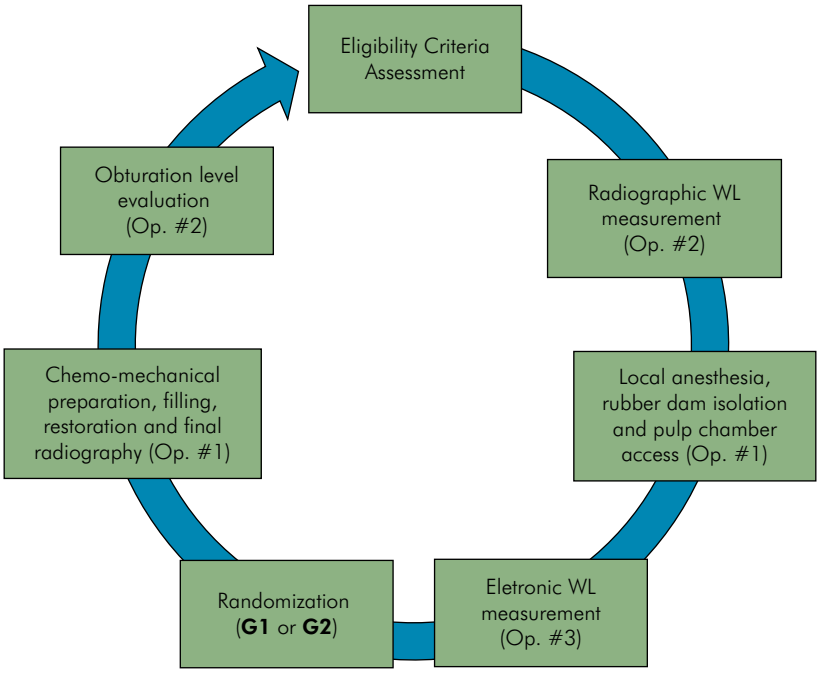

Figure 1. Summary of clinical procedures.

with paper points, and sealed with zinc oxide eugenol (ZOE)[2,3] (Biodinamica, Ibipora, Brazil) with the aid of a #25 Lentulo drill (Dentsply Maillefer, Baillagues, Switzerland), at 400 rpm. The final restoration was performed with composite resin.[18] At the end of the clinical procedure, a final conventional radiograph was obtained using a positioner. The pulpectomy procedure was performed in a single session for all cases.

The obturation level and adequacy of root canal filling were evaluated radiographically using an x-ray viewer and a magnifying glass (operator #3). All final conventional radiographs were measured with the same plastic ruler. The adequacy of root canal filling was recorded as: short-filled (when ZOE ended 2 mm shorter of the radiographic apex); acceptable (when ZOE ended within 0–2 mm of the radiographic apex) and; overfilled (when ZOE extruded past the apex).[19]

Data analysis

The data analysis was performed in the Statistical Package for Social Sciences version 21.0 (IBM SPSS Statistics, Chicago, USA). The *Kappa* agreement coefficient was used to describe the intra-examiner agreement for level of obturation. *Cronbach's* Alpha was used to evaluate the operators' internal consistency for the measurement methods. Data were analyzed by repeated measures logistic regression. The independent variable (level of obturation) was dichotomized as acceptable (adequate cases) or unacceptable (short and overfilled cases). Variables with a p-value ≤ 0.20 in the unadjusted model were included for the adjusted model. Statistical significance was set at 5%.

Results

The flowchart of patient assessment is shown in Figure 2. Initially, 491 children were assessed for eligibility criteria and 427 were excluded. From these, 409 did not meet the clinical and radiographic inclusion criteria, 7 declined to participate, and in 11 cases the intervention could not be appropriately performed in one appointment and were therefore excluded. Finally, 64 primary molars were included, totalizing 192 root canals. Thirty-one primary molars (94 canals) were allocated to G1 (radiographic method). One first primary molar had 4 canals and the others had three canals. Thirty-three primary molars (98 canals) were allocated to G2 (electronic method). All molars from this group

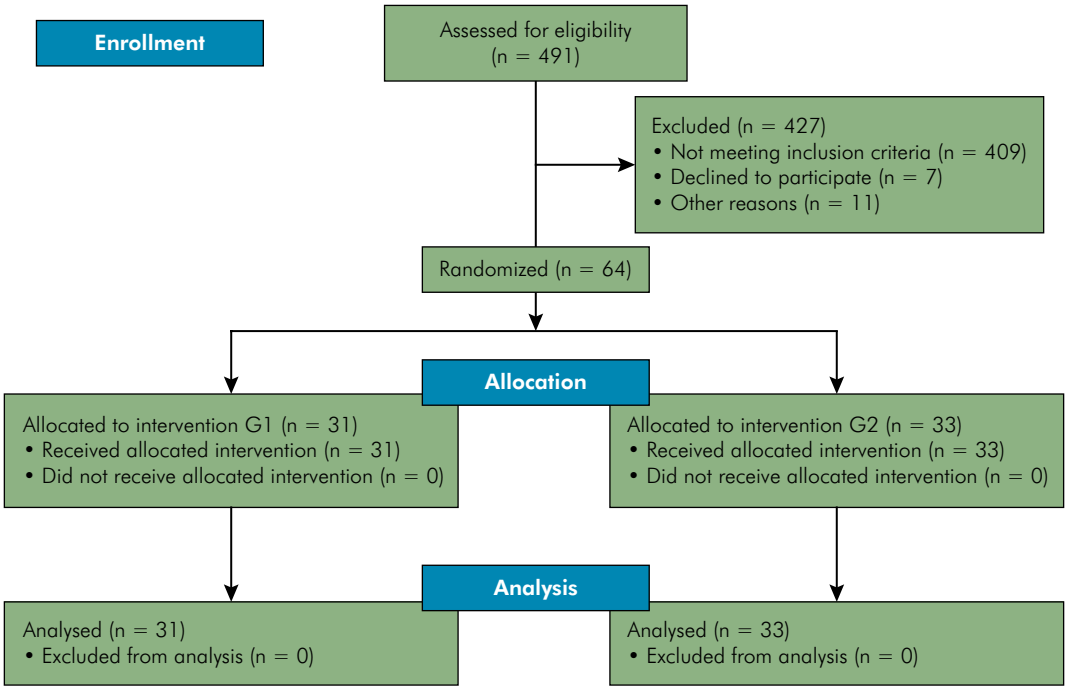

Figure 2. Flowchart of participants' assessment adapted from Consort.

had three canals. One canal was excluded because the electronic measurement could not be done properly.

A high internal consistency was achieved for both radiographic (*Cronbach's* Alpha of 0.959) and electronic (0.947) methods. Furthermore, a *Kappa* value of 0.750 was obtained for intra-examiner agreement for level of obturation.

The sample distribution according to obturation level is presented in Table 1. Most cases presented acceptable obturation level (53.6%), while 46.4% presented an unacceptable level (short: 26.6%; overfilled: 19.8%). Table 2 shows the results from the logistic regression model. The main predictor (determination method) was not associated with level of obturation in the present sample ($p = 0.44$). Likewise, the other investigated variables (sex, age, type of teeth, dental arch position, root canal location, and last instrumentation file) were not associated with obturation level ($p > 0.05$).

Discussion

The present study found no differences in the obturation level of primary molar pulpectomies performed with two methods for working length determination (radiographic and electronic). Similarly, other investigated factors such as age of children, tooth type, dental arch position, canal location, and last instrumentation file were not associated with obturation level. These findings demonstrate that it is possible to obtain an adequate canal obturation independently of the investigated variables or how the working length was measured. Therefore, the null hypothesis was accepted.

Radiographs remain essential for a correct diagnosis.[9] In regular clinical practice, it is also often used to determine the working length of root canals during pulpectomies. The reproducibility and accuracy of the radiographic method for working length measurements are still significant.[9] Moreover, radiographs are accessible, cost-effective, and offer a relatively good image resolution.[9] However, caution should be taken in order to avoid unnecessary x-ray exposure.[9]

EALs have been used in endodontic treatment for many years, especially in permanent teeth.[10] However, despite being accurate, safe, and relatively painless, it is still not routinely used in pediatric

Table 1. Sample distribution according to the obturation level (n = 192).

Variables	Acceptable (Adequate level)	Unacceptable (Short or overfilled)
WL measurement method		
Radiographic	47 (24.4)	47 (24.5)
Electronic	56 (29.2)	42 (21.9)
Sex		
Female	48 (25.0)	31 (16.2)
Male	55 (28.6)	58 (30.2)
Age		
6–7 years	43 (22.4)	29 (28.3)
8–9 years	60 (31.2)	60 (21.1)
Type of teeth		
First molars	22 (11.5)	20 (10.4)
Second molars	81 (42.1)	69 (36.0)
Dental arch position		
Upper arch	27 (14.1)	24 (12.6)
Lower arch	76 (39.5)	65 (33.8)
Root canal location		
Palatal or distal	32 (16.6)	33 (17.2)
Mesio or distobuccal	71 (37.0)	56 (29.2)
Last instrumentation file		
#40	82 (42.6)	72 (37.3)
#35	21 (11.0)	17 (9.1)
Total	103 (53.6)	89 (46.4)

WL: Working length

Table 2. Unadjusted repeated measures logistic regression model for the obturation level and possible associated variables (n = 192).

Variables	Obturation level	
	Unadjusted model*	
	OR (95%CI)	p-value
WL measurement method		0.44
Radiographic	1	
Electronic	1.33 (0.64–2.76)	
Sex		0.11
Female	1	
Male	1.63 (0.90–2.95)	
Age		0.32
6–7 years	1	
8– 9 years	0.67 (0.31–1.46)	
Type of teeth		0.89
First molars	1	
Second molars	1.07 (0.43–2.65)	
Dental arch position		0.93
Upper arch	1	
Lower arch	1.04 (0.45–2.41)	
Root canal location		0.34
Palatal or distal	1	
Mesio or distobuccal	1.31 (0.75–2.28)	
Last instrumentation file		0.87
#40	1	
#35	1.08 (0.42–2.82)	

WL: Working length; *Only sex had $p \leq 0.20$ in the unadjusted model.

clinical practice.[10] In the radiographic method, a linear root canal measurement is achieved based on a 2D image. In the electronic method, a flexible file is inserted into the root canal. Because the file can adjust to the root canal shape, the obtained measure can be more accurate[9,11,20] especially when canals are overlapped by anatomical structures.[11,21] The use of EALs in pediatric dentistry has some limitations, such as difficulty in controlling the reference point, cost, limited visualization of the exact position of the file's tip, and observation of anatomical details.[6]

Physiological and pathological root resorption are common in primary teeth and constantly change the root canal morphology.[22] One of the advantages of EALs is detecting root perforation or a resorption connecting with the periodontal ligament.[22] Moreover, root resorptions occurring on buccal or lingual root surfaces are frequently not detectable radiographically, increasing the risk of overinstrumentation and/or overfilling.[23] Previous clinical studies[8,24] reported no significant difference between the use of EALs and conventional radiography for determining the working length in primary teeth. In addition, the radiographic method has some important limitations, such as superposition of roots and adjacent anatomical structures, image distortion, increased appointment time, limited access in children's mouths, and exposure to ionized radiation.[8,21] Therefore, the use of EALs in primary teeth should be evaluated as an alternative to the conventional radiographic method.

Successful obturation is achieved when a homogeneous mass completely seals the root canal with minimal voids, preventing bacterial invasion and persistence of infection.[25] However, there is no consensus in the literature about the influence of obturation level on pulpectomy success rate. Bawazir and Salama[25] found that adequately filled or overfilled canals showed a higher radiographic success rate than short-filled canals. Another study[26] reported no statistically significant difference between success rate and extent of root canal filling. Coll and Sadrian[27] reported a higher success rate for short-filled teeth compared to overfilled teeth. Therefore, given the controversial reports, further clinical trials with longer follow-ups are needed to elucidate the role of obturation level on the success rate of primary tooth pulpectomies.

The present study also evaluated other factors that could influence the obturation level, such as the children's age, tooth type, dental arch position, canal location, and last instrumentation file. However, none of these were associated with the obturation level of the root canals. A previous clinical study reported that the obturation level was similar in first and second primary molars.[28] Likewise, children's age and tooth arch position did not seem to impact the obturation level in primary teeth.[25] In contrast, it was previously reported[6] that the working length of the upper distobuccal and lower mesiolingual canals was significantly different when using an EAL (compared to the radiographic method). However, no association was found between the obturation level and the canal position in the present study. Other variables that could not be evaluated, such as the operator's ability and the obturation technique, should be investigated in future studies.

In private clinical practice, the method for determining the working length (electronic or radiographic) can be chosen by the dentist, considering the pros and cons of each method. Although there is a tendency to use EAL in clinical practice, further studies are necessary to ensure its accuracy based on long-term treatment success. If the electronic device is not available (*e.g.*, public services), this should not prevent the dentist from performing the procedure, as the radiographic method has similar accuracy in determining the working length in primary molars. Thus, endodontic treatment of primary molars is not dependent on the measurement method.

Some limitations of the present study should be stated. The difficulties in performing and standardizing radiographs that clinicians face in daily clinical practice are well known, especially in children. Thus, to minimize possible bias, all radiographies were performed with a positioner. Excluding cases would mean that the result of this research would not reflect clinical practice. Another limitation was the use of two different rulers for the measurement methods. A plastic ruler was used in the radiographic method and a sterilized metal ruler was used the electronic method.

Blinding the operators and performing adequate sample randomization decreased the risk of bias. Besides, to eliminate further discrepancies, a single operator carried out the pulpectomies, and two blinded, calibrated operators performed each measurement method. It was considered important that only a single operator performed all canal treatments to carefully follow the pre-established protocol, avoiding, for example, possible variations in technique or operator experience.

Conclusions

In conclusion, according to the present findings, working length determination by EALs or conventional radiography did not affect the obturation level of primary molars after pulpectomy.

References

1. Moura J, Lima M, Nogueira N, Castro M, Lima C, Moura M, et al. LSTR Antibiotic paste versus zinc oxide and eugenol pulpectomy for the treatment of primary molars with pulp necrosis: a randomized controlled trial. Pediatr Dent. 2021 Nov;43(6):435-42. https://doi.org/10.17796/1053-4628-40.3.175

2. Coll JA, Vargas K, Marghalani AA, Chen CY, AlShamali S, Dhar V, et al. A systematic review and meta-analysis of nonvital pulp therapy for primary teeth. Pediatr Dent. 2020 Jul;42(4):256-461.
3. Coll JA, Dhar V, Vargas K, Chen CY, Crystal YO, AlShamali S, et al. Use of non-vital pulp therapies in primary teeth. Pediatr Dent. 2020 Sep;42(5):337-49.
4. Keratiotis G, Kournetas N, Agrafioti A, Kontakiotis EG. A comparative evaluation of two working length determination methods. Aust Endod J. 2019 Dec;45(3):331-6. https://doi.org/10.1111/aej.12321
5. Kayabasi M, Oznurhan F. Evaluation of the accuracy of electronic apex locators, cone-beam computed tomography, and radiovisiography in primary teeth: an in vitro study. Microsc Res Tech. 2020 Nov;83(11):1330-5. https://doi.org/10.1002/jemt.23524
6. Alencar NA, Oriano MD, Bolan M, Cardoso M. Is there any difference in length measurement methods for pulpectomies in primary teeth?-A double-blind, controlled clinical trial. Int J Paediatr Dent. 2019 Nov;29(6):712-9. https://doi.org/10.1111/ipd.12567
7. Kumar LV, Sreelakshmi N, Reddy ER, Manjula M, Rani ST, Rajesh A. Clinical evaluation of conventional radiography, radiovisiography, and an electronic apex locator in determining the working length in primary teeth. Pediatr Dent. 2016 Jan-Feb;38(1):37-41.
8. Bhat KV, Shetty P, Anandakrishna L. A comparative evaluation of accuracy of new-generation electronic apex locator with conventional radiography to determine working length in primary teeth: an in vivo study. Int J Clin Pediatr Dent. 2017 Jan-Mar;10(1):34-6. https://doi.org/10.5005/jp-journals-10005-1403
9. Mello-Moura AC, Bresolin CR, Moura-Netto C, Ito A, Araki AT, Imparato JC, et al. Use of artificial primary teeth for endodontic laboratory research: experiments related to canal length determination. BMC Oral Health. 2017 Nov;17(1):131. https://doi.org/10.1186/s12903-017-0420-3
10. Vasconcelos BC, Bastos LM, Oliveira AS, Bernardes RA, Duarte MA, Vivacqua-Gomes N, et al. Changes in root canal length determined during mechanical preparation stages and their relationship with the accuracy of root ZX II. J Endod. 2016 Nov;42(11):1683-6. https://doi.org/10.1016/j.joen.2016.07.022
11. Ahmad IA, Pani SC. Accuracy of electronic apex locators in primary teeth: a meta-analysis. Int Endod J. 2015 Mar;48(3):298-307. https://doi.org/10.1111/iej.12315
12. Priyadarshini P, Jeevanandan G, Govindaraju L, Subramanian EM. 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 Dec;21(6):693-701. https://doi.org/10.1007/s40368-020-00518-w
13. ElAyouti A, Kimionis I, Chu AL, Löst C. Determining the apical terminus of root-end resected teeth using three modern apex locators: a comparative ex vivo study. Int Endod J. 2005 Nov;38(11):827-33. https://doi.org/10.1111/j.1365-2591.2005.01024.x
14. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, et al. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. BMJ. 2010 Mar;340 mar23 1:c869. https://doi.org/10.1136/bmj.c869
15. 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 Sep;22(5):369-81. https://doi.org/10.1111/j.1365-263X.2011.01210.x
16. Trairatvorakul C, Chunlasikaiwan S. Success of pulpectomy with zinc oxide-eugenol vs calcium hydroxide/iodoform paste in primary molars: a clinical study. Pediatr Dent. 2008 Jul-Aug;30(4):303-8.
17. Pramila R, Muthu MS, Deepa G, Farzan JM, Rodrigues SJ. Pulpectomies in primary mandibular molars: a comparison of outcomes using three root filling materials. Int Endod J. 2016 May;49(5):413-21. https://doi.org/10.1111/iej.12478
18. Topçuoğlu G, Topçuoğlu HS, Delikan E, Aydınbelge M, Dogan S. Postoperative pain after root canal preparation with hand and rotary files in primary molar teeth. Pediatr Dent. 2017 May;39(3):192-6.
19. Ravanshad S, Adl A, Anvar J. Effect of working length measurement by electronic apex locator or radiography on the adequacy of final working length: a randomized clinical trial. J Endod. 2010 Nov;36(11):1753-6. https://doi.org/10.1016/j.joen.2010.08.017
20. Odabaş ME, Bodur H, Tulunoğlu O, Alaçam A. Accuracy of an electronic apex locator: a clinical evaluation in primary molars with and without resorption. J Clin Pediatr Dent. 2011;35(3):255-8. https://doi.org/10.17796/jcpd.35.3.7w71656740286960
21. Ahmed HM. Anatomical challenges, electronic working length determination and current developments in root canal preparation of primary molar teeth. Int Endod J. 2013 Nov;46(11):1011-22. https://doi.org/10.1111/iej.12134
22. Rimondini L, Baroni C. Morphologic criteria for root canal treatment of primary molars undergoing resorption. Endod Dent Traumatol. 1995 Jun;11(3):136-41. https://doi.org/10.1111/j.1600-9657.1995.tb00475.x
23. Mente J, Seidel J, Buchalla W, Koch MJ. Electronic determination of root canal length in primary teeth with and without root resorption. Int Endod J. 2002 May;35(5):447-52. https://doi.org/10.1046/j.1365-2591.2002.00500.x
24. Oznurhan F, Ünal M, Kapdan A, Ozturk C, Aksoy S. Clinical evaluation of apex locator and radiography in primary teeth. Int J Paediatr Dent. 2015 May;25(3):199-203. https://doi.org/10.1111/ipd.12128
25. Bawazir OA, Salama FS. Clinical evaluation of root canal obturation methods in primary teeth. Pediatr Dent. 2006 Jan-Feb;28(1):39-47.

26. Moskovitz M, Sammara E, Holan G. Success rate of root canal treatment in primary molars. J Dent. 2005 Jan;33(1):41-7. https://doi.org/10.1016/j.jdent.2004.07.009
27. Coll JA, Sadrian R. Predicting pulpectomy success and its relationship to exfoliation and succedaneous dentition. Pediatr Dent. 1996 Jan-Feb;18(1):57-63.
28. Mokhtari N, Shirazi AS, Ebrahimi M. A smart rotary technique versus conventional pulpectomy for primary teeth: a randomized controlled clinical study. J Clin Exp Dent. 2017 Nov;9(11):e1292-6. https://doi.org/10.4317/jced.53968