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ORIGINAL RESEARCH

Extrusion of Debris from Primary Molar Root Canals following Instrumentation with Traditional and New File Systems

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ABSTRACT

Introduction: To assess the amount of debris extruded apically during instrumentation of distal canals of extracted primary molars by three instrument systems [ProTaper Universal (PTU), ProTaper NEXT (PTN), and self-adjusting file (SAF)] compared with conventional stainless steel hand K-files (HF, control).

Materials and methods: Primary mandibular molars (n = 120) with a single distal canal were selected and randomly divided into four groups (n = 30) for root canal instrumentation using group I, HF (to size 0.30/0.02 taper), group II, PTU (to size F3), group III, PTN (to size X3), and group IV, SAF. Debris extruded during instrumentation was collected in preweighed Eppendorf tubes, stored in an incubator at 70°C for 5 days and then weighed. Statistical analysis was performed by one-way analysis of variance (ANOVA), followed by Turkey's *post hoc* test ($p = 0.05$).

Results: All the groups resulted in extrusion of debris. There was statistically significant difference ($p < 0.001$) in the debris extrusion between the three groups: HF (0.00133 ± 0.00012), PTU (0.00109 ± 0.00005), PTN (0.00052 ± 0.00008), and SAF (0.00026 ± 0.00004).

Conclusion: Instrumentation with SAF resulted in the least debris extrusion when used for shaping root canals of primary molar teeth.

Clinical significance: Debris extrusion in primary teeth poses an adverse effect on the stem cells and may also alter the permanent dental germ. Debris extrusion is rarely reported for primary teeth and it is important for the clinician to know which endodontic instrumentation leads to less extrusion of debris.

Keywords: Apical extrusion, Debris, Hand files, K-files, ProTaper NEXT, ProTaper Universal, Self-adjusting file.

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INTRODUCTION

Retention of primary teeth is important for the development of the jawbone and musculature, eruption of succeeding permanent teeth into ideal position, and functional reasons, such as speech.[1] In general, it has been suggested that conservative treatment, with minimal intervention is recommended in primary teeth to allow the pulp to salvage once the irritation has been removed. Nevertheless, endodontic intervention may be indicated for teeth with evidence of chronic inflammation or necrosis of the radicular pulp with or without periradicular involvement.[2,3] Although conventionally root canals of primary teeth were instrumented using hand files, the use of motorized nickel–titanium files results in instrumenting and shaping root canals in a significantly faster way providing ample time to focus on disinfection.[4,5] These files resulted in consistently uniform shaping aiding in ideal obturation and were clinically successful and safe for instrumenting root canals in primary molars.[1,5-8]

Root canal instrumentation includes mechanical debridement with endodontic files and chemical disinfection with irrigants; however, debris formed during

instrumentation containing dentinal chips, pulpal fragments, necrotic debris, irrigation solution, and microorganisms might extrude from the root canal into periapical tissues. This often results in inflammation, postoperative pain, and delayed healing.[9-12]

Most of the currently used endodontic rotary instruments are intended to be used in the crown-down approach. The use of different motions (rotary/reciprocating), the number of file sequence, and the taper of the files used can influence the amount of debris extrusion.[11-13] Recently developed multiple file rotary instrumentation system, PTN (Dentsply Tulsa Dental, Tulsa, OK) has a unique design with the center of mass and the center of rotation offset creating a wave when in motion that travels along the length of the file. This minimizes the engagement between the file and dentin and also augers debris coronally.[11,14] Another strategy for root canal preparation is based on a single-hollow compressible file design (SAF; ReDent-Nova, Ra'anana, Israel). This instrument is used with vibrating movement accompanied by continuous irrigation with any desired irrigant, usually sodium hypochlorite. This file undergoes compression in the nonprepared root canal and adapts to the root canal shape, thereby, claiming to offer superiority in preparation of root canal systems.[11,14,15]

Many studies have been carried out and reported on the amount of apically extruded debris during root canal preparation using these newer instruments in permanent teeth.[1-5,11-13,16-18] The SAF reportedly is associated with less debris extrusion in studies reported on permanent teeth.[11,12] To the best of our knowledge , debris extrusion after instrumenting primary teeth using the aforementioned methods is yet to be reported. Hence, the aim of this study was to evaluate and compare the amount of debris extrusion by HF, PTU, PTN, and SAF, when used for instrumenting primary teeth. The null hypothesis was that there was no difference between the instrumentation systems in the amount of extruded debris.

MATERIALS AND METHODS

Sample Preparation

This study was performed on 120 distal canals of freshly extracted primary mandibular molar teeth based on a protocol approved by the institutional review board and ethics committee of the university. The teeth were extracted for reasons unrelated to this study (preventive orthodontic treatment). The teeth were cleaned of debris and soft tissues present externally and stored in distilled water at room temperature until their use for the study.

The samples were acquired according to the following inclusion criteria; primary mandibular molars with at least two-thirds of the root, without root resorption (internal/external), root caries, fractures, and a curvature <5° that was determined according to Schneider's method.[19] The teeth were radiographed buccolingually and mesiodistally to rule out any variations in the canal morphology and confirm a single canal in the distal root. The mesial roots, with their respective crowns, were sectioned at the furcation level using a low-speed diamond saw (Isomet 1000; Buehler Ltd., Lake Bluff, Illinois, USA) with water and discarded. Endodontic access cavities were prepared using Endo Access Kit (Dentsply Tulsa). The canal patency was then checked by inserting a #10 K-file (Mani Inc., Tokyo Japan). This file was inserted until it was just visible at the apical foramen and the working length (WL) was determined to be 1 mm short of this measurement.

The 120 samples were randomly divided into four groups (n = 30) to be instrumented by four different instrumentation protocols: Group I: HF: Samples were instrumented using a balanced force technique with stainless steel K-files used at WL in the following sequence: size 0.15 to 0.30, with a taper of 0.02.

Group II: PTU: Root canals were instrumented with the PTU rotary files in the sequence Sx (size 17/0.04 taper), S1 (size 17/0.06 taper), S2 (size 20/0.06 taper), F1 (size 20/0.07 taper), F2 (size 25/0.08 taper), and F3 (size 30/0.09 taper) with an endodontic motor (X-Smart plus; Dentsply Maillefer, Ballaigues, Switzerland) at a rotational speed of 300 rpm and 2 Ncm torque, according to the manufacturer's instructions until the determined WL. A gentle in-and-out outward brushing motion away from the cut furcation section was used.

Group III: PTN: Root canals were instrumented with PTN rotary files with the sequence; X1 (size 17, 0.04 taper), X2 (size 25, 0.06 taper), and X3 (size 30, 0.07 taper) using an endodontic motor (X-smart plus; Dentsply Maillefer, Ballaigues, Switzerland) at a rotational speed of 300 rpm and 2 Ncm torque, according to the manufacturer's instructions as in Group II.

Group IV: SAF: A 2 mm SAF file was used in a preprogramed endomotor (SAF^{pro}; Redent Nova, Ra'anana, Israel) operated with in-and-out pecking motion till the WL at 5000 vibrations/min for 4 min.

In all groups, the volume and time of irrigation were standardized to 16 mL of bidistilled water during instrumentation (flow rate of 4 mL/min) and a final rinse of 3 mL bidistilled water for 3 minutes. Irrigation was done using a syringe and needle (NaviTip 31ga; Ultradent, South Jordan, Utah, USA) for groups I to III, placed 2 mm short of the WL. Furthermore, for all the groups, Ethylenediaminetetraacetic acid gel was used as a lubricant throughout the instrumentation procedure. The debris extruded apically after instrumentation was

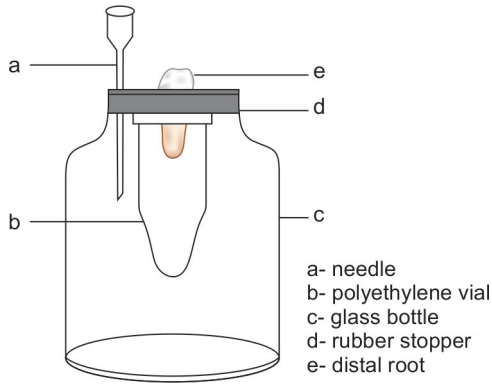


Fig. 1: Schematic representation of the apparatus designed by Myers and Montgomery, which was used for this study

collected using an apparatus designed by Myers and Montgomery[20] (Fig. 1), and the weights obtained for the four groups were subjected to quantitative comparison.

Debris Collection

An analytical balance (Sartorius Cubis, Göttingen, Germany) with an accuracy of 10^{-6} g was used to measure the initial weights of the tubes. Three consecutive weights were obtained for each tube, and the mean was calculated. Each tooth was inserted up to the cementoenamel junction, and a 27-G needle was placed alongside the stopper as a drainage cannula and to balance the air pressure inside and outside the tubes. Then, each stopper, with the tooth and the needle, was attached to its Eppendorf tube, and the tubes were fitted into vials. One calibrated operator, who was experienced in using all the systems, performed all the instrumentation techniques. A silver foil covered the Eppendorf tube preventing the operator from seeing the apex during instrumentation.

Evaluation of Debris

A single calibrated examiner who was blinded did the evaluation of debris to the experimental groups. On completion of canal preparation, the Eppendorf tubes were removed from the vials. Washing the root with distilled water (1 mL) in the tube, collected the debris adherent to the external surface of the root apex. The tubes were then stored in an incubator at 70°C for 5 days allowing evaporation of the distilled water resulting in remainder of dry debris for weighing. The weight of the dry debris was determined by subtracting the original weight of the empty Eppendorf tube from the gross weight.

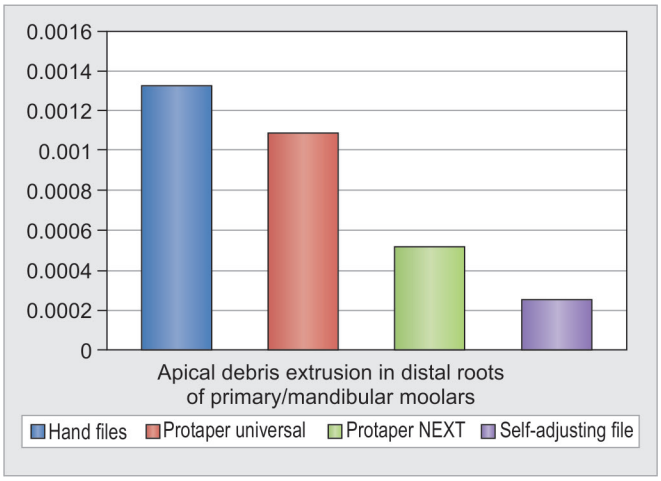
Statistical Analysis

The data obtained were weight of debris in mg (outcome variable). The data were analyzed by application of one-way ANOVA and Tukey's *post hoc* test to determine the significant group (Statistical Package for the Social Sciences version 20, SPSS Inc., Chicago, Illinois). A p = 0.05 was considered to indicate a significant difference in all tests.

Table 1: Weight of apically extruded debris after instrumentation of root canals with the experimental groups (n = 30)

Instrumentation	*Mean ± SD*
Hand file	0.00133 ± 0.00012[d]
PTU	0.00109 ± 0.00005[c]
PTN	0.00052 ± 0.00008[b]
SAF	0.00026 ± 0.00004[a]

Values with different superscript letter exhibited significant difference between each other ($p < 0.05$); SD: Standard deviation



Graph 1: Meanwise comparison of debris extrusion by different file systems when used for instrumenting distal roots of primary molars

RESULTS

The mean values of extruded debris with standard deviations are presented in Table 1 and Graph 1. The values for all the four groups presented a significant difference between them ($p < 0.001$). The following multiple *post hoc* tests revealed that the samples instrumented with SAF were associated with significantly less debris extrusion apically followed by PTN, and then PTU ($p < 0.05$). The samples instrumented with HF were associated with the highest amount of debris extrusion among all the groups tested ($p < 0.001$).

DISCUSSION

Apical extrusion of debris is sparsely investigated on primary teeth.[8,21] The main reason for this could be attributed to the start of physiologic resorption soon after the completion of the formation of a primary tooth. These teeth are associated with wide apical diameter than permanent teeth, hence increasing the chances of more debris extrusion periapically during root canal instrumentation.[8] The distal root of primary mandibular molars was selected for this study as they possess a large single

root canal with a uniform canal outline and relatively less intracanal ramifications compared with mesial roots.[21]

The results of this study exhibit that all systems caused apical debris extrusion during the root canal instrumentation. These results reinforce the established fact that in endodontic treatment, any instrument used for shaping results in apical extrusion. The HF were associated with higher amount of debris extrusion apically in this study, and this is in agreement with the existing literature.[8,11,12,21-24] Our results showed that rotary files used in crown-down fashion extruded more debris than the SAF system. This may be detrimental to the underlying stem cells and lead to alterations in the dental germ, such as hypoplasia, morphological alteration on the dental crown, or total arrest of radicular formation.[21,25,26]

The association of high debris extrusion with HF is attributed to the reason that the filing motion leads the file to act as a piston in the apical one-third of the tooth being instrumented. Furthermore, as these files have smaller taper (0.02 taper) and less space is available to flush out debris coronally, causing it to be pumped out through the apical foramen.[22,23] The rotary PTU files possess convex triangular cross-section, a noncutting safety tip, and a flute design with multiple tapers. The files with similar cross-section are reported to cut dentin effectively.[27] Tanalp et al reported high amount of debris extrusion apically associated with PTU system. Using the same instrument sequence and final size of apical tip diameter (#30), similar result for the PTU group was found in this study, where this instrumentation resulted more debris extrusion compared with PTN and SAF.[28] In another recent study, the PTU F2 file produced the highest mean debris extrusion when compared with other instrument systems.[29] It should be noted that with a smaller tip diameter, these files tend to extrude considerable debris apically.

The debris extrusion produced by PTN was significantly less than PTU and HF in this study. This result of this study for PTN group is in accordance with the study reported by Topçuoglu et al.[21] This instrument has been shown to extrude less debris in permanent teeth root canals as well.[11,12,16,24,30] These results can be explained by the offset center of mass and rotation design of these files, providing more cross-sectional space for enhanced cutting, loading, and successfully allowing the debris to travel out of a canal (toward the coronal direction), compared with a file with a centered mass and axis of rotation. This also decreases packing the debris laterally, aiding in minimizing the chances of canal blockage.[11,12,14]

The SAF instrumentation was associated with the least debris extrusion. This result is consistent with various studies reported in literature for permanent teeth, wherein this file was associated with less debris extrusion.[11,12,30] This file does not possess a central metal core and cutting edge or flutes, instead has an abrasive surface, and is to be operated with in-and-out vibratory motion. The hollow nature of the file allows continuous irrigation throughout the scraping of the dentin. This could facilitate the augering of debris out of the canal and decreasing the amount of apically extruding debris.[30] The continuous irrigation does not build up any pressure in the canal as the meshwork allows the free escape of irrigant. In the narrowest apical part of a canal, this file leaves more than 38% of the canal cross-section free for back-flow of fluid and dentinal debris.[15] It is also reported that the SAF system was associated with cleaner radicular walls (free of debris) apically.[31] There is no study reported in literature using SAF in primary teeth; hence, this file was included in this study as it is being advantageous in permanent teeth.

The apparatus used in this study was based on the one developed by Myers and Montgomery.[20] Distilled water was used as an irrigation solution to avoid any possible crystallization of sodium hypochlorite, which may cause misleading results of debris. The inherent demerit of these *in vitro* studies is the absence of a physical back-pressure provided by periapical tissues.[11,12] Some investigators suggest simulating the periodontal ligament by the use of floral foam,[32] but they lead to absorption of the irrigant as well as the debris.[33] Hence, this study did not use such an approach. Future studies should evaluate the extrusion of debris with these instruments using different irrigation regimens.

CONCLUSION

The SAF with combined continuous irrigation resulted in less debris extrusion when used for instrumenting distal root canals of primary molar teeth. Furthermore, the rotary file with asymmetric cross-section PTN resulted in lower debris extrusion compared with PTU and HF.

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