In vitro evaluation of root canal wall cleanliness in primary molars after preparation with Self-Adjusting-File (SAF) or Mtwo NiTi-instruments and final irrigation



S. Baxter, K.-M. Phan, M. Hülsmann

Department of Preventive Dentistry, Periodontology and Cariology, University Medical Center Göttingen, Göttingen, Germany

E-mail: steffi.baxter@med.uni-goettingen.de

DOI 10.23804/ejpd.2021.22.01.02

Abstract

Aim In vitro evaluation of cleanliness of root canal walls of primary molars after preparation with the Self-Adjusting-File and Mtwo-instruments and final irrigation with citric acid and sodium hypochlorite.

Materials and methods Study Design: In 23 matched pairs, teeth were prepared either with SAF or with Mtwo NiTi-instruments, and final irrigation was performed with 2 mL citric acid and 4 mL NaOCl. Roots were split longitudinally, SEM-images were taken, and smear layer was evaluated by two blinded observers using a four-grade score. Statistical evaluation was performed with Mann-Whitney-U-Test and Wilcoxon Signed Rank Test ($P<0.05$).

Results No significant difference between SAF and Mtwo ($P=0.9454$) was observed. Overall removal of the smear layer was significantly better in the coronal part of the root canal than in the apical one ($P=0.0004393$). Mtwo showed no significant difference in cleanliness when comparing the coronal and apical part of the root canal ($P=0.1089$), whereas SAF cleaned the coronal part of the root canal significantly better than the apical part ($P=0.00108$).

Conclusion None of the two instruments was superior concerning cleanliness in root canals of primary molars. Both show good cleaning ability when using an irrigation protocol with citric acid and sodium hypochlorite.

KEYWORDS Primary teeth, Smear layer, Debris, Cleanliness, SAF, Mtwo-

Introduction

In recent years major progress has been achieved in prevention of early tooth loss in children [de Oliveira et al., 2017; Cvikl et al., 2018] but still a number of primary teeth are extracted due to deep carious lesions, pulpitis, pulp necrosis, or apical abscess [Ahamed et al., 2012; Chugh et al., 2018].

In the primary dentition, loss of a tooth is always associated with loss of aesthetics [Kapur et al., 2005; Holan and Needleman, 2014], or a compromised ability of chewing and speaking properly, and frequently also with orthodontic problems [Law, 2013]. Pulp or root canal treatment, in the primary dentition, can prevent loss of a tooth and thus eliminate unpleasant consequences for the child [de Paula et al., 2015]. Treatment options of an inflamed vital pulp in primary teeth include pulpotomy [Coll et al., 2017], or root canal treatment (pulpectomy).

The success rate of root canal treatment in the primary dentition has been reported to range from 85% to 100% [Pramila et al., 2016]. For treatment of children it is important to find a fast and effective way of endodontic therapy. Crespo et al. [2008] showed that rotary nickel-titanium instrumentation of the root canal requires less time than manual root canal preparation. Traditionally, root canals in the primary dentition have been instrumented with hand files, frequently resulting in severe root canal transportation or even perforation. To overcome this problem rotary nickel-titanium root canal instruments have been used for root canal preparation in primary teeth. Studies comparing manual instrumentation and nickel-titanium instrumentation have demonstrated better results for nickel-titanium preparation [Martinho et al., 2010], although this has not been thoroughly investigated in all aspects such as shaping outcome, cleaning efficacy and working safety, among others. Just as in the permanent dentition, cleaning of the root canal wall, removal of infected dentine, sufficient irrigation with sodium hypochlorite (NaOCl), and removal of the smear layer with citric acid or EDTA are essential for a successful endodontic treatment [Barcelos et al., 2012].

Many nickel-titanium files for preparation of the root canal have been investigated in the past. Mtwo has shown good results for smear layer removal in permanent teeth [Bürklein et al., 2012]. The SAF-File also shows good results in its cleaning ability [Keles et al., 2016]. This file resembles a hollow NiTi tube constructed of two NiTi lattices connected together by thin NiTi cross-beams. With the use of the EndoSTATION-motor unit (ReDent NOVA, Ra´anana, Israel) permanent irrigation during preparation is possible. So far studies on smear layer removal in primary teeth with the SAF are not available. The instruments work in a vibrating mode while the Mtwo is a more conventional NiTi system that uses a

single length technique. The Mtwo system includes Hedstroem-type files with two shaping blades and a non-cutting tip in the following sizes: 10/.04, 15/.05, 20/.06, 25/.06, 30/.05, 35/.04. The instruments are used in a rotary motion at 280 rpm.

Therefore, the purpose of this investigation was to evaluate root canal wall cleanliness following preparation with two different, rotary and vibrating, nickel-titanium systems, SAF and Mtwo, in combination with an irrigation protocol using citric acid and sodium hypochlorite in primary molars.

Materials and methods

The study was approved by the Ethics Committee of the University of Göttingen, Germany (DOK_155_2016).

Selection of teeth and preparation of specimens

Eighty-three maxillary and mandibular primary molars extracted for reasons not related to this study were selected. All teeth with root resorption that extended to more than one third of the root, and all teeth with perforations or severe carious damage of the crown were excluded. Sixty-five teeth were included, from which 23 matched pairs were formed (46 teeth). The remaining 19 teeth were not used in the study.

Matching criteria for the matched pairs were the same tooth (upper or lower molar), comparable size of tooth, same number of roots, no difference of more than 2.5 mm in root canal length, and a similar root canal curvature (radius 5.5–16.5 mm, angle 15–40°) as calculated by the method described by Schneider et al. [1971]. Of the 23 matched pairs, in 9 of the pairs each tooth had three roots, and in 14 pairs each tooth had four roots with a total of 83 roots, and 83 root canals respectively, with 23 teeth in each group.

An access cavity was prepared with a diamond bur (Brasseler, Lemgo, Germany) and a size 08 Reamer (VDW, Munich, Germany) was inserted into the root canal until the tip of the instrument was visible at the apical opening. For determination of the endodontic working length, 1 mm was subtracted from the root canal length. The teeth were stored in 0.1% thymol solution.

Root canal preparation

Both teeth of a pair were numbered and randomly assigned to one of the two groups. In Group 1 root canal preparation was performed with SAF instruments, in group 2 the root canals were instrumented with Mtwo rotary nickel titanium instruments.

Group 1: Self Adjusting File

A glide path was prepared using a size 20 hand instrument, followed by vibratory instrumentation with the SAF-file (diameter 1.5 mm and 21 mm length) used with a RADT3-handpiece and the EndoSTATION-motor (ReDent NOVA, Ra´anana, Israel). Root canal instrumentation was performed for three minutes at 5.000 rpm, and the root canal was irrigated with 1% sodium hypochlorite at 4 mL/min resulting in a total amount of irrigant of 12 mL for each root canal. Apical patency was ensured with a size 10 reamer following instrumentation. A new SAF-file was used for each root canal.

Group 2: Mtwo

The root canals in the other tooth of the matched pair was instrumented with Mtwo rotary nickel-titanium instruments up to size 35/.04 taper, using the instruments 10/.04, 15/.05, 20/.06, 25/.06, 30/.05, and 35/.04, respectively, with a single-length technique following the manufacturer`s recommendations. Apical patency was ensured throughout instrumentation with a size 10 reamer after each instrument. The root canals were irrigated manually with 2 mL 1% NaOCl in a 5 mL syringe and a NaviTip irrigation needle (Ultradent, Munich, Germany) with an outer diameter of 0.3 mm at working length minus 2 mm after each instrument resulting in a total amount of irrigant of 12 mL for each root canal. The irrigation time was 30 seconds after each instrument, resulting in a total irrigation time of 3 minutes.

After complete preparation in both groups final irrigation was performed for 1 minute with 4 mL sodium hypochlorite (1%) and 2 mL 10% citric acid using a 5 mL syringe with a NaviTip irrigation needle. The irrigation needle was placed at working length minus 2 mm into the root canal. During irrigation the root tip was held against a gauze swab to simulate resistance of apical tissues. In both groups, the same amount of irrigant was used during preparation and during final irrigation. After completed preparation all root canals were dried with size 35 paper points (VDW, Munich, Germany).

SEM evaluation

A longitudinal groove was prepared on the buccal and lingual side of each root with a small diamond bur (Brasseler, Lemgo, Germany) and all roots were split longitudinally in bucco-lingual direction using a Heidemann spatula (Aesculap, Tutlingen, Germany). To protect the root canal wall from contamination with dentinal dust and dentine chips a size 35 gutta-percha (VDW) cone was placed in the root canal before final separation.

After separation of the root, only one half of each root was used for further examination, resulting in 83 specimens (root halves) in each group.

All root halves were dried for two weeks and sputtered for observation under the Scanning-Electron-Microscope (Zeiss Ultra Plus, Zeiss, Oberkochen, Germany) at 1.000x magnification. Two images were taken from randomly selected areas in the coronal and the apical part of each root canal. The areas were selected at low magnification by the SEM-operator, who was blinded to the aims of the study and was not informed about the respective preparation technique. Following adjustment of the area to be scored magnification was increased to 1.000x.

The samples were analyzed for the amount of remaining smear layer. Scoring (Fig. 1–4) was performed as follows.

Score 1: 0–25% root canal wall covered by smear layer.
Score 2: 26–50% root canal wall covered by smear layer.
Score 3: 51–75% root canal wall covered by smear layer.
Score 4: 76–100% root canal wall covered by smear layer.

The two examiners were blinded to the root canal preparation technique and the location in the root canal. Calibration of the two blinded observers had been performed before evaluation of the images by scoring 50 coronal and 50 apical SEM images. After scoring, the results were discussed using reference photographs. The scoring for calibration was repeated five days later. For the main evaluation both observers scored the specimens independently. In cases of disagreement, agreement was achieved through joint discussion of the image.

Remnants of debris were not evaluated due to the very low, mostly not visible amounts of debris in all samples of both groups.

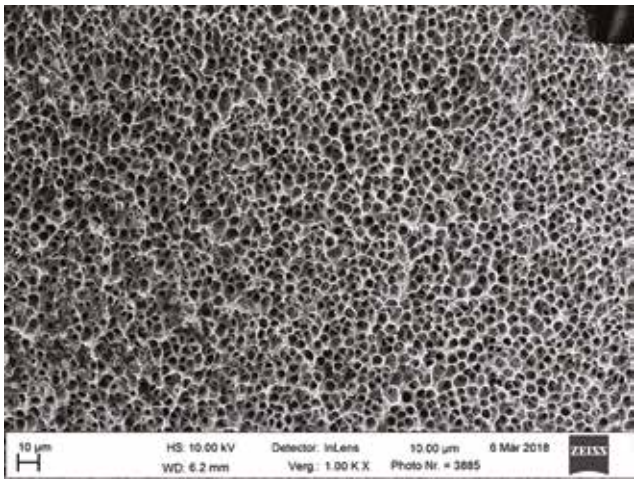


FIG 1 Score 1 (0-25% of the surface covered with smear layer).

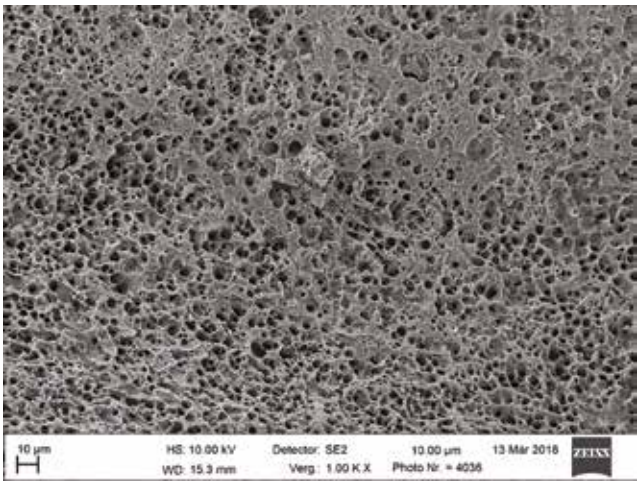


FIG 2 Score 2 (25-50% of the surface covered with smear layer).

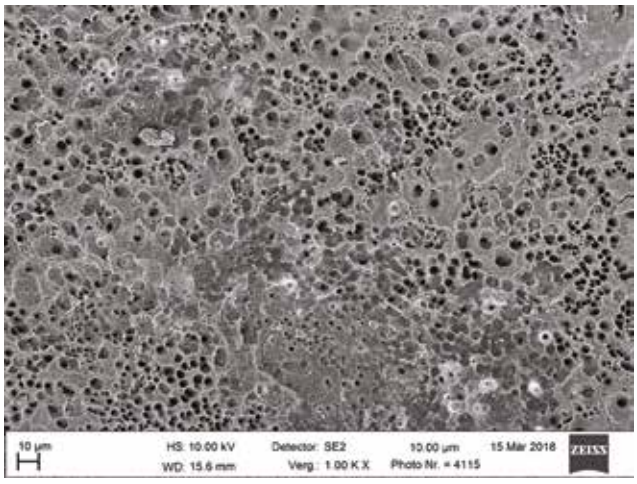


FIG 3 Score 3 (50-75% of the surface covered with smear layer).

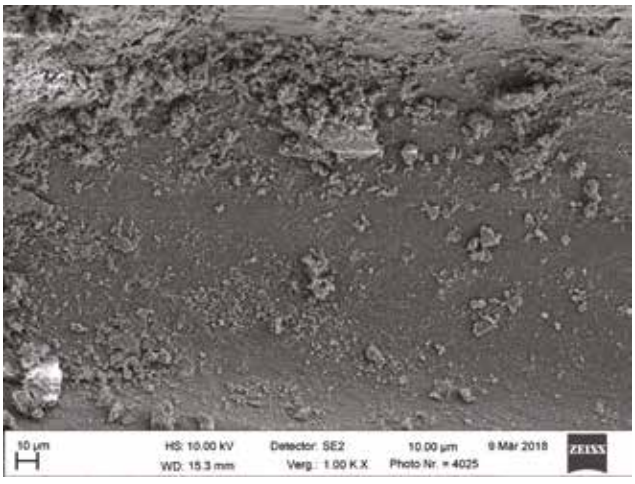


FIG 4 Score 4 (75-100% of the surface covered with smear layer).

Statistical analysis

Intra- and interobserver reliability were analysed using Cohen`s Kappa. Comparison of the instruments was analysed by using the Mann-Whitney-U-Test and the Wilcoxon signed-rank test was used for comparison of coronal and apical area of the root canal. The level of significance was set at P>0.05.

Results

The intraobserver reproducibility was 0.87 and 0.76 and the interobserver agreement was 0.70 (Cohen`s Kappa), respectively, demonstrating good reliability of scoring.

The results of the SEM analysis of the root canal walls examining the residual smear layer are summarised in Table 1.

Both NiTi systems removed most of the debris and smear layer from the root canal wall leaving well cleaned dentinal surfaces with the majority of dentinal tubules showing non-obstructed orifices. For smear layer removal most of the specimens were scored 1 and 2 in the SEM examination.

The comparison of SAF and Mtwo, irrespective of the location in the coronal or apical part of the root canal, did not show any significant difference between the two systems regarding smear layer removal (P=0.945). Overall smear layer removal from the coronal and apical root canal wall, irrespective of the root canal instruments, shows significantly better results for the coronal part of the root canal wall (P<0.001).

In the coronal part of the root canal there was no significant difference between the two nickel-titanium systems (P=0.441). When comparing the apical part of the root canal wall also no significant difference was found (P=0.446).

	SAF			Mtwo		
Score	Coronal	Apical	Total	Coronal	Apical	Total
1	49	31	80	47	34	81
2	21	22	43	15	23	38
3	5	16	21	14	19	33
4	6	12	18	6	6	12
Not assess.	2	2	4	1	1	2
n	83	83	166	83	83	166

TABLE 1 Results of the SEM evaluation of remaining smear layer on the root canal walls. Few specimens could not be evaluated for smear layer as the root canal wall was covered by debris.

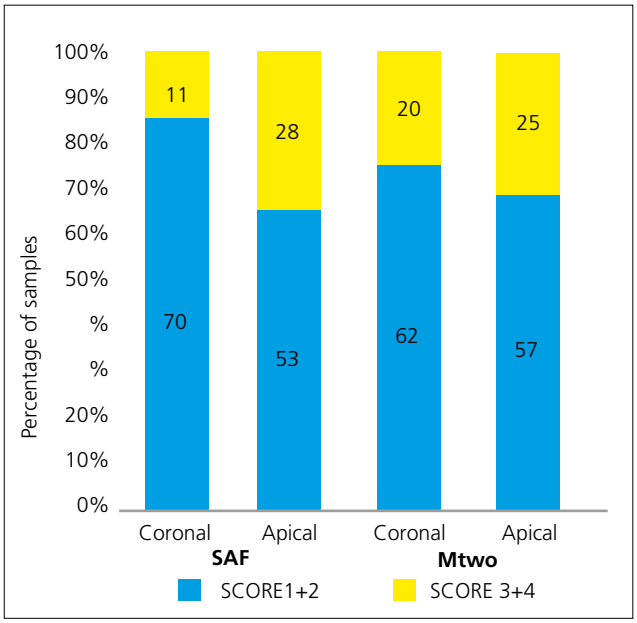


FIG 5 Distribution of smear layer scores of SAF and Mtwo in the coronal and apical part of the root canal wall.

For root canal preparation with Mtwo there was no significant difference in the removal of smear layer in the coronal and apical part of the root canal wall (P=0.109), whereas SAF showed a significantly better cleaning ability in the coronal part of the root canal compared to the apical half (P=0.001). Two specimens in the SAF group and one in the Mtwo group could not be scored for smear layer due to large amounts of debris on the root canal surface.

The percentage of scores 1 and 2, representing very good to good cleanliness, and scores 3 and 4, representing poor and insufficient cleanliness with large amounts of the surface covered by smear layer, are summarised in Fig. 5.

Discussion

In this study maxillary and mandibular primary molars were distributed into matched pairs, instrumented with SAF vibratory nickel-titanium instruments and Mtwo rotary nickel-titanium files, and irrigated with citric acid and sodium hypochlorite for investigation of the cleanliness of the root canal wall.

For root canal treatment in primary teeth it is important to use an instrumentation technique that is fast and well accepted by children. Several studies reported a significantly faster instrumentation with nickel-titanium files compared to manual instrumentation [Crespo et al., 2008]. Also, the original shape of the root canal is obtained better when using nickel-titanium instruments compared to hand files [Schäfer et al., 2006; Crespo et al., 2008].

Several studies examined the cleanliness of the root canal wall after preparation with different nickel-titanium rotary instruments in the primary dentition. Azar and Mokhtare examined root canal cleanliness after rotary preparation with Mtwo and manual instrumentation and found no significant difference between the two methods [Azar and Mokhtare, 2011]. Regarding the cleaning ability of different nickel-titanium systems and manual instrumentation of the root canals, several studies showed no significant difference between manual instrumentation and nickel-titanium instruments. Mtwo performed significantly faster than other file systems and manual instrumentation [Azar and Mokhtare 2011].

So far, no study researching the cleaning ability of SAF in root canals in primary teeth has been published. SAF has been shown to achieve good results in cleanliness and disinfection of root canal walls in permanent teeth [Metzger et al., 2010]. Overall, no significant differences were found between Mtwo and SAF regarding cleanliness of the root canal wall in this study. The cleaning efficacy was better in the coronal part of the root, which was also found in permanent teeth in other studies [Metzger et al., 2010; Adigüzel et al., 2011]. Mtwo did not show significant differences between the coronal and apical part in this study, which was also found in a study by Bürklein et al., [Bürklein et al., 2012] in permanent teeth.

The size of apical preparation in primary teeth is very controversial. Some studies recommend an apical size of 30 [Llewelyn and Faculty of Dental Surgery, Royal College of Surgeons, 2000; Ahmed, 2013] or even larger apical preparation sizes [Silva et al., 2004; Rocha and Cardoso, 2004]. In primary teeth the risk of perforations during instrumentation of the root canal is higher than in permanent teeth, due to the thinner root canal walls and physiological interradicular root resorption. In this study instrumentation of the root canal walls was performed with Mtwo to an apical size of 35, taper .04 which is recommended by other studies and for the SAF preparation time was limited to 3 minute, one minute less than recommended for permanent teeth [Metzger et al., 2010]. The SAF file does not prepare to a defined apical size and apical cross-section and diameter, but has been shown to leave less unprepared areas and to result in only little root canal transportation [Hidalgo et al., 2017] as well as in good cleanliness of the root canal walls. Shaping the root canal to a defined three-dimensional geometry is not essential for preparation of primary molars since root canals have to be obturated with a resorbable root filling material not requiring a certain geometry, so the benefit of the SAF in better maintaining the original shape can be advantageous.

In primary teeth root canal disinfection is essential [Barcelos et al., 2012] and NaOCl has been shown to sufficiently clean the root canal from debris and smear layer [Tannure et al., 2011]. The American Academy of Pediatric Dentistry (AAPD, 2014) recommends 1% NaOCl for root canal irrigation in the primary dentition. A better clinical success was reported when adding citric acid as a final irrigant.

In this study both groups were irrigated with the same volumes of citric acid (10%) and NaOCl (1%) to improve the cleanliness of the root canal walls, and to avoid differences in cleanliness caused by different amounts of irrigant. Since irrigation was performed with citric acid following preparation, the good results for cleanliness of the root canal walls, to some degree, have to be contributed to the smear layer dissolving ability of this irrigant. It has to be cleared in further studies, whether activation of the irrigants can further increase cleanliness without deleterious extrusion of the irrigants beyond the apical opening of the resorbing roots. Also, in another study, the effect of the irrigant on root canal wall cleanliness should be examined

and a group with simply water irrigation should be added to compare the results with and without the use of sodium hypochlorite and citric acid as irrigants.

The matched pairs were formed to achieve comparable anatomic environments in both groups at least in terms of size of teeth, number of roots, degree of curvature and root length. Nevertheless, it is difficult to find exactly identical teeth due to varying degrees of root resorption.

Many of the studies which examined the cleanliness of the root canal walls in primary teeth used the microscope for magnification [Azar et al., 2012]. In this study a SEM examination with 1.000x magnification was performed for the scoring of the residual smear layer which allows a more accurate scoring of the remnants. Other studies on permanent teeth often used a four-grade-scoring system described by van der Sluis et al. [2007], Zmener et al. [2011] established a three-grade-scoring system, and Hülsmann et al., [1997] a five-grade-scoring system. To have a more precise semi-quantitative classification, a four-grade scoring system that classified the amount of smear layer by percentage, was used in this study. After thorough calibration of the blinded examiners an interindividual agreement of 70% and intraindividual reliability of 87% and 76%, respectively, were achieved. The differences in scoring in no case exceeded one score. One limitation of this study is that only a very limited part of the root canal wall was examined. Areas for SEM examination were chosen randomly in the coronal and apical part of the root to avoid observer bias in favour of clean surfaces showing open dentinal tubules. Roots in primary molars are very small and fragile resulting in some loss of specimens due to splitting of the root sections so that only one half of the root could be used after longitudinal separation. Therefore, only a small area in one half of the root was examined which does not represent the whole root canal surface. Nevertheless, it was obvious under SEM magnification that only very small areas of the root halves were covered with debris remnants which resulted in exclusion from scoring residual debris in this study.

Conclusion

Within the limitations of the study, both systems in combination with a defined irrigation protocol including 10% citric acid and 1% sodium hypochlorite, achieved good cleanliness of the root canal wall in primary molars showing mainly scores 1 and 2. Overall smear layer removal, regardless of instrumentation, showed better results in the coronal part of the root canals than apically. Regarding the SAF, smear layer removal was better in the coronal part than in the apical part. For clinical use both systems can be recommended in combination with adequate irrigation.

References

- Adigüzel O, Yiğit-Özer S, Kaya S, et al. Effectiveness of ethylenediaminetetraacetic acid (EDTA) and MTAD on debris and smear layer removal using a self-adjusting file. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:803–808.
- Ahamed SSS, Reddy VN, Krishnakumar R, et al. Prevalence of early loss of primary teeth in 5-10-year-old school children in Chidambaram town. Contemp Clin Dent 2012;3:27–30.
- Ahmed HMA. Anatomical challenges, electronic working length determination and current developments in root canal preparation of primary molar teeth. Int Endod J 2013;46:1011–1022. doi: 10.1111/iej.12134
- Azar M-R, Mokhtare M. Rotary Mtwo system versus manual K-file instruments: efficacy in preparing primary and permanent molar root canals. Indian J Dent Res 2011;22:363.
- 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 (Isfahan) 2012;9:146–151.
- Barcelos R, Tannure PN, Gleiser R, et al. 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;22:369–381.
- Bürklein S, Hinschitza K, Dammaschke T, Schäfer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J 2012;45:449–461.
- Coll JA, Seale NS, Vargas K, et al.Primary tooth vital pulp therapy: A systematic review and meta-analysis. Pediatr Dent 2017;39:16–123.
- Crespo S, Cortes O, Garcia C, Perez L. Comparison between rotary and manual instrumentation in primary teeth. J Clin Pediatr Dent 2008;32:295–298.
- Cvikl B, Moritz A, Bekes K. Pit and fissure sealants-A comprehensive review. Dent J (Basel) 2018;6:. doi: 10.3390/dj6020018
- de Oliveira KMH, Nemezio MA, Romualdo PC, et al. Dental flossing and proximal caries in the primary dentition: A systematic review. Oral Health Prev Dent 2017;15:427–434.
- de Paula JS, Sarracini KLM, Meneghim MC, et al. Longitudinal evaluation of the impact of dental caries treatment on oral health-related quality of life among schoolchildren. Eur J Oral Sci 2015;123:173–178.
- Hidalgo LR da C, Silva LAB da, Leoni GB, et al. Mechanical preparation showed superior shaping ability than manual technique in primary molars - A micro-computed tomography study. Braz Dent J 2017;28:453–460.
- Holan G, Needleman HL .Premature loss of primary anterior teeth due to trauma--potential short- and long-term sequelae. Dent Traumatol 2014;30:100–106.
- Hülsmann M, Rümmelin C, Schäfers F. Root canal cleanliness after preparation with different endodontic handpieces and hand instruments: a comparative SEM investigation. J Endod 1997;23:301–306.
- K Chugh V, K Sahu K, Chugh A. Prevalence and risk factors for dental caries among preschool children: A cross-sectional study in Eastern India. Int J Clin Pediatr Dent 2018;11:238–243.
- Kapur A, Chawla HS, Goyal A, Gaube K. An esthetic point of view in very young children. J Clin Pediatr Dent 2005;30:99–103.
- Keles A, Kamalak A, Keskin C, et al. The efficacy of laser, ultrasound and self-adjustable file in removing smear layer debris from oval root canals following retreatment: A scanning electron microscopy study. Aust Endod J 2016;42:104–111.
- Law CS Management of premature primary tooth loss in the child patient. J Calif Dent Assoc 2013;41:612–618.
- Llewelyn DR, Faculty of Dental Surgery, Royal College of Surgeons. UK National Clinical Guidelines in Paediatric Dentistry. The pulp treatment of the primary dentition. Int J Paediatr Dent 2000;10:248–252.
- Martinho FC, Chiesa WMM, Marinho ACS, et al. Clinical investigation of the efficacy of chemomechanical preparation with rotary nickel-titanium files for removal of endotoxin from primarily infected root canals. J Endod 2010;36:1766–1769.
- Metzger Z, Teperovich E, Cohen R, et al. The self-adjusting file (SAF). Part 3: removal of debris and smear layer-A scanning electron microscope study. J Endod 2010;36:697–702.
- Pramila R, Muthu MS, Deepa G, et al. Pulpectomies in primary mandibular molars: a comparison of outcomes using three root filling materials. Int Endod J 2016;49:413–421.
- Rocha MJ de C, Cardoso M. Endodontic treatment of traumatized primary teeth - part 2. Dent Traumatol 2004;20:314–326.
- Schäfer E, Erler M, Dammaschke T. Comparative study on the shaping ability and cleaning efficiency of rotary Mtwo instruments. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endod J 2006;39:203–212.
- Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271–275.
- Silva LAB, Leonardo MR, Nelson-Filho P, Tanomaru JMG. Comparison of rotary and manual instrumentation techniques on cleaning capacity and instrumentation time in deciduous molars. J Dent Child (Chic) 2004;71:45–47.
- Tannure PN, Azevedo CP, Barcelos R, et al. Long-term outcomes of primary tooth pulpectomy with and without smear layer removal: a randomized split-mouth clinical trial. Pediatr Dent 2011;33:316–320.
- van der Sluis LWM, Shemesh H, Wu MK, Wesselink PR. An evaluation of the influence of passive ultrasonic irrigation on the seal of root canal fillings. Int Endod J 2007; 40:356–361.
- Zmener O, Pameijer CH, Alvarez Serrano S, Hernandez SR. Cleaning efficacy using two engine-driven systems versus manual instrumentation in curved root canals: a scanning electron microscopic study. J Endod 2001;37:1279–1282.