The effect of four irrigation techniques on the amount of apically extruded debris in pulpectomy of primary teeth

Dört farklı irrigasyon tekniğinin süt dişi kök kanal tedavisi sırasında apikalden taşan debris miktarına etkisi

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SUMMARY

Aim: The aim of this in vitro study was to compare the amount of apically extruded debris of primary molar root canals during pulpectomy using four irrigation techniques.

Materials and Methods: Root canals of eighty primary second molar teeth were instrumented using ProTaper Next rotary system and randomly divided into 4 experimental groups (n=20): group I –EndoVac, group II- manual dynamic agitation (MDA), group III- Self Adjusting File (SAF), and group IV- conventional needle irrigation (CNI). Bidistilled water was used as irrigant and the apically extruded debris was collected and dried in preweighed Eppendof tubes. Data were analyzed statistically using the ANOVA and the Bonferroni post hoc t-test (p=0.05).

Results: EndoVac and SAF extruded significantly less debris than did MDA and CNI (p<0.05), while no statistically significant difference was found between EndoVac and SAF (p>0.05). Conclusions: Within the limitations, all irrigation systems extruded debris. EndoVac and SAF extruded less debris compared with MDA and CNI.

Keywords: Apical extrusion, primary teeth, pulpectomy, root canal irrigation

ÖZET

Amaç: Bu in-vitro çalışmanın amacı, dört farklı irrigasyon tekniği kullanılarak gerçekleştirilen süt dişi kök kanal tedavisi sırasında apikalden taşan debris miktarını karşılaştırmaktır.

Gereç ve Yöntem: Seksen insan süt ikinci molar dişlerinin kök kanalları, ProTaper Next rotary sistem kullanılarak prepare edildi ve rastgele 4 deney grubuna (n = 20) ayrıldı: grup I -EndoVac, grup II-manuel dinamik ajitasyon (MDA), grup III- Self- Adjusting File (SAF), ve grup IV- geleneksel şırınga irrigasyonu (GŞİ). İrrigasyon solüsyonu olarak bidistille su kullanıldı ve apikalden taşana debris önceden tartılmış Eppendof tüpleri içinde toplandı ve kurutuldu. İşlem öncesi ölçülen Ependorf tüplerinin ağırlığı, işlem sonrası değerinden çıkarılarak apikalden taşan debris miktarı hesaplandı. Veriler, ANOVA ve Bonferroni post hoc t-testi kullanılarak istatistiksel olarak analiz edildi (p=0.05).

Bulgular: EndoVac ve SAF, istatiksel olarak anlamlı biçimde MDA ve GŞİ'na göre daha az debris taşımına neden olurken (p<0.05), EndoVac ve SAF arasında istatiksel olarak anlamlı bir fark görülmedi (p> 0.05).

Sonuç: Çalışmanın sınırlamaları çerçevesinde, kullanılan tüm irrigayon sistenleri apikalden debris taşımına neden oldu. EndoVac ve SAF, MDA ve GŞİ'na göre daha az debris taşımına neden oldu.

Anahtar Kelimeler: Apikal ekstrüzyon, süt dişler, pulpektomi, kök kanal irrigasyon

INTRODUCTION

Irrigation is an integral part of chemical debridement of root canals.[1] Especially, in primary teeth, debridement of the root canals by chemical irrigation agents is as important as the mechanical instrumentation. Evenmore, chemical irrigation agents are mostly in the foreground during root canal treatment of primary teeth.[2,3] Although irrigation solutions and systems are generally considered to be safe, severe complications can occur during or as a consequence of root canal irrigation which become more crucial when the proximity of the permanent tooth germs are regarded.[4-6] Because of the large number of accessory canals located in the furcation area of deciduous teeth,[7] irrigation solutions can easily pass into the furcation area, which poses a high risk for permanent tooth germ exists in that area.[8] Klein and Kleier[9] reported in their case report of a 10-year old patient that a sodium hypochlorite accident is a rare event in adults, but even more so in children. Also, Siqueira[10] reported the prevalence of complications associated with NaOCl ranging from 1% to 16% in adult patients. According to Kleier [4] 42% of the responding endodontists in US had experienced at least one NaOCl accident. For these reasons, it is necessary to prevent the possible toxic effects of irrigation solutions in the treatment of dairy root canal.

As known, the apical foramen, which is enlarged due to the physiological/pathological resorption, lateral/ accessory canals and iatrogenic perforations in primary teeth, is the current pathway for the extruded materials. Therefore in primary teeth, one of the most important complication is apical extrusion of intracanal debris, irrigation solutions and microorganisms and their by-products.[7,11] These extruded materials can cause periradicular inflammation, post-operative pain and failure after treatment.[12] Also, extruded materials can have toxic effects on underlying tooth germ during endodontic treatment.[13] Thus, prevention of the cytotoxic effects of apically extruded debris and irrigants on the periapical tissues and tooth germs is a relevant factor for safety endodontic procedures in pediatric root canal therapy.[8]

Although conventional needle irrigation (CNI) is the most widely used irrigation technique in endodontic procedures, several irrigation techniques and devices are being used to improve the disinfection of root canal system.[14] New developments in irrigation delivery systems have led to new design concepts which efficiently clean and disinfect entire root canal system with minimal risk of apical extrusion of harmful content.[15]

EndoVac (Discus Dental, Culver City, CA) is an apical negative pressure irrigation system that safely delivers irrigation solutions into the apical areas and irregularities of the root canal, and also suctions out debris.[16] This system provides significantly less debris extrusion and irrigant, therefore have less risk of NaOCI accident.[17]

Manual dynamic agitation (MDA) with gutta-percha points has been described as a cost-effective technique for debridement of the entire root canal system.[18] In this technic, a well-fitted gutta-percha master cone is placed into a previously prepared root canal and irrigation solution was agitated by pumping gutta-percha. Gu .[19] reported that MDA may be an alternative irrigation activation system to conventional needle irrigation to eliminate vapor lock effect, which is a physical phenomenon of gas entrapment within a closed-end microchannel, in the apical part of root canal.

Self-Adjusting File (SAF) is a system with hollow file designed which is composed of a thin NiTi lattice, 1.5-mm-diameter in diameter with continuous irrigation provided by a peristaltic pumb.[20] Metzger[20] stated that SAF can also be used without activation of the file, as a non activated device for the irrigation of root canals. As an important clinical factor during pedodontic patients treatment, and also because of its use of single-file with continuous irrigation, SAF can clinically reduce treatment time in primary teeth.

Although several studies have examined the irrigation systems in permanent teeth regarding apical extrusion,[12,21-24] to our knowledge, to date there is no study which is conducted in primary teeth. The anatomical variations show more importance and difference in primary teeth than permanent teeth,[7] since as physiological or pathological resorption begins and extends into the primary roots, resulting in additional anatomical communications with the periapical tissues that cause easily extrusion of intracanal content and irrigants to periapical tissue.[25] Thus, the results of previous studies obtained in permanent teeth can not be directly routed to primary teeth.

The aim of this in vitro study was to compare the amount of apically extruded debris of primary molar root canals using different irrigation delivery and activation systems with EndoVac, non activated SAF, MDA and CNI. The null hypotesis tested in this study was that there is no difference between the amounts of apically extruded debris associated with these irrigation systems.

MATERIALS AND METHODS

Ethical approval and sample size calculation

Ethical approval was obtained from the Health Ethics Committee of the University of Cumhuriyet, Sivas, Turkey (ID: 2016-06/12). The sample for each group consisted of 20 teeth, and the power analysis revealed $P = 0.93145$ with using the values based on a previous study[23] and $\alpha = 0.01$, $\beta = 0.10$, $1-\beta = 0.90$.

Specimen Preparation

Human primary second mandibular molar teeth recently extracted were collected from patients aged [5-8], due to periapical pathology and orthodontic reasons, and stored in distilled water at 4°C. Multidimensional preoperative radiographs were taken to determine root curvature less than 30° using the Schneider method[26], and the presence of single, noncomplicated canal of distal roots. The determination of the amount of root resorption was performed using the formula described by Rajan.[27] The distal roots were examined under an operating microscope (Zeiss, Oberkochen, German) for any visible resorption. The distance between the cemento-enamel junction and the first point of visible root resorption was recorded using a digital caliper. Teeth with <33% of their root length affected by resorption were included in the study, since primary root canal treatment is indicated where pathologic root resorption involves less than one third of the root. Mesial roots of each tooth were removed with a diamond blazer under water cooling. Coronal access was prepared using diamond burs. Canal patency was controlled with insertion a size #20 K file into root canal under a 20× magnifying loupe. Canals with larger apical foramen than 0.02 mm dimensions were excluded from study. Finally, eighty primary molar teeth ml inclusion criteria. Specimens were randomly divided into four experimental groups; Group 1. EndoVac (n = 20), Group 2. MDA (n=20), Group 3. Non activated SAF(n=20), and Group 4. CNI (n=20). The homogenity of the groups in terms of root length was comfirmed by analysis of variance (ANOVA). A size #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was inserted into the root canal until visible apically under a 20× magnifying loupe to determine the working length (WL), which is 1 mm less than real length. One single operator performed all instrumentation to facilitate consistent instrumentation protocols using ProTaper Next rotary files (Dentsply Maillefer, Ballaigues, Switzerland). ProTaper Next files were used in the sequence X1, X2 and X3 (full WL) with an endodontic motor (NSK, Shimohinata, Japan) at a rotational speed of 300 rpm and 200 gcm torque. Each file was used with a gentle in-and-out brushing action. Instruments were used to prepare three canals only.

Irrigation Procedures

Group I EndoVac:

Microcycle technique was used according to manufacturers' recommendations. The master delivery tip delivered irrigant into the pulp champer and the irrigant was suctioned with macrocanula for 30 seconds, followed by leaving the canal full of irrigant for 30s. Three irrigation cycles were performed with the microcanula placed at working length for 6 second (s), 2 mm shorter working length for 6s, and working length for 6s. The cycles were performed as follows: 30s of irrigant, followed by 30s soaking.

Group II MDA:

After irrigant was delivered into canal, an apically best-fitted size 40.06 master gutta-percha cone with short vertical push-pull strokes was used in 1 ml shorter working length to activate the irrigant for 1 minute, followed by 1min of soaking. All push-pull strokes of the gutta-percha cone were performed at a frequence of 100 strokes per minute.

Group III Non-activated SAF:

SAF system is used with a 1.5 mm diameter and 25 mm length of file in the canal using a vibrating RDT3 head (ReDent-Nova) with an endomotor at a frequency of 5000 vibrations/min and an amplitude of 0.4 mm. In this study, we used non-activated SAF only for continuous irrigation with bidistilled water that was applied throughout the procedure at the rate of 2 mL/min using a special irrigation device (VATEA, ReDent-Nova). As the non-activated design, all experimental procedures were performed without the vibrating mechanism in WL.

Group IV CNI:

Irrigant was delivered into canal with a syringe and a 27 gauge conventional needle was inserted into the canal 2 mm shorter WL with positive pressure.

Total volumes of irrigants which were delivered into per canal were 8 mL for all groups.

Debris Collection

The experimental model described by Myers & Montgomery28 was used in this study. The stoppers of Eppendorf tubes were removed, following tubes without stoppers were weighed using an electronic balance (Percisa, Dietikon, Switzerland) with an accuracy of 10-4g to determine initial weight. Three consecutive measurements were taken for each tube, and the mean values were calculated. A hole was drilled in the each stopper of the tubes, and each tooth was forcely inserted up to the cementoenamel junction. A 27-gauge needle was placed alongside the cover as a drainage canula to equalize the internal and external air pressure. Then, each unit including stopper, tooth and needle was fixed to its ependorf tube. The tubes were fitted into vials to hold the device during preparation. The vials were covered with aluminium foil to prevent examiner from seeing extruded debris. After preparation, each tooth separated from vials and eppendorf tubes, and the surface of the root was washed with 1mL of bidistilled water to collect the debris adhering to the root surface. The tubes were then stored in an incubator at 70°C for 5 days to evaporate the moisture before weighing the dry debris. The mean value for each tube obtained from three consecutive weights was recorded. The dry weight of apically extruded debris was calculated by subtracting the preoperative weight from the postoperative weight.

RESULTS

Data were analyzed statistically using the ANOVA and the Bonferroni post hoc t-test at a significance level of $p<0.05$. All data were processed by SPSS 15.0 software (SPSS Inc., Chicago, IL).

The mean values and standard deviations of the amount of apically extruded debris (g) for all groups are shown in Table 1. The results showed that all irrigation techniques caused a significant amount of extruded debris. EndoVac and non activated SAF extruded significantly less debris than did the MDA and CNI ($p<0.05$), while no statistically significant difference was found between EndoVac and SAF ($p>0.05$).

Table 1. Mean and standard deviation (SD) of the amounts of apically extruded debris (g) for all groups.

Irrigation Techniques	*n*	Mean Weight (g)	SD
EndoVac[a]	20	0.000760	0.000208
MDA[b]	20	0.001170	0.000197
Non-activated SAF[a]	20	0.000795	0.000221
CNI[b]	20	0.001085	0.000163

Note. MDA; Manual Dynamic Agitation; SAF= Self Adjusting File; CNI: Conventional Needle Irrigation
The same superscript letters indicate statistically no significant values ($p>0.05$).

DISCUSSION

There is no available data concerning the use of new irrigation systems in pediatric endodontics. This is the first study which examines the effect of irrigating systems on apical extrusion of debris in primary teeth. Thus, we compared and discussed the results of this study with previous studies performed in permanent teeth.

There are several laboratory experimental set-ups to examine apically extruded debris.[12,28] In this study, we used the system described by Myers and Montgomery[28] to evaluate the amount of apically extruded debris. This system is the most known and used one in dental literature. However, in vivo conditions exhibiting the presence of periapical tissue were not simulated in our study since in vivo simulations using materials to close the apical foramen may lead to the absorption of the irrigant and debris which may lead to different results.[29] As described in previous studies,[12,21,29] to avoid the possible crystallization of NaOCl and an intense affiliation with debris, we used bidistilled water as irrigant instead of NaOCl.

This study showed that all irrigation systems tested were associated with apically extruded debris in primary molar root canals. In consistent with previous studies,[12,21,23] the results of this study showed that all irrigation techniques were associated with apically extruded debris. Similar to Karatas.[23] EndoVac and non-activated SAF which use negative pressure system were associated with less extrusion of debris than MDA and needle. Karatas[23] compared the effect of five different irrigation systems on apical extrusion of debris in permanent teeth and concluded that non activated SAF was associated with less amount of apically extruded debris compared with EndoVac, Vibringe, passive ultrasonic irrigation and conventional needle. This finding is similar to the results of our study, whilst we found that non-activated SAF and EndoVac had produced similar apical extrusion of debris without statistically significance.

The results of this study can be attributed to design and working mechanism of irrigation systems and the penetration depth of the irrigation needle. In the present study, the irrigation activation and delivery systems were used as follows: apical negative pressure system with EndoVac, positive pressure system with CNI, manual agitation activation system with MDA, continuous irrigation without positive pressure with SAF and positive pressure with CNI. Also, Boutsioukis[30] stated that another important issue associated with apical extrusion is the depth of irrigation needle. The placement and depth of needle affects apically extruded materials. In the present study, all irrigation systems expect than conventional needle was placed into canal at WL. However, conventional needle was placed into canal 2 mm shorter WL with positive pressure since recommendations for the use of needle irrigation include not binding the needle, not placing the needle to WL, and using a gentle expression of irrigant in order to avoid forcing irrigants through periapical areas.[19] Similar to previous studies[14,17,23] which concluded that EndoVac is a controlled effective system to deliver irrigation solutions into the apical third of the canal system, EndoVac extruded least debris among experimental groups in the current study. However, SAF caused similar amount of apically extruded debris to EndoVac and less than MDA with conventional needle. The SAF system delivered the irrigation solutions to root canal from coronal to apical direction without positive pressure. Also, the hollow file design which has holes in the lattice file of the SAF leads easily move of debris from apical to coronal through the root canal system. This may be why SAF extruded less debris than MDA and conventional needle in the current study. Also, there was no statistically significant difference among EndoVac and SAF as these systems do not use positive pressure during irrigation. In the MDA group, the possible rationale for the greatest amount of apically extruded debris could be that the activation of the irrigation solution in the apical third of the root canal may force it toward the apical foramen, resulting in increased apically extruded debris. Although the penetration of conventional needle was shorter than other groups, conventional needle caused more apical extrusion than EndoVac and SAF. This may be related to that the positive pressure in the conventional needle usage might have caused incerased apical extrusion, contrary to other irrigation systems which use negative pressure or coronoapical direction.

Although the principles of root canal irrigation are similar in both primary and permanent teeth, the curvatures and irregularities of the root canal walls of primary teeth influence the effectiveness of irrigation systems used[7]. Also, care should be taken with the narrow and thin root canals of the primary teeth. Since the root canals of the primary molar teeth are round and strip-like, it is expected that the irrigation systems used should be appropriate for the root canal anatomy.

There are various drawbacks in the clinical use of these irrigation systems in primary teeth. First, the long and relatively complicated period of clinical use of the EndoVac system can lead to cooperative problems in pediatric patients. In the MDA system, because of apical irregularity of the primary teeth roots, it may be difficult to find a well-fitted gutta-percha cone in consistent with apical foramen.

CONCLUSION

In conclusion, the null hypothesis was rejected, as significant differences were found among the irrigation systems. Within the limitations of the present in vitro study, all irrigation systems extruded debris. However, EndoVac and non-activated SAF extruded significantly less debris than did the other techniques, while no statistically significant difference was found between EndoVac and non-activated SAF techniques. Further in-vivo studies are needed to evaluate the effect of irrigation systems on the clinical success of root canal treatment in primary teeth.

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