Evaluation of different instrumentation systems for apical extrusion of debris

Farklı enstrümentasyon sistemleri kullanılarak yapılan kök kanal preparasyonu sırasında apikalden taşan debris miktarının değerlendirilmesi

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SUMMARY

Aim: The aim of present study was to investigate the amount of debris extruded apically during preparation with ProTaper Gold (PTG; Dentsply Maillefer, Ballaigues, Switzerland), WaveOne Gold (WOG; Dentsply Maillefer), One Shape New Generation (OSNG; MicroMega, Besancon, France), Twisted File Adaptive (TFA; SybronEndo, Orange, CA, USA), and K3XF (SybronEndo) nickel-titanium instrumentation systems.

Materials and Method: Seventy-five extracted human single-rooted mandibular premolar teeth were randomly assigned to 5 groups (n = 15). The root canals were prepared according to the manufacturers' instructions using the PTG, WOG, OSNG, TFA, and K3XF instruments. Debris apically extruded during instrumentation was collected in pre-weighed eppendorf tubes. The eppendorf tubes were then stored in an incubator at 70°C for 5 days. The tubes were weighed again, and the difference between the initial and final weights was calculated. The data were statistically analyzed using one-way ANOVA and Tukey's post-hoc tests.

Results: The TFA group extruded significantly more debris compared with all other groups ($P<0.05$). Statistically, K3XF and OSNG groups were associated with more debris extrusion compared with the WOG and PTG groups ($P<0.05$). There was no statistically significant difference between the K3XF and OSNG groups ($P>0.05$). Additionally, there was no statistical difference between the WOG and PTG groups in the amount of extruded debris ($P>0.05$).

Conclusions: Under the conditions of this study, all instrumentation systems resulted in apical extrusion of debris. The WOG and PTG instrumentation systems caused the least amount of extruded debris compared with the other groups. The amount of apically extruded debris may vary according to metallurgy, kinematics and design of the instrument used.

Key Words: Apical extrusion, rotary files, gold-file systems

ÖZET

Amaç: Bu çalışmanın amacı, Protaper Gold (PTG; Dentsply Maillefer, Ballaigues, Switzerland), WaveOne Gold (WOG; Dentsply Maillefer), One Shape New Generation (OSNG; MicroMega, Besancon, France), Twisted File Adaptive (TFA; SybronEndo, Orange, CA, USA), and K3XF (SybronEndo) nikel-titanyum enstrümantasyon sistemleri ile preparasyon boyunca apikalden taşan debris miktarını araştırmaktır.

Gereç ve Yöntem: Yetmiş beş insan tek köklü mandibular premolar diş rastgele olarak 5 gruba ayrılmıştır (n=15). Kök kanalları PTG, WOG, OSNG, TFA, ve K3XF eğeleri kullanılarak üreticinin talimatlarına göre prepare edilmiştir. Enstrümantasyon boyunca apikalden taşan debris önceden tartılmış ependorf tüplerin içinde toplanmıştır. Ependorf tüpler daha sonra 5 gün boyunca 70°C'de bir inkübatör içerisinde muhafaza edilmiştir. Tüpler yeniden tartıldı ve ilk ve son ağırlıkları arasındaki fark hesaplanmıştır. Veriler istatistiksel olarak tek yönlü ANOVA ve Tukey post-hoc testleri kullanılarak analiz

edilmiştir.

Bulgular: TFA grubu diğer tüm gruplar ile karşılaştırıldığında önemli ölçüde daha fazla debris taşırmıştır (P<0,05). İstatistiksel olarak, K3XF ve OSNG grupları, WOG ve FTG gruplar ile karşılaştırıldığında daha fazla debris taşması ile ilişkili bulunmuştur (P<0,05). K3XF ve OSNG gruplar arasında istatistiksel olarak anlamlı bir fark saptanmamıştır (P>0,05). Buna ek olarak, WOG ve FTG grupları arasında apikalden taşan debris miktarında istatistiksel olarak anlamlı bir farklılık bulunmamıştır (P>0,05).

Sonuç: Bu çalışmanın koşulları altında, tüm enstrümantasyon sistemleri debrisin apikal ekstrüzyonu ile sonuçlandı. WOG ve PTG enstrümantasyon sistemleri diğer gruplar ile karşılaştırıldığında en az miktarda debris ekstrüzyonuna neden olmuştur. Apikalden taşan debris miktarı, kullanılan enstrümanın metalürjisine, kinematiğine ve tasarımına göre değişebilir.

Anahtar Kelimeler: Apikal ekstrüzyon, rotary eğeler, gold-file sistemler

INTRODUCTION

The extrusion of necrotic pulp, bacteria, and irrigants may be occured during root canal instrumentation into the periradicular tissues. Apically extruded materials have clinically been shown to cause discomfort, postoperative inflammation and flare-up, and apical healing failure.[1,2] It is generally accepted that all preparation techniques and instruments have a potential in terms of debris extrusion.[3,4] The extruded debris may vary with the instrumentation technique used and the design of the root canal instruments.[5,6] Rotary nickel-titanium (Ni-Ti) instruments provided less extruded debris than hand files.[7,8]

The ProTaper Gold (PTG; Dentsply Maillefer, Ballaigues, Switzerland) system is a new system that shares an identical instrument design with a triangular cross section and a variable progressive taper. PTG is manufactured using advanced proprietary metallurgy that reportedly increases its flexibility and resistance to cyclic fatigue.[9] Another recently introduced system is WaveOne Gold (WOG; Dentsply Maillefer), a new generation of reciprocating files. The manufacturers of WOG claim that WOG technology boosts cyclical fatigue resistance and reduces the screwing effect. WOG design has also been optimized to increase cutting efficiency.

The new Twisted File Adaptive system (TFA; SybronEndo, Orange, CA, USA) uses a combination of continuous rotation and reciprocating motions.[10] The manufacturer claims that the adaptive technology and the twisted file design that incorporates R-phase technology increases debris removal and flexibility.

The K3XF (SybronEndo) is the next generation of the K3 (SybronEndo) instrument system. K3XF provides clinicians an improved level of flexibility and resistance to cyclic fatigue with the proprietary R phase technology. One Shape New Generation (OSNG; MicroMega, Besancon, France) is another new file system that uses a traditional, continuous, rotational motion. The OSNG file has an asymmetric cross-sectional geometry and longer pitch.[11] The manufacturer claims that the design of the OSNG file increases the available volume for upward debris elimination.

There is no research yet on the apically debris extrusion following the root canal treatment using PTG, WOG, and OSNG instruments. Therefore, the evaluation of debris extrusion was intended during root canal preparation using WOG, PTG, OSNG, TFA, and K3XF rotary Ni-Ti instruments.

MATERIALS AND METHODS

Freshly extracted human mandibular incisor teeth with a single root and canal and a curvature <5°, in accordance with Schneider's criteria[12] were used for this study. The diamond burs (Diatech, Coltene Whaledent, Altststten, Switzerland) were used to prepared endodontic access cavities under water-cooling. Following the access cavity preparation, canals that exceeded the International Standards Organization (ISO) size 15 were discarded,[13] and seventy five teeth were included. The cusp edge of each tooth was flattened to standardize the lengths of samples to 19 mm. The working length (WL) was determined by subtracting 1 mm from this measurement.

Debris Collection

Debris collection was done according to Myers and Montgomery' protocol.[14] The equalization of air pressure was provided with 25-G needle that placed into the stopper. Then, each stopper with the tooth and the needle was attached to its eppendorf tube and the tubes were fitted into vials. The prepared eppendorf tubes were weighed using a microbalance (Sartorius AG, Göttingen, Germany) before root canal preparation. For each tube, consecutive measurements were repeated 3 times and the mean value was recorded. All teeth were coded and then randomly allocated into 5 groups of 15 specimens each.

Experimental Groups and Instrumentation Procedures

PTG Group

PTG instruments were used to prepare the root canals. The following sequence was used: SX file to 1/2 of the WL, S1 and S2 files to 2/3 of the WL, and F1 files (size 20, 0.07 taper) and F2 files (size 25, 0.08 taper) to the full WL. For SX and S1, instruments were used at 300 rpm with a torque of 3 Ncm, 1.5 Ncm for F1 instruments, and 2 Ncm for F2 instruments.

WOG Group

The root canals were instrumented using a WOG Primary file (size 25, 0.08 taper) in a reciprocating working motion at 300 rpm.

TFA Group

TFA (SybronEndo) instruments were used and set to the TFA program of their motor, which allows for torque control and stability, in a sequence of ML1 (size 25, 0.08 taper). ML1 instruments were carefully placed into the canal until the WL was achieved using a Sybron Elements motor (Sybron Endo) set at the adaptive motion. Each instrument was moved in the apical direction using an in-and-out motion within a span of about 3 mm.

OSNG Group

The root canals were prepared with OSNG (Micro-Mega) instruments (size 25, 0.06 taper). In-and-out movements were made with minimal pressure at a rotational speed of 400 rpm and 2 Ncm torque at the WL. A torque-controlled electric motor (VDW Silver; VDW) was used.

K3TMXF Group

K3XF instruments (Sybron Endo) were used with a gentle in-and-out motion at a rotational speed of 400 rpm. K3XF files (size 25, 0.04 taper and size 25, 0.06 taper) were used at the WL. All systems were used in the file sequence recommended by the respective manufacturer. Canal patency was checked using a size 10 K-file. A total of 10 ml distilled water was used in each canal for irrigation. A single operator prepared the all root canals.

Evaluation of Apically Extruded Material

On completion of the instrumentation procedure, the root was washed with 1 ml distilled water in the tube to collect the debris adherent to external surface of the apex. The evaporation of irrigants used during instrumentation before weighing the dry debris was provided with storage of tubes in an incubator at 70°C for 5 days.[6] By subtracting the original weight of the empty eppendorf tube from the gross weight, the net weight of the dry debris was determined.

Statistical Analysis

The statistically analysis was performed with a one-way analysis of variance (ANOVA). For multiple comparisons, Tukey's post hoc test was used. The level of significance was set at P<0.05. All statistical analyses were done with SPSS version 20.0.

RESULTS

The mean, minimum, and maximum extrusion values (g) for each group were shown in Table 1. TFA group showed statistically greater amount of debris than other groups (P<0.05). Although OSNG and K3XF groups indicated no significant difference (P>0.05), both groups resulted in more debris extrusion than the WOG and PTG groups (P<0.05). No significant difference was observed between the PTG and WOG groups (P>0.05).

Table 1: Mean, minimum and maximum values (g) according to groups were shown in the table.

Groups	Mean (SD)	Minimum	Maximum
Group 1 *ProTaper Gold*	0.0006 (0.00038)a	0.00011	0.00119
Group 2 *WaveOne Gold*	0.0007 (0.00027)a	0.00023	0.00110
Group 3 *Twisted File*	0.0023 (0.00040)b	0.00189	0.00302
Group 4 *OneShape New Generation*	0.0012 (0.00038)c	0.00078	0.00180
Group 5 *K3xf*	0.0013 (0.00032)c	0.00089	0.00188

By the One way ANOVA, F= 55.183, P= 0.000 (P<0.05).
Values (g) with same superscript letter show no statistically different at P<0.05 by Tukey's post-hoc Test.

DISCUSSION

In the present study, to prevent WL loss or non-standardized preparation, straight single-rooted mandibular premolar teeth were included. An evaluation of the efficacy of apical constriction damage on extruded debris determined that an increase in the diameter of the apical patency may increase the extrusion of debris.[15] In the present study, a size 15 K-file was advanced to the WL to control the size of the minor foramen. Some investigators suggest the use of a barrier material to simulate apical resistance.[5,16] However, barrier materials, such as agar or foam may absorb irrigation solution and debris. Therefore, periodontal tissue was not imitated with any material. An in vivo treatment may indicate various results because the periapical tissues, which serve as a natural barrier, may inhibit apical extrusion of debris.[17] Therefore, the results of the present study should not be directly extrapolated to the clinical environment.

Sodium hypochlorite is commonly used as an irrigation solution in root canal preparation. In present study, distilled water was preferred as an irrigation solution to prevent sodium hypochlorite crystallization.[13] Side-vented needles extrude less irrigant compared with regular needles.[5] Therefore, side-vented needles were used to minimize irrigation extrusion in all groups.

The amount of apically extruded debris from new instrument systems was evaluated in the present study. Each

instrument system tested had a different design, recommended number of files, and kinematics. Continuous rotation movement may improve coronal transportation of dentin chips and debris by acting like a screw conveyor, but reciprocal motion may enhance debris transportation toward the apex. 3 PTG, OSNG, and K3XF are designed to work with continuous rotational movement. TFA is designed to use motion similar to continuous rotation, but when load is applied, the system converts to a reciprocal motion, which could reduce cyclic fatigue of the file.[18]

The TFA instrument extruded the greatest amount of debris. Instrumentation using K3XF and OSNG files resulted in less debris extrusion compared with TFA. Although there was an insignificant difference between K3XF and OSNG, K3XF files extruded slightly more debris. A possible explanation for this is that the K3XF opener file removes more dentin in the coronal section than OSNG. Thus, the greater coronal width may facilitate the K3XF transport of debris toward the coronal area, thereby decreasing apically extruded debris. Another possibility is that the variable pitch of K3XF increases the transport of debris to the coronal section. The longer pitch design of the OSNG file may increase the volume of upward debris elimination. The amount of apical debris extrusion can be related to root canal anatomy and/or the instrumentation technique.[19-22] Currently, no method completely avoids debris extrusion. A greater amount of debris extrusion was detected in the TFA group compared with the OSNG and K3XF groups. This may be due to the reciprocal motion of TFA when it is subjected to pressure and resistance. Reciprocation movement increases debris extrusion compared with continuous rotation movement.[3]

The least amount of extruded debris was observed in the WOG and PTG groups. These results might be explained by differences in the metallurgy and design of the instruments. WOG instruments are manufactured using a new proprietary thermal process in which the ground Ni-Ti files are heat-treated and slowly cooled, producing a super-elastic Ni-Ti file. This elasticity may cause less debris extrusion compared with the other groups. Furthermore, the ogival, roundly tapered, and semi-active features of WOG reduce the mass at the center of the tip and improve its penetration into any canal with a confirmed, smooth, and reproducible glide path. These features may explain the minimal amount of debris extrusion caused by WOG.

PTG are manufactured from different alloys achieved through an enhanced proprietary heat treatment technology. This provides the instruments with greater flexibility and a reduced restoring force.[23-25] These features may play a crucial role in extruding less debris. PTG also has a different geometry: smaller dimensions, off-centered mass, and a regressive taper. The centering ability of the PTG instruments may maintain greater dentin thickness of the root canal and this may explain why it resulted in less apically extruded debris.[25] Additionally, the low transportation and canal wall contact values of the WOG and PTG instrumentation systems may show variances.[26,27] These differences in the WOG and PTG systems may be other significant reasons for less extruded debris than the other systems. WOG and PTG are safe and efficient systems for preparing canals. Sophisticated metallurgy and design of WOG and PTG result in improved flexibility and cyclic fatigue life with less binding and torsional stress on the file during work. Specifically, the WOG single file system reduces preparation time.

CONCLUSIONS

All instrument systems cause apical debris extrusion in extracted mandibular premolar teeth. OSNG, TFA, and K3XF instruments caused more debris extrusion compared to WOG and PTG instruments. Within the limitations of this study, one can conclude that metallurgy and design of the instrument may affect the amount of apically extruded debris.

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