ODOVTOS
International Journal of Dental Sciences
https://revistas.ucr.ac.cr/index.php/Odontos | ISSN: 2215-3411

BASIC RESEARCH

DOI: 10.15517/IJDS.2021.47147

Received:
27-IV-2021

Accepted:
25-VI-2021

Published Online:
20-VIII-2021

The Effect of Rotation Speed of XP-endo Shaper on Apically Extruded Debris During Endodontic Procedures: an *In Vitro* Study

El efecto de la velocidad de rotación de XP-endo Shaper sobre los desechos extruídos apicalmente durante los procedimientos de endodoncia: un estudio *in vitro*

Koray Yılmaz DDS,MSc[1]; Pelin Tüfenkçi DDS, PhD[2]

1. Assoc Prof., Department of Endodontics, Faculty of Dentistry, Hatay Mustafa Kemal University, Hatay, Turkey. https://orcid.org/0000-0001-6096-7385
2. Assoc Prof., Department of Endodontics, Faculty of Dentistry, Hatay Mustafa Kemal University, Hatay, Turkey. https://orcid.org/0000-0001-9881-5395

Correspondence to: Dr. Pelin Tüfenkçi - pelintufenkci@gmail.com

ABSTRACT: The aim of this study was to evaluate the effect of using a higher rotation speed with the XP-endo Shaper (XPS) on apically extruded debris and operation time during endodontic treatment and retreatment procedures. Sixty mesial roots of mandibular first molar teeth were randomly assigned to four groups (Initial treatment groups: XPS used at 1000 or 3000rpm rotation speeds and Retreatment groups: XPS used at 1000 or 3000rpm rotation speeds). During the initial treatment and retreatment procedures preweighed eppendorf tubes were used to collect apically extruded debris, and the operation time was recorded in seconds. The extruded debris was quantified by subtracting the preinstrumentation from the postinstrumentation weight of the Eppendorf tubes. Data were analysed using two-way ANOVA at a significance level of 0.05. In all groups, the use of the XPS at 1000 or 3000rpm rotation speeds had no statistically significant effect on the amount of apically extruded debris ($p>0.05$). The use of the XPS at a 3000rpm rotation speed significantly decreased the instrumentation time ($p<0.05$). In summary, the use of the XPS at high rotation speeds in initial treatment and retreatment procedures did not have a significant effect on the amount of apically extruded debris but significantly decreased the operation time.

KEYWORDS: Debris extrusion; Endodontic treatment; Retreatment; XP-endo Shaper.

RESUMEN: El objetivo de este estudio fue evaluar el efecto del uso de una mayor velocidad de rotación con XP-endo Shaper (XPS) sobre los desechos extruidos apicalmente y el tiempo de operación durante el tratamiento endodóntico y los procedimientos de retratamiento. Sesenta raíces mesiales de los primeros molares mandibulares se asignaron aleatoriamente a cuatro grupos (grupos de tratamiento inicial: XPS usado a velocidades de rotación de 1000 o 3000rpm y grupos de retratamiento: XPS usado a velocidades de rotación de 1000 o 3000rpm). Durante el tratamiento inicial y los procedimientos de retratamiento se utilizaron tubos Eppendorf pesados previamente para recoger los desechos extruidos apicalmente, y el tiempo de operación se registró en segundos. Los residuos extruidos se cuantificaron restando la preinstrumentación del peso postinstrumentación de los tubos Eppendorf. Los datos se analizaron mediante ANOVA bidireccional a un nivel de significación de 0,05. En todos los grupos, el uso del XPS a velocidades de rotación de 1000 o 3000rpm no tuvo un efecto estadísticamente significativo sobre la cantidad de detritos extruidos apicalmente ($p>0.05$). El uso del XPS a una velocidad de rotación de 3000rpm disminuyó significativamente el tiempo de instrumentación ($p<0.05$). En resumen, el uso del XPS a altas velocidades de rotación en los procedimientos de tratamiento inicial y retratamiento no tuvo un efecto significativo en la cantidad de detritos extruidos apicalmente, pero disminuyó significativamente el tiempo de operación.

PALABRAS CLAVE: Extrusión de escombros; Tratamiento de endodoncia; Retratamiento; XP-endo Shaper.

INTRODUCTION

During the mechanical instrumentation of the root canals in endodontic treatments, the residuals such as dentin and pulp tissue debris, irrigation solutions, and microorganisms are extruded to the periradicular tissues and it may cause several complications such as postoperative pain, infection/inflammation, and delaying periradicular healing (1). Several studies reported that all the techniques used in instrumentation the root canal and removing the root canal filling material are associated with apically extruded debris (2,3). However, as it is not possible to clinically measure the amount of debris and root canal filling material extruded during the endodontic procedures, the *in vitro* studies mimicking different clinical conditions related with this subject are carried out (4).

Nowadays, the mechanical instrumentation of root canals is generally performed using rotary instrument systems and the single-file rotary instrument systems are preferred for both shortening the duration of clinical time and minimizing the complications related with rotary instruments (5). XP-endo Shaper (XPS, FKG, La Chaux-de-Fonds, Switzerland), which is one of these single-file systems, is made of registered MaxWire (FKG Dentaire SA) alloy and has a snake-shaped design. The file has the size/initial taper of 30/.01 in its martensitic phase when it is cooled, but, upon exposure to body temperature (35°C), the taper

changes to .04. The studies carried out using XPS reported that the file showed a good adaptation to the root walls during the root canal shaping and caused low levels of apical debris extrusion (6).

The manufacturer recommends using the XPS file system with a continuously rotating endodontic motor at 800 or 1000rpm and 1 Ncm settings (6). However, in their studies, Webber *et al.* (7) and Azim *et al.* (8) reported that increasing the rotation speed of XPS from 1000 rpm to 3000 rpm during endodontic treatment and retreatment procedures yielded better results from the aspect of mechanical instrumentation, shortened the duration of operation, and caused no additional file-related complication.

In studies examining the amount of apically extruded debris during the endodontic treatment and retreatment procedures using XPS, the file was generally used at 800 or 1000rpm in accordance with the manufacturer recommends (5,6). In a few studies, the XPS was used at high rotation speed and the effects on the shaping ability and the efficiency of removal the root canal filling materials were investigated (7,8). For this reason, the present study aims to effect of increasing rotation speed of XPS to 3000rpm on the amount of apically extruded debris during the endodontic treatment and retreatment procedures. The null hypothesis was that the increase of the XPS's rotation speed would have no effect on the amount of apically extruded debris and the operation time.

MATERIAL AND METHODS

SAMPLE SELECTION

The Institutional Committee of Ethics in Research approved the study protocol (Ref no: 2020/15). Based on a similar study carried out previously (9), it was determined that the sample size for each group should be a minimum of twelve (power=0.91, effect size=0.864, significance level of p=0.05). Finally, 15 teeth were selected for each group. Sixty caries-free mandibular first molar teeth extracted due to periodontal reasons were involved in the present study. The inclusion criteria were to be permanent mature tooth, to have no intracanal calcification and previous root canal treatment history, to have 2 independent canals in the mesial root, and the degree of root canal curvature less than 20°C. The degree of root canal curvature was measured according to Schneider's method (10) using digital radiographs which were taken in buccolingual and mesiodistal directions. The mesial roots of the teeth were removed from the cemento-enamel junction using a high-speed fissure bur to obtain a 14-mm root length. The teeth, in which the apical patency could not be achieved in the mesiobuccal canal by using 10-K file, were excluded from the study. The size 10 K-file was introduced into the mesiobuccal canal until its tip was visible at the major apical foramen, and the working length (WL) was determined by subtracting 0.5mm from this length. The specimens were randomly allocated to four groups (n=15).

APPARATUS FOR THE COLLECTION OF EXTRUDED MATERIAL

The modified method of Myers & Montgomery (11) was used in order to assess the apically extruded debris in all the groups. The teeth were placed in a rubber stopper and fixed with cyanoacrylate cement. The Eppendorf tubes, in which the teeth were placed at the cement-enamel junction point, were placed in vials. Before placing each tooth in the tube, the weights of each tube were measured three times by using an electronic scale (Pioneer, Oahu's Corp., NJ, USA) with 10-4g sensitivity, and the average value of these measurements was calculated. A 25-gauge syringe was added to the rubber stopper in the bottle to equalize the internal and external air pressures.

The vials were covered with a rubber dam sheet to prevent the operator from observing the root apex during root canal instrumentation.

INSTRUMENTATION PROTOCOLS

A new file was used in the instrumentation of each new root canal and all these procedures were performed by an experienced endodontist. All procedures were performed at 37°C inside a glass cabinet. The aim of this setting was to simulate the body temperature for the XPS to undergo the phase change.

INITIAL TREATMENT GROUPS

XPS-1000 RPM GROUP

A manual glide path was established up to a size 15-K file. The XPS was operated at 1000 rpm and 1-Ncm torque by applying a vertical pecking motion until reaching the WL followed by 1 set of 10 long strokes to complete the root canal instrumentation. After each set, the file was cleaned and the apical patency was confirmed using a 15-K file.

XPS-3000 RPM GROUP

A manual glide path was established up to a size 15-K file. The XPS was operated at 3000 rpm and 1-Ncm torque and all instrumentation procedures were performed as previously described.

RETREATMENT GROUPS

All the root canals in the retreatment groups were prepared to the size 25.06 by using Mtwo rotary file system (VDW; Munich, Germany). During all the instrumentation procedures, 5.25% NaOCl and 17% EDTA (in final irrigation) were used for the irrigation. The root canals were dried using paper points and filled using the lateral compaction technique of gutta-percha cones (VDW) and AH Plus sealer (Dentsply De Trey, Konstanz, Germany). Periapical radiographs were taken in order to confirm the quality of the root canal filling. The access cavities were then sealed using a small piece of cotton and temporary filling material (Cavit; 3M ESPE, St Paul, MN). The specimens were stored at 37°C and 100% humidity for 30 days.

XPS-1000 RPM GROUP

The temporary filling material was removed. XPS was operated at 1000rpm and 1 Ncm torque. The retreatment procedure was continued by removing all the filling material residues from the root canal until reaching the WL. Once the WL was reached, 10 vertical strokes were applied along the entire canal length by brushing against all of the canal walls. This procedure was continued until there was no clinically visible root canal filling material on the canal orifice or the file. At the end of the procedure, patency was confirmed using a 15-K file.

XPS-3000 RPM GROUP

The temporary filling material was removed. XPS was operated at 3000rpm and 1 Ncm torque and all the retreatment procedures were performed as previously described.

In all initial treatment groups and retreatment groups, the irrigation was performed throughout the instrumentation and the removal of root canal filling materials using a total of 10mL distilled water for each tooth. Distilled water was delivered into the canal using a syringe and a 29-gauge double-side port needle (NaviTip; Ultradent, South Jordan, UT, USA). The irrigation solutions were also warmed to and kept at 37°C in a digital water

bath. In all the groups, the total time required for the instrumentation and irrigation procedures was recorded as second using a digital chronometer.

EVALUATION OF APICALLY EXTRUDED DEBRIS

After completion of all the instrumentation procedures, the Eppendorf tubes were removed from the vials. To collect the apically extruded debris that had adhered to the root apex, the apex of tooth was washed with 1mL distilled water. Before weighing the extruded debris, the tubes were kept in an incubator at 70°C for 5 days in order to vaporize the distilled water in the tube. Each of the tubes was weighed three times consecutively using an electronic scale and the average values were recorded. The dry weight of debris was calculated by subtracting the weight of the empty tube from the weight of the tube containing extruded debris.

STATISTICAL ANALYSIS

The statistical analyses were performed using SPSS software Ver. 20.0.1 (SPSS, Chicago, IL, USA). The normality of the variables was analyzed using the Shapiro-Wilk test. Data were analyzed using Two-way ANOVA and multiple comparison test with Bonferroni correction (α=0.05) at the significance level of 0.05.

RESULTS

The amount of apically debris extruded and the durations of mechanical instrumentation procedures after using XPS at 1000 and 3000rpm rotation speeds in initial treatment and retreatment procedures are presented in Table 1. XPS caused debris extrusion from the apical at both rotation speeds. In both initial treatment and retreatment groups, the use of XPS at 1000 or 3000rpm rotation speeds caused no statistically significant effect on the amount of apically debris extruded ($p>0.05$). Examining the operating time of the root canals, it was determined that the use of XPS at 3000rpm rotation speed significantly decreased the instrumentation time in all the groups ($p<0.05$).

Table 1. Amount of apically extruded debris in miligrams and operation time (second).

Group (n=15)	1000rpm Mean ± SD	T (s)	3000rpm Mean ± SD	T (s)
Initial Treatment	1.7 ± 2.1^{Aa}	42^{Aa}	1.3 ± 1.1^{Aa}	25^{Ab}
Retreatment	2.6 ± 4.7^{Aa}	202^{Ba}	1.4 ± 1.2^{Aa}	126^{Bb}

*Different superscript letters lowercase, in row and uppercase in columns, indicate statistically significant difference between groups ($p<0.05$).

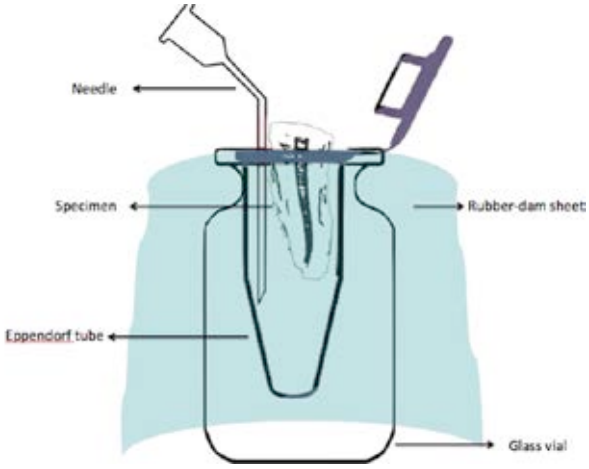

Figure 1. A schematic illustration of the experimental model.

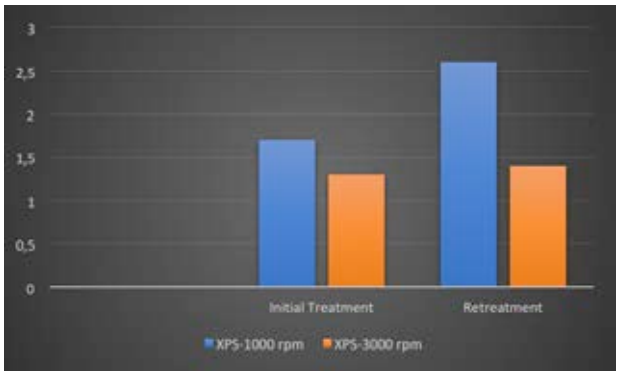

Figure 2. The bar figure display the amount of apically extruded debris.

DISCUSSION

In the literature, there are many studies examining the amount of apically extruded debris as a result of mechanical instrumentation in both initial treatment and retreatment procedures (5,6,8,12). In these studies, different rotary instrument systems were compared to each other and hand files and it was aimed to investigate the effect of files' cross-section design, tip size, kinematic, and thermomechanical characteristics on the amount of apically extruded debris.

The concept of using rotary instruments at high speeds is not a new concept in endodontics. Ha *et al.* (13) determined that no change was observed in torsional resistance values of K3XF (SybronEndo, Glendora, CA), BLX (B&L Biotech, Ansan, Korea), and OneShape (MicroMega, Besancon, France) files when used high rotation speed, Gao *et al.* (14) reported no change in cyclic fatigue resistance values of ProFile Vortex (DENTSPLY Tulsa Dental, Tulsa, OK), and Lopes *et al.* (15) determined that the cyclic fatigue resistance of ProTaper Universal (Maillefer SA, Ballaigues, Switzerland) decreased when used high rotation speed. The common idea of the authors is that, when compared to the low speeds, the high rotation speeds cause a higher level of heat emission. Therefore, together with the rapid increase in temperature on the surface of the file, the stress accumulation on the file increases, and consequently the fatigue resistance values decrease. However, it was reported that the files can become more resistant to high rotation speeds by means of their alloy characteristics and heat treatments applied during the production (16,17). Versiani *et al.* (18) reported that using the XPS at 3000 rpm speed could increase the shaping ability of file and significantly reduce the duration of clinical procedure.

There is no study examining of rotary instruments using at different rotation speeds would affect the amount of apically extruded debris in the literature. In a previous study carried out on XPS, it was reported that, the use of file at 3000 rpm increased the shaping ability but caused no additional complication when compared to the use at 1000rpm recommended by the manufacturer, Moreover, in the same study, the authors also reported that the use of XPS at high rotation speed reduced the operation time (7). Therefore, it was aimed to examine the amount of apically extruded debris after using the XPS at high rotation speed on both initial treatment and retreatment groups and to compare the operation time in this study.

In the present study, the method by Myers & Montgomery (11) was modified in order to measure the extrusion of debris. Because Hemptine *et al.* (19) reported that increasing the internal temperature of the root canal to approximately 35° may mimic the clinical condition at best.

According to the results of present study, although the increase of XPS's rotation speed from 1000 rpm to 3000 rpm resulted in a slight decrease in the amount of apically extruded debris in both initial treatment and retreatment groups, but no statistically significant difference was found between the groups ($p>0.05$). In the literature, there is no study, which compared the amount of apically extruded debris when XPS or another rotary instrument was used at different rotation speeds, to directly compare the present results. In the previous studies, Alves *et al.* (5) and Uslu *et al.* (6) used the XPS at 800rpm rotation speed and compared it to the other single-file systems and they reported that XPS caused less apical debris extrusion. Low amount of apical debris extrusion of XPS found in the present study are similar with the previous studies.

Weber *et al.* (7) reported that the use of XPS at 3000rpm significantly reduced the time of reaching the WL and the number of strokes to reach this length. Azim *et al.* (8) examined the efficiency of XPS in the removal of root canal

filling material from the root canal and they reported that the use of XPS at 3000rpm obtained the easier penetration of file to the gutta-percha when compared to the use at 1000rpm. Given the result of the present study, it is thought that the slight decrease in the amount of apically extruded debris when using XPS at high rotation speed might be because the file can reach the working length very easily and thus the operation time shortens. The snake-shaped design with a small nominal core of XPS might have played a role in this result. For this reason, further studies are needed in order to determine how the high rotation speeds of other rotary instrument systems affect the debris extrusion.

In the present study, increasing the rotation speed of XPS significantly decreased the operation time ($p<0.05$). Thus, the null hypothesis was rejected. This result is also in similar with few studies in literature examining the operation time at high rotation speeds of XPS (8,18). We believed that this result might be because the file encountered less resistance within the root canal when using the file at high rotation speeds, as well as the increase in dentin removal efficiency.

The main limitation of this study was that the periapical resistance was not simulated. In several studies examining the amount of apical extrusion, materials such as floral foam and agar were used for this purpose (20,21). However, Altundaşar *et al*. (22) reported that the foam used might be absorbed within the canal and, since there is no exact evidence indicating how much agar should be used in order to create apical resistance, it may cause the clinical conditions to not be clearly mimicked and it may yield different results. Moreover, no clinically apparent deformation or fracture occurred in any XPS during the mechanical instrumentation procedures in the present study. Moreover, further studies are also needed to determine how the mechanical properties of file change at high speeds.

CONCLUSION

Within the limitations of the present study, it was determined that using the XPS at high rotation speeds in initial treatment and retreatment procedures didn't cause a significant difference in the amount of apically extruded debris. However, when using the XPS at a high rotation speed, the operation time significantly decreased.

FUNDING

The study was self-funded.

CONFLICT OF INTEREST

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

ACKNOWLEDGEMENTS

All authors contributed equally to this work.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization and design: KY, PT.
Literature review: KY, PT.
Methodology and validation: KY, PT.
Formal analysis: KY, PT.
Investigation and data collection: PT.
Resources: KY, PT.
Data analysis and interpretation: KY, PT.
Writing-original draft preparation: KY.
Writing-review and editing: KY, PT.
Supervision: KY, PT.
Project administration: KY, PT.
Funding acquisition: KY, PT.

REFERENCES

1. Seltzer S., Naidorf I.J. Flare-ups in endodontics: I. Etiological factors. J Endod. 1985; 11 (11): 472-8.

2. Tanalp J., Kaptan F., Sert S., Kayahan B., Bayirl G. Quantitative evaluation of the amount of apically extruded debris using 3 different rotary instrumentation systems. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006; 101 (2): 250-7.
3. Keskin C., Sariyilmaz E., Sariyilmaz O. Effect of solvents on apically extruded debris and irrigant during root canal retreatment using reciprocating instruments. Int Endod J. 2017; 50 (11): 1084-8.
4. Topçuoğlu H.S., Zan R., Akpek F., Topçuoğlu G., Ulusan Ö., Aktı A., et al. Apically extruded debris during root canal preparation using Vortex Blue, K3XF, ProTaper Next and Reciproc instruments. Int Endod J. 2016; 49 (12): 1183-7.
5. Alves F.R.F., Paiva P.L., Marceliano-Alves M.F., Cabreira L.J., Lima K.C., Siqueira J.F., et al. Bacteria and Hard Tissue Debris Extrusion and Intracanal Bacterial Reduction Promoted by XP-endo Shaper and Reciproc Instruments. J Endod. 2018; 44 (7): 1173-8.
6. Uslu G., Ozyurek T., Yılmaz K., Gündoğar M., Plotino G. Apically extruded debris during root canal instrumentation with Reciproc blue, HyFlex EDM, and XP-endo shaper nickel-titanium files. J Endod. 2018; 44 (5): 856-9.
7. Webber M., Piasecki L., Jussiani E.I., Andrello A.C., Dos Reis P.J., Azim K.A., et al. Higher Speed and No Glide Path: A New Protocol to Increase the Efficiency of XP Shaper in Curved Canals-An In Vitro Study. J Endod. 2020; 46 (1): 103-9.
8. Azim A.A., Wang H.H., Tarrosh M., Azim K.A., Piasecki L. Comparison between Single-file Rotary Systems: Part 1-Efficiency, Effectiveness, and Adverse Effects in Endodontic Retreatment. J Endod. 2018; 44 (11): 1720-24.
9. Silva E.J., Sa L., Belladonna F.G., Neves A.A., Accorsi-Mendonça T., Vieira V.T., et al. Reciprocating versus rotary systems for root filling removal: assessment of the apically extruded material. J Endod. 2014; 40 (12): 2077-80.
10. Schneider S.W. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol. 1971; 32 (2): 271-5.
11. Myers G.L., Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. J Endod. 1991; 17 (6): 275-9.
12. Kocak S., Kocak M.M., Saglam B.C., Türker S.A., Sağsen B., Er Ö. Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. J Endod. 2013; 39 (10): 1278-80.
13. Ha J.H., Kwak S.W., Kim S.K., Sigurdsson A., Kim H.C. Effect from Rotational Speed on Torsional Resistance of the Nickel-titanium Instruments. J Endod. 2017; 43 (3): 443-6.
14. Gao Y., Shotton V., Wilkinson K., Phillips G., Johnson W.B. Effects of raw material and rotational speed on the cyclic fatigue of ProFile Vortex rotary instruments. J Endod. 2010; 36 (7): 1205-9.
15. Lopes H.P., Ferreira A.A., Elias C.N., Moreira E.J., de Oliveira J.C., Siqueira J.F. Jr. Influence of rotational speed on the cyclic fatigue of rotary nickel-titanium endodontic instruments. J Endod. 2009; 35 (7): 1013-16.
16. Yared G.M., Bou Dagher F.E., Machtou P. Influence of rotational speed, torque and operator's proficiency on ProFile failures. Int Endod J. 2001; 34 (1): 47-53.
17. Kitchens G.G. Jr., Liewehr F.R., Moon P.C. The effect of operational speed on the fracture of nickel-titanium rotary instruments. J Endod. 2007; 33 (1): 52-54.

18. Versiani M.A., Carvalho K.K., Mazzi-Chaves J.F., Sousa-Neto M.D. Micro-computed tomographic evaluation of the shaping ability of XP-endo Shaper, iRaCe, and EdgeFile systems in long oval-shaped canals. J Endod. 2018; 44 (3): 489-95.
19. de Hemptinne F., Slaus G., Vandendael M., Jacquet W., De Moor R.J., Bottenberg P. In vivo intracanal temperature evolution during endodontic treatment after the injection of room temperature or preheated sodium hypochlorite. J Endod. 2015; 41 (7): 1112-5.
20. Hachmeister D.R., Schindler W.G., Walker W.A. 3rd, Thomas D.D. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod. 2002; 28 (5): 386-90.
21. Stefopoulos S., Tsatsas D.V., Kerezoudis N.P., Eliades G. Comparative in vitro study of the sealing efficiency of white vs grey Pro-root mineral trioxide aggregate formulas as apical barriers. Dent Traumatol. 2008; 24 (2): 207-13.
22. Altundasar E., Nagas E., Uyanik O., Serper A. Debris and irrigant extrusion potential of 2 rotary systems and irrigation needles. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011; 112 (4): e31-35.