

Assessment of the apically extruded debris between a rotary system, a reciprocating system and hand files during the root canal instrumentation of the deciduous molars

Ocena przepchnięcia wierzchołkowego zawartości kanałów po zastosowaniu systemu rotacyjnego, recyprokalnego i pilników ręcznych podczas opracowywania kanałów korzeniowych mlecznych zębów trzonowych

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Abstract

Background. One of the factors that most negatively affect the endodontic instrumentation process in primary teeth is the presence of extruded debris in the periapical region. Therefore, different techniques have been evaluated to reach an answer to the question regarding which root canal preparation method produces the least amount of debris extrusion.

Objectives. The main objective of this study was to assess the amount of debris extrusion as well as irrigation associated with 3 different instrumentation techniques: a rotary system (PROTAPER NEXT® – PTN), a reciprocating system (WaveOne® – WO) and hand K-files.

Material and methods. Forty-eight primary mandibular molars with a single distal canal were selected and randomly divided into 3 groups (n = 16). Three different techniques were used for the canal instrumentation of each group, comprising PTN, WO and hand K-files. Pre-weighed Eppendorf tubes were used for the collection of debris extrusion, then stored in an incubator at 70°C for 5 days. A one-way analysis of variance (ANOVA) test was used for data analysis, followed by Tukey's post hoc test.

Results. Statistically significant differences were found while comparing the PTN and WO systems with the hand files. Both PTN and WO showed less debris extrusion toward the periapical tissues than the hand files. Still, no statistically significant differences were seen between the PTN and WO groups.

Conclusions. Generally, debris extrusion occurred in all of the 3 experimental groups. The PTN and WO systems showed the least debris extrusion as compared to the hand files during the root canal instrumentation of the primary teeth, and for these reasons along with the shorter operating time, it may be concluded that using rotary and reciprocating systems rather than manual files is highly advisable. However, a clinical assessment is suggested.

Key words: extruded debris, hand files, rotary system, primary teeth, reciprocating system

Słowa kluczowe: przepchnięta zawartość kanałów, pilniki ręczne, system rotacyjny, zęby mleczne, system recyprokalny

Introduction

Keeping the primary dentition healthy is crucial for maintaining normal development of the jawbones, natural muscle function, good speech, and even natural eruption of the secondary dentition. However, it has been reported that premature eruption of the primary teeth may lead to many problems, some of which are bad oral habits and changes in the arch dimensions, as well as disturbances in the eruption sequence of the permanent dentition.¹

Despite the fact that the endodontic treatment of the primary teeth with the optimal preparation has been recommended as a successful therapy for irreversible pulpitis or even pulp necrosis,² a few reports have mentioned that using traditional endodontic files for this purpose is time-consuming and causes fatigue for both dentists and patients.³

Since the introduction of rotary-file systems for the endodontic treatment of the primary teeth by Barr and his colleagues in 2000,⁴ many studies have reported the efficacy of these instruments in maintaining the original root canal anatomy of the primary teeth and reducing the frequent errors that usually occur during the traditional treatment process with the use of normal hand files.^{4,5} The use of nickel-titanium (NiTi) rotary instruments makes the endodontic treatment faster and easier with less file breakage incidents. Furthermore, NiTi instruments provide better shaping for the cleaning procedure, irrigation and obturation during the root canal therapy.⁵

Debris extrusion resulting from the endodontic preparation and irrigation during the root canal treatment, including dentinal fragments, microorganisms and irrigation solutions, can all cause pain and inflammation, and delay the healing of the periapical tissues. Most traditional techniques, which depend on normal hand files, lead to these undesired effects. Therefore, eliminating debris extrusion in the apical region has been recommended for the successful root canal therapy of the primary teeth.⁶

The primary teeth are subject to physiologic resorption due to the eruption of the succedaneous teeth. This causes more apical foramen enlargement of the primary teeth, which, in turn, allows more extrusion of the debris periapically.⁷ However, the amount of the extruded debris is affected by the techniques and systems used during the endodontic treatment.⁸⁻¹⁰

Recently, PROTAPER NEXT® (PTN) rotary files (Dentsply Maillefer, Ballaigues, Switzerland) have utilized different designs that contribute to both increased flexibility and increased cyclic fatigue resistance. These designs incorporate an M-wire alloy, which, in turn, enables an off-centered rectangular cross-section and the application of variable tapers of rotary files.¹¹

Reciprocating rotation was suggested as an alternative to continuous rotation for the preparation of curved canals by applying a single instrument.¹² This technique forms the root canal safely,¹³ enabling better irrigation as well as removing less dentin from the internal walls of the canals, especially in the danger zones, which decreases the possibility of damage or fracture in the dentinal walls or in the file itself.¹⁴ The WaveOne® (WO) system (Dentsply Maillefer) applies a reciprocating movement using just 1 instrument with 3 size options (small – 21/06; primary – 25/08; and large – 40/08).¹⁵

The aim of this study was to evaluate the differences in the amount of the extruded debris between the WO file, PTN files and hand K-files, used in the treatment of the primary teeth.

Material and methods

The protocol of this *in vitro* study was approved by the research ethics committee of Damascus University, Syria (No. of the ethical approval: 1788/2017). This study was carried out on 48 distal canals of primary mandibular molars extracted due to periapical pathology and preventive orthodontic treatment. The teeth were cleaned of the external debris and soft tissue remnants, then stored in a saline solution at room temperature to be used later.

The study, according to the required criteria, involved primary mandibular molars with 2/3 of the root present and the moderate curvature of the distal root ranging between 10° and 20°, according to the Schneider protocol,¹⁶ without pathological resorption, fracture, cracks, or caries in the root. The teeth were examined by means of digital periapical radiography to confirm the presence of a single canal.

Each primary tooth was sectioned at the furcation area using a low-speed diamond saw (IsoMet™ 1000; Buehler, Lake Bluff, USA) with water cooling to separate the mesial root with its respective section of the crown from the distal one. Then, the mesial portion was discarded and the distal portion was kept for further investigations. The access cavities were prepared using an Endo-Z® bur (Dentsply Maillefer) at a high speed under cooling. All root canals were prepared by the same researcher and randomly divided into 3 groups.

A size 10 K-file (Dentsply Maillefer) was inserted in the distal root canal to verify its patency. This was followed by determining the working length; firstly, the size 10 K-file was inserted into the distal canal until it became visible at the apical foramen, then the working length was calculated by subtracting 1 mm from the previous measurement. Moreover, a radiograph was taken using the parallel technique to ensure correct measurement of the working length. It was considered that the canals with dimensions greater than those of the International Organization for Standardization (ISO) size 15 were to be excluded.¹⁷

In this study, the experimental model mentioned by Myers and Montgomery was used for the evaluation of the extruded debris collection (Fig.1).¹⁸ A hole was created in each stopper of the Eppendorf tube and each tooth was inserted under pressure through the stopper to the level of the cemento-enamel junction. In order to ensure balance of the air pressure between the inside and outside of the tube, a 27-gauge needle was inserted into each Eppendorf tube. Then, each stopper with its tooth and needle were attached to the Eppendorf tube, which, in turn, was fitted into a vial. All the equipment was handled using the vial without touching it with fingers. Furthermore, a microbalance was used to weigh the Eppendorf tube with 10^{-5} precision. Three weights were taken sequentially, and the mean value was registered for each tube. The irrigation protocol was standardized using 5 mL of distilled water with a 29-gauge needle (NaviTip®; Ultradent Products, Inc., South Jordan, USA) after using each file or after 3 pecks of the reciprocating file (as recommended by the manufacturer). The 48 specimens were randomly assigned to 3 groups after marking each tooth for encoding. Each group was made up of 16 samples as follows:

- hand file control group (group 1): hand preparation was completed using a stainless steel K-file taper 0.02 in the step-back technique, starting with size 15 and continuing in the following sequence: 20, 25 and 30;
- PTN (group 2): the PTN files were applied using an endodontic motor (X-Smart Plus; Dentsply Maillefer) in the following order: X1 (size 17, taper 0.04) and X2 (size 25, taper 0.06); the rotational speed was set at 300 rpm and 2 Ncm torque (according to the manufacturer's instructions); brushing movements were performed gently using an in-and-out motion;
- WO group (group 3): a small file (21/06) was used with a reciprocal motion (according to the manufacturer's instructions).

The evaluation of the debris was performed by a single, blinded operator. Finally, the Eppendorf tubes were separated from the vials after the successful completion of the canal preparation. Then, the debris stuck to the root surface was collected by rinsing the root with 1 mL distilled water in the Eppendorf tube. Evaporation of the distilled water was performed using an incubator at 70°C



Fig. 1. Experimental system used to evaluate the debris extrusion

for 5 days before weighing the dry debris.¹⁹ The net weight of the dry debris was calculated by subtracting the weight of the empty Eppendorf tube from the total weight.

Statistical analysis

The Kolmogorov-Smirnov test showed that the data was normally distributed. Then, Levene's test for homogeneity was used to confirm the homogeneity between the variances. The differences between the groups were analyzed with one-way analysis of variance (ANOVA), followed by Tukey's post hoc test for multiple comparisons, and the level of significance was set at 0.05. The IBM SPSS software v. 20.0 (IBM SPSS, Inc., Chicago, USA) was used for data analysis.

Results

The mean values, standard deviations (SD) and ANOVA results regarding the 3 groups are listed in Table 1. The p -value was ≤ 0.05 for the ANOVA test, which showed significant differences between the experimental groups. Tukey's post hoc test showed that there were no statistically significant differences in the extruded debris between the PTN and WO groups ($p > 0.05$), as shown in Table 2. The highest amount of the apically extruded debris was seen in the hand file group. In other words, there were statistically significant differences between the PTN and manual file group, in addition to the presence of statistically significant differences between the WO and manual file groups, but at the same time there were no statistically significant differences between the PTN and WO groups while comparing their results.

Table 1. Weight of the extruded debris in the experimental groups (one-way analysis of variance – ANOVA)

Group	n	Mean	SD	F	p -value
WO	16	0.00242	0.00033	72.716	0.000*
PTN	16	0.00262	0.00030		
Hand file	16	0.00379	0.00039		

WO – WaveOne; PTN – PROTAPER NEXT; SD – standard deviation; * significant difference at $p \leq 0.05$.

Table 2. Pairwise comparisons with Tukey's test

Pair	Mean differences of debris weight	p -value
WO – PTN	–0.00019	0.240
WO – Hand files	–0.00137	0.000*
PTN – Hand files	–0.00117	0.028*

*significant difference at $p \leq 0.05$.

Discussion

Root canal treatment may lead to dramatic effects in the periapical tissues. Many inflammatory changes and pain that occur during the mechanical and chemical preparation of the root canals are a result of debris extrusion into the periapical region. The debris contains dentinal particles, irrigation solutions, necrotic pulp, and microorganisms. On the other hand, the undesirable effects of the extruded debris pose a threat to the permanent dentition, as they may alter the morphology of the permanent tooth germ.⁶ Therefore, the major purpose of this study was the assessment of the apically extruded debris and irrigants as a result of the root canal preparation with different instrumentation system techniques.

In the present study, 5 mL of distilled water was used for the root canal irrigation to prevent the crystallization of sodium hypochlorite, which may cause misleading findings of the debris.¹⁷ The generally accepted method of Myers and Montgomery was used for the collection of the extruded debris.¹⁸ There have been different results obtained in studies in vivo and in vitro due to the fact that the normal periapical tissues act as a physical barrier that helps to control the extrusion of the necrotic debris.²⁰ Therefore, there is a limitation when applying the results of this study clinically due to the lack of a back pressure, naturally caused by the periapical tissues. Floral foam has been mentioned in the literature as a substance used for the periapical tissue stimulation.²¹ However, this material may absorb the irrigating solution as well as the resulting debris, and hence influence the results.

The distal root of the primary mandibular molar was chosen for this study, because it has a large single canal, a regular canal outline and less intracanal divergence as compared to the mesial root of the primary mandibular molar. The current study revealed that all of the preparation techniques caused the apical extrusion of debris and irrigants. It is in agreement with the findings of other studies, which have mentioned the lack of any existing technique that could totally prevent debris extrusion.^{22,23} Different authors have stated that the PTN system extruded significantly less debris than the hand file technique.^{23,24} Madalena et al. reported that the amount of the apically extruded debris was smaller in the case of the root canal preparation with a single reciprocating file (WO) as compared to the hand files.²⁵ This study confirmed that observation.

To the best of our knowledge, no study has ever evaluated the apical extrusion of the debris during the root canal instrumentation of the primary teeth by comparing the PTN and WO systems. Thus, the results of our study can only be compared with the results of other studies that have used both instrumentation techniques in the treatment of the permanent teeth. In this study, no statistically significant differences between the reciprocating single-file WO system and the rotary multiple-file PTN system were observed, which corresponds to the observations of Ozsu et al.²⁶

There are several factors responsible for differences between the root canal preparation systems, such as technique, direction and kinematics of the instrumentation. Different files have different cross-sectional designs. For example, the PTN file has a rectangular cross-section with a unique design (an offset center of mass and rotation). This design provides greater cross-sectional space for reinforced cutting, loading and the movement of the debris toward the orifice area of the canal, and results in less extruded debris in the PTN group when compared with the hand file group.²⁷ Another reason for decreasing the amount of debris in the PTN group could be the instrumentation technique. Since the PTN file is a rotary system file, the method used for the canal preparation is the crown-down technique, depending on the early flaring of the coronal area of the canal, which may increase directing the debris toward the orifice area during the rotational movement.²⁸ On the other hand, the middle and coronal portions of the WO files have a convex triangular cross-section, whereas the tip portion has a modified convex triangular cross-section.¹³ There is consensus that balanced forces lead to good control of the apically extruded debris. Due to the reciprocating motion of the WO file, leading to automatically balanced forces with less pressure, the amount of the apical debris during the canal preparation is well-controlled.²⁹


Finally, regarding the hand file group, the step-back technique was used for the root canal shaping of the primary teeth during biomechanical preparation. The hand file was acting as a piston in the apical area of the canal, which increased the amount of the apically extruded debris in the periapical region.³⁰


Conclusions

The results of the present study showed that all instrumentation techniques used for the root canal preparation of the primary teeth caused debris extrusion. However, the hand files extruded more debris than both PTN and WO, whereas the PTN and WO systems both extruded less debris and showed better results.

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