Eğimli Kanallarda Apikal Debris Ekstrüzyonu: Dört Farklı Döner Eğe Sisteminin ve Yer Çekiminin Etkileri

Apical Debris Extrusion in Curved Root Canals: The Effect of Four Rotary Instruments and Influence of Gravitational Force

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ÖZ

Giriş ve Amaç: Farklı döner eğe sistemleri ile genişletilen kanallardaki apikal debris ekstrüzyonunu incelemek ve yer çekiminin etkisini belirlemek

Yöntem ve Gereçler: Doksan altı adet eğimli kök kanalı; Twisted File Adaptive, WaveOne, ProTaper Next ve MTwo sistemleri ile genişletildi. Her grup alt ve üst çene grupları olmak üzere iki alt gruba ayrıldı ve alt ve üst çeneyi taklit eden deneysel bir düzenek kullanıldı. Taşan debris miktarı 10^{-5} hassasiyetinde hassas tartı ile ölçüldü.

Bulgular: Diş pozisyonlarının, eğe sistemleri üzerine apikalden taşan debris miktarı açısından anlamlı bir etkisi görülmedi (p> 0, 05). Ancak eğelerden bağımsız olarak değerlendirildiğinde alt çene pozisyonunda daha fazla debris taştığı gözlemlendi (p< 0, 05).

Tartışma ve Sonuç: Tüm eğe sistemlerinde apikalden belli miktarda debris taştığı görüldü. Eğe sistemleri ve yer çekiminin apikalden taşan debris üzerine etkisi gözlenmedi.

Anahtar Kelimeler: *Debris ekstrüzyonu, NiTi sistem, Eğimli kanal, Yer çekimi, Resiprokasyon*

ABSTRACT

Introduction: To examine the amount of apically extruded debris produced by different rotary systems in curved root canals and to find out the effect of gravitational forces on extrusion.

Methods: Ninety-six severely curved root canals were instrumented with; Twisted File Adaptive (SybronEndo, Orange, CA, USA), WaveOne (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next (Dentsply Maillefer) and Mtwo (VDW, Munich, Germany) systems. Each group was divided into two subgroups of maxillary and mandibular considering their location and a trial model was used as a phantom head to simulate the upper and lower jaws. The amount of extruded debris was weighed using a 10^{-5} microbalance.

Results: The location of the tooth and the instrument used had no significant effect on the amount of extrusion (p> 0, 05). When the gravitational force was considered regardless of the instruments, significantly more debris was extruded in teeth with mandibular location (p< 0, 05).

Discussion and Conclusion: All rotary instruments caused apical extrusion of debris. Instrument technique and gravity has no impact on the amount of extruded debris.

Keywords: *Debris extrusion, NiTi system, Canal curvature, Gravity, Reciprocation*

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INTRODUCTION

Biomechanical root canal instrumentation is one of the most important steps in root canal treatment[1] since dentin chips, necrotic pulp tissue, bacteria, and irrigants may be extruded into the periapical tissue. These may cause undesired consequences, such as postoperative inflammation with pain, and impede or unsuccessful periapical healing.[2,3] Accumulating evidences showed that all root canal instrumentation techniques result in debris extrusion; however, debris extrusion in severely curved root canals have not yet been thoroughly investigated[4] In previous studies, the amount of extruded debris was evaluated in either straight root canals[5-7] or in roots with curvature angles ranging between 15° and 45°[8-11]. In nearly all studies on debris extrusion, all apices of the teeth were located downward in the experimental model representing a mandibular tooth, although many authors mentioned the effect of gravity on the amount of extruded debris[8,9,12]. There is only one study which investigated the effects of gravity on the amount of extruded debris in retreatment[13].

Twisted File Adaptive (TFA), MTwo, WaveOne (WO), ProTaper Next (PTN) rotary NiTi systems have not yet been evaluated in terms of the apical extrusion of debris while taking the aforementioned parameters into consideration.

The aim of this *ex vivo* study, therefore, was to evaluate the amount of apically extruded debris produced by different rotary systems, and also, to determine the influence of gravity on extrusion.

MATERIALS AND METHODS

Selection of teeth

The study was approved by the Human Ethical Committee of Ege University (2015/15-1.1/11). Two hundred extracted human molars from both jaws were collected according to the visual and digital radiographic examination. These molars did not have previous endodontic treatment, open apices, root caries, fractures or cracks, signs of internal or external resorption. These extracted molars were disinfected in 0 5% of chloramine T and stored in an aqueous thymol solution (0.1%) at 4°C. Of these selected samples, mesio- or disto-buccal roots of maxillary and mesial root canals of mandibular molars were separated. Digital radiographs were taken in the buccal and proximal directions, and canal curvatures and radii were measured by a single operator analysing with the image analysis program (AutoCAD 2007, USA) according to Pruett's et al. method[14]. Only 96 root canals with angles and radius of curvature ranging between 36° and 49° and 10-12 mm and with an initial apical size equivalent to a size 10 K-file were selected for the study. The specimens were randomly divided into four groups of 24 teeth, and in each group, two subgroups were created according to the maxillary and mandibular location (n= 12).

Access cavities were prepared with straight line access and coronal flaring to minimize working length (WL) changes. The WL of each root canal was visually determined under 10x microscopic magnification with the use of size ISO 10 K-files to one mm short of the major apical foramen. After access cavity preparation, the appropriate reference cusps were flattened by using a grinding/polishing wheel to provide the standardization of WL at 18 mm.

The method used for the collection of extruded debris was similar to that described by Myers and Montgomery's (1991) study[15]. A 15 mm x 45 mm glass vial (Smart Kimya, İzmir, Turkey) was used as a container for the collection of the extruded debris. Before the experimental procedure, vials were weighed using a microbalance with 10^{-5} precision (Denver Instrument GmbH, Göttingen, Germany). Three weights were acquired for each vial, and the average was calculated. All of the teeth were inserted into rubber stoppers, which were then affixed firmly to the vials. A 25-G needle was placed alongside the stopper to balance the air pressure inside and outside of the tube. The experimental model for gravity effect was used as previously described in a previous study by Kaşıkçı Bilgi et al [13].

Instrumentation

Initially, ISO size 10, 15, and 20 K-files was used in order to create a glide path. The apical diameter was standardized by inserting a size 15 K-file until it protruded one mm through the major foramen. Root canals were prepared up to size 25 in each group. All files were used at a WL of 18 mm. Apical patency was controlled with a size 15 K-file after each in-and-out motion or between file changes. After each use of single file NiTi systems, the flutes of the files were cleaned with a sponge. During instrumentation of each root canal, a total amount of 9 mL of distilled water was used as an irrigant with a 30-G side-vented irrigation needle (NaviTip, Ultradent, South Jordan, UT), at an insertion depth of two mm short of the WL.

With the exception of the TFA system, all rotary NiTi instruments were used with a torque- and speed-controlled motor (X Smart plus, Dentsply Maillefer) at the torque, speed and movement recommended by the manufacturers' instructions.

Group 1 (TFA system): The instruments were used with the Sybron Endo Elements Motor (SybronEndo, Orange, CA, USA) at the TF Adaptive mode in the sequence of SM1 and SM2 to the full length of the root canals. The files were used with a controlled motion without pecking and forcing apically. The files were completely withdrawn from the canal when they engaged the dentin. The procedure was repeated until the WL was reached; then the file was removed, and the next instrument in the sequence was used.

Group 2 (WO System): Primary Files (tip size #25.08) were used in a slow in-and-out motion. After three pecking movements, the file was removed from the root canal and cleaned. The procedure was repeated until the WL was reached.

Group 3 (PTN system): X1 and X2 files were used sequentially with a brushing motion in PTN mode; 300 rpm, 2.5 Ncm with a X Smart Plus motor for root canal instrumentation was used.

Group 4 (MTwo system): All basic sequence MTwo instruments (#10.04 taper, 15.05, 20.06, 25.06 taper) were used to WL using a gentle in-and-out motion.

Debris Collection

All collecting vials were weighed to 10^{-5} precision using a microbalance, as previously stated. After instrumentation procedure, the operator stored the vials in a dry-heat oven (FN 120, Nüve, Ankara, Turkey) at 95°C for 48 hours, allowing for irrigant evaporation. The final measurement of extruded debris was calculated by subtracting the initial weight from the post-operative weight.

Statistical Analyses

The effects of gravity and the instruments on the amount of debris were analysed with the Two Way Analysis of Variance (ANOVA) at a 0.05 level of significance, using IBM SPSS version 20.0 software (IBM SPSS Inc, Chicago, IL, USA). One-way ANOVA was performed to compare the amount of debris extrusion between the file systems.

RESULTS

The mean values for the extruded debris in both jaw positions associated with each system are displayed in Table 1. Gravity had no impact on the amount of extruded debris in all rotary systems (p>0,05). However, when teeth were evaluated in general, significantly more debris extruded in the mandibular location (p<0,05). No statistically significant differences were observed between the amounts of extruded debris in four file systems (p>0,05). The comparison between the four groups in terms of extruded debris resulted with a ranking order as follows: MTwo > PTN > TFA > WO.

No procedural incidents were detected for any of the systems.

Table 1- Mean, standard deviations (SD), minimum and maximum values of extruded debris (g) associated with the four file systems in maxillary or mandibular teeth.

			Type of Instrument			
			TF Adaptive	WaveOne	ProT Next	MTwo
Extruded Debris (g)	MandibularLocation	Mean (SD)	.00048 (.00037)	.00039 (.00020)	.00063 (.00066)	.00084 (.00093)
		Min.	.00012	.00009	.00013	.00009
		Max.	.00134	.00065	.00255	.00304
	Maxillary Location	Mean (SD)	.00028 (.00015)	.00025 (.00010)	.00027 (.00020)	.00036 (.00045)
		Min.	.00008	.00007	.00008	.00003
		Max.	.00049	.00043	.00083	.00153

DISCUSSION

Several factors have been found to affect the amount of extruded materials from root canals, including mechanical factors such as; instrumentation technique[12, 16] and pitch design[9], irrigation needle type[17,18] irrigation devices[19], WL changes during instrumentation on a curved root canal, and hand movements of the operator during preparation[9]. Natural factors such as the degree of root canal curvature[8], the anatomy of the apical constriction[20] also affect the amount of extruded materials.

In the current study, gravity had no impact on the amount of extruded debris in each group. However, when the mean amount of extruded debris of all the samples was evaluated between the maxillary and mandibular locations independent from the instrumentation techniques, significantly more debris was extruded in mandibular location which was in line with the previous study[13]. Salzgeber and Brilliant[21] found the extruded material appeared to be scattered in the apical lesion in an *in vivo* study. Considering this study and ours; it would be recommended to be more cautious while working on necrotic cases involving periapical lesion at mandible. Therefore, it may be suggested that the maxillary teeth with periapical lesions have less flare-ups when transferring this data to the clinical situations. The gravity impact on the amount of extruded debris should be evaluated in further *in vivo* studies.

Additionally, no significant differences in extruded debris were demonstrated among the four different rotary systems. This is consistent with the results from previous studies, which found that the WO, TFA and PTN[16], PTN and TFA[6], PTN and WO [7,22] file systems caused similar amounts of debris extrusion. In contrast, there are various studies which demonstrated that reciprocating motions were associated with less[23] or more[5,12] debris extrusion than continuous rotation systems. Reciprocating kinematics is an automatized balanced force pressureless technique[24], and the balanced force technique resulted in the smallest amount of extruded debris between hand instrumentation kinematics[25]. In the current study, even though less extruded debris was observed for reciprocating systems, the file systems had no significant influence on the amount of extruded debris. These contrary findings may be explained by operator-related variables or experimental set-up modifications and the type of teeth used in different study designs[24].

In this study, the reciprocating and adaptive systems extruded less debris in line with the results of previous studies[6,23,26] The WO system uses a reciprocation movement only, whereas the TFA predominantly uses a rotary movement, but also includes the reciprocation movement when the file encounters too much resistance against the dentinal wall. Both the TFA and WO have a triangular cross-section[16]; however, the WO file has a different cross-section along its entire active portion with the tip having a triangular cross-section modified with radial lands[5]. Regarding the instruments' design, it may be suggested that WO and TFA systems might have less cutting power, which results in less debris extrusion.

Recently, *in vitro* extrusion study designs and set-ups have included other parameters such as the apical resistance caused by the periapical tissues and lesions (e.g. periapical granulomas or cysts) in order to simulate *in vivo* conditions more accurately and to provide more credible information regarding extrusion[4]. Different materials such as floral foam and agar gel have been used to imitate the resistance of the periapical tissues, but the absorption of foam and the difficulty in adjusting the agar gel thickness at the apex have also been reported[17,27]. Thus, no material was used to mimic the periapical tissues in the present study. On the other hand, there are *in vivo* studies measuring Substance P and Calcitonin gene-related peptide in periodontal ligament[28,30]. These neuropeptides could be released during the inflammatory response and present in the periodontal ligament when stimulated by apical debris extrusion. Nevertheless, the working length changes, the kinaesthetic mechanical stress of the root canal treatment and extruded irrigation solutions may also affect the measured amount of neuropeptides[31].

CONCLUSION

In the present study, the effect of gravity and instrument design on the apical extrusion of debris in teeth with standardized root canal curvatures and diameters of the apical constriction were investigated. Within the limitations of this study, it can be concluded that none of the analysed parameters had a significant effect on the amount of debris, and all of the instruments caused similar debris extrusion.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

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