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Efficiency of XP Endo Shaper (XPS) and Irrigation Protocol on the Quality of Cleaning the Apical Third of Root Canal: SEM Study

SUMMARY

Background/Aim: *The aim of this study was to evaluate the efficacy of new rotary NiTi instrument XP- endo SHAPER (XPS) used with two irrigation protocols on the root canal cleaning in the apical area.* ***Material and Methods:*** *The research was conducted on 30 single-rooted teeth extracted for orthodontic reasons which were divided into the two groups. Instrumentation of the canals was−conducted with XPS instrument and 2% solution of NaOCl was used as irrigant. Instrumentation in the first group was performed using a conventional continuous irrigation, in the second group, protocol of final irrigation was performed intermittently in 3 cycles. The SEM analysis of the apical third of the canal was performed on longitudinal root cross-section standardized photomicrography with a magnification of 2000X.* ***Results:*** *Results showed that a thicker smear layer was observed in the first group and with continuous irrigation protocol (2,10) in relation to the intermittent irrigation protocol in 3 cycles (1,96), but without significant differences.The walls of the root canal in the apical third of the samples of the second group were slightly cleaner (73.3%) in comparison with the teeth of the first group (64, 7%), but also without significant differences.* ***Conclusions:*** *The use of XPS and 2% solution of NaOCl in the root canal enables efficient cleaning of the apical third of tooth. The final irrigation protocol in three cycles improves the efficiency of the smear layer removal in the apical segment of the canal.*

Key words: XP-endo Shaper, Smear Layer, Irrigation Protocol, Apical Third

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Introduction

Cleaning and shaping the root canal system is the most important phase in an endodontic treatment. However, complex anatomy of a canal often prevents adequate cleaning of this space using actual instruments and techniques[1,2]. A particular problem is the irregularity of the canal system (isthmus, ramifications, and additional lateral canals) or apical third of the root canal, which cannot be reached by most of the instruments, and almost 30-50% of the surface of the canal walls remains untouched[1,3].

Mechanical instrumentation with manual or mechanical instruments leads to the formation of smear layer and dentin debris on the walls of the canal, and often to their accumulation in inaccessible areas of the canal system[4,5]. In this way there is significant efficiency reduction of irrigant on the residual bacteria and significant linkage material disturbance for obturation of the canal walls[3,6,7].

In order to clean the root effectively, type and quantity of the irrigant or irrigation techniques and protocol are significant. These intracanal solutions provide **a** lubricating effect during instrumentation, have an antibacterial effect, remove debris and smear layer from the root canal walls and from inaccessible areas of the canal system[8,9,10].

The most frequently used endodontic irrigant is sodium hypochlorite (at various concentrations), primarily due to its antibacterial[11] and solvent effect[12], although higher concentrations can cause irritation of the periapical tissue[13]. Exceptional and prolonged antibacterial effect of chlorhexidine on the large number of bacteria in the canal, makes this irrigant often used in endodontic treatments[8,14]. Researches has also shown that it is possible to increase the efficiency of the irrigant, or to achieve better penetration and better cleaning of the canal walls using some forms of solution activation like: ultrasound[15,16], a new instrument XP-endo Finisher[1,17] or laser[18].

Chemo- mechanical procedure provides a significantly lower number of bacteria in the canal, but not complete disinfection of the canal system. In addition, any available set of manual or mechanical burnishing tool results in the formation of smear layer and dentin debridement on processed canal walls[2,6,8]. For the success of this endodontic treatment, it is necessary to remove this layer, and the removal efficiency is significantly affected by irrigating solutions on the basis of the chelating agent, which effectively remove the smear layer from all areas of the canal[2,19,20].

The aim of this study was to evaluate the efficiency of the apical third of the canal after the instrumentation of the NiTi rotating instrument XP- endo Shaper and the application of two final irrigation protocols using SEM analysis.

Material and Methods

The study was conducted on 30 premolars extracted for orthodontic reasons. Teeth were stored up to the experiment in a 0.2% solution of thymol, at a temperature of 4 °C.

Root Canal Instrumentation

In all teeth the access cavity was formed and established initial passage with K-file #15. The working length is determined to be 1 mm shorter than the length at which the tip of the hand file appears on the apical foramen. To prevent leakage of the solution for irrigation during instrumentation, a wax ball was placed at the apex of each root.

The teeth were randomly divided into two groups (each of 15 teeth) and the complete mechanical instrumentation was performed by one researcher. As an irrigant, a 2% solution of NaOCl (Cloraxid 2%, Cerkamed, Poland) was used, and the canal was washed with plastic syringes, a volume of 2 ml, and needle size 27. A 4 ml solution for irrigation was used for each canal, and the flushing protocol lasted 150 sec.

The canal instrumentation was carried out in both groups by the new NiTi rotating instrument XP-endo Shaper (FKG, Dentaire, Swiss) (dimensions 30/04)[21]. This instrument represents a new generation of NiTi rotating instruments that, thanks to its extraordinary superelasticity, can change its shape in the canal and thus, reach inaccessible areas of the canal. A special production technique and specific geometry of the cutting part ensures the cleaning and shaping of the canal with only one instrument (800 rpm).

GROUP 1- In the first group, a conventional technique of continuous irrigation was applied. The canal is filled with an irrigant (0.5 ml) and then the XPS instrument is inserted into the canal with gentle insertion and withdrawal placed to the working length (3-5 times for 30 sec). Then the irrigant (0.5 ml) was re-inserted into the canal and usage of XPS provided the final apical preparation 8-10 times over 30 sec. The final irrigation with 2% NaOCl solution was performed after the completion of the instrumentation with another 3 ml solution for 90 sec.

GROUP 2- In the second group, XPS instrumentation was done in the same way as in the first group, but the final irrigation was performed intermittently in 3 steps (3 times 1ml for 30 sec).

SEM analysis

After finishing the instrumentation, the crowns of all teeth were cut at the cement-enamel junction and then the roots were cut with diamond disc (without penetration into the canal) longitudinally in the vestibulo-oral direction and separated into two halves with sharp chisel. Obtained halves were placed on a carrier, gold-coated and analyzed by SEM (JOEL, JSM, 64660 LV, Japan).

Only an apical third (region 3 mm from the instrumentation border) was analyzed, so that, for each sample (half of the teeth) 5 standardized microphotographs were taken at 2000x magnification. SEM photographs of teeth samples (300 images) were analyzed by two researchers who independently rated each photo. In case of disagreement, it was discussed to reach a consensus. The evaluation of cleaning efficiency was based on qualitative estimation of residual smear layer in the apical segment of the canal with the criteria presented by Hülsmann et al.[22]:

Grade 1 - no smear layer, dentinal tubules open,
Grade 2 - small amount of smear layer, several dentinal tubules open,
Grade 3 - homogeneous smear layer covers the canal wall, small number of dentinal tubules open,
Grade 4 - the entire wall of the canal covered with smear layer, no open dentinal tubules,
Grade 5 - non-homogeneous smear layer covering the entire wall of the canal.

The clean wall canal included ratings 1 and 2, and the wall with the present smear layer grades 3, 4 and 5. The obtained results were processed in the SPSS 20 (IBM, CHICAGO) program. Methods of descriptive statistics and Mann Whitney test were used in statistical analysis.

Results

The results of the analysis of SEM photographs after the instrumentation and canal irrigation are shown in Tables 1 and 2 and in Figures 1 and 2. The analysis of the apical thirds samples indicated mainly clear canal walls, without the smear layer in both tested groups (Figure 1).

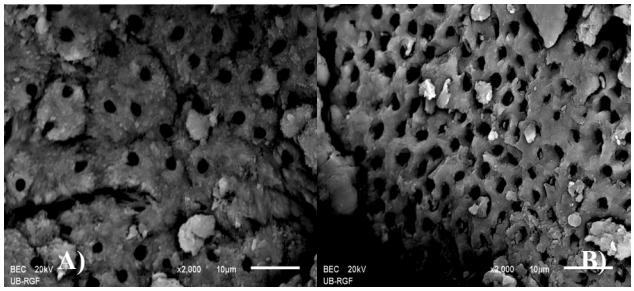

Figure 1. The representative evaluation microphotographs of the smear layer in the apex third of the canal

Samples of the first group where the technique of continuous irrigation (grade 2) was applied. SEM 2000x, B) Samples of the second group where the final irrigation was performed by intermittent technique in 3 steps (grade 1). SEM 2000x.

A slightly smear layer was registered in the first group where the instrumentation was performed using the XPS instrument and with the continual irrigation protocol (2,10) in comparison to the second group where the instrumentation was performed using XPS and an intermittent 3-step irrigation protocol (1,96), but without statistically significant differences (Table 1).

Table 1. Evaluation of smear layer in the apical third of the root canal

		Smeared layer ratings					
		N	Mean	SD	Med	Min	max
Group	Continuous irrigation	150	2.10	1.03	2.00	1.00	4.00
	Irrigation in 3 steps	150	1.96	0.98	2.00	1.00	4.00
	Total	300	2.03	1.00	2.00	1.00	4.00

The obtained results also indicated cleaner walls in the apical third of the samples of the second group (73,3%) compared to the canal walls of the first group (64,7%) (Figure 2, Table 2).

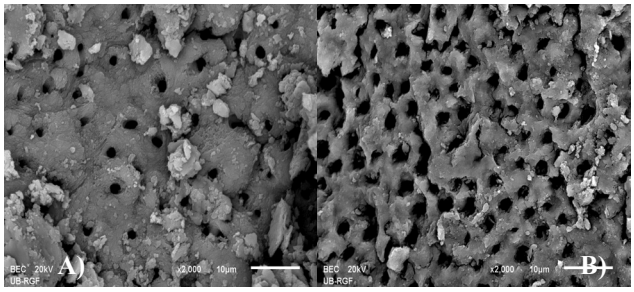

Figure 2. Evaluation of cleaning quality in the apical third of the canal, A) Samples of the first group where the technique of continuous irrigation was applied (Grade 3). SEM 2000x, B) Samples of the second group where the final irrigation was performed by intermittent technique in 3 steps (Grade 2). SEM 2000x.

Table 2. Evaluation of cleaning quality in the apical third of the root canal

			Cleaning ratings		
			Good (Grade 1,2)	With smeared layer (Grade 3,4,5)	total
Group	Continuous irrigation	N	97	53	150
		%	64.7%	35.3%	100%
	Irrigation in 3 steps	N	110	40	150
		%	73.3%	26.7%	100%
Total		N	207	93	300
		%	69%	31%	100%

Discusion

Although there were earlier controversies, today there is a generally accepted consensus among endodontists about the necessity of removing the smear layer from the walls of the root canal[10,11,14]. This layer significantly influences the success of endodontic treatment because it can contain bacteria and its presence can reduce the efficacy of intra canal medicaments, or reduce the adhesion of endodontic sealers to canal walls during obturation[6,7,8].

The possibilities of light microscopy in the debris and smear layer identification after chemo-mechanical canal preparation are quite high[23]), but SEM analysis is certainly the most reliable and most popular method, primarily because of the possible magnification and high image resolution[5,8,18].

Studies have confirmed that the smear layer from the canal walls is easier to remove from the coronal and middle third[2,6,9,18], while the cleaning problem is particularly pronounced in the area of the apical third[1,11,15,19,24].

These research were realized by an identical protocol (all canals were processed by one researcher), with one type of instrument (XPS), with the same amount and duration of irrigation and with two final irrigation protocols (2% NaOCl). The obtained results indicated a very efficient cleaning of the apical segment of the canal and the walls mostly without a smear layer in both tested groups. A more efficient removal of the smear layer and better cleaning was observed after the intermittent final irrigation protocol in three steps in comparison to continuous irrigation protocol.

Clean canal walls in apical third of the nearly all samples could be explained primarily by the simplicity of canal morphology, but also by the effects of the new XPS instrument, or by its specific design, at a speed of 800 rpm, and by the fact that it can change its shape in the canal during the instrumentation and thus, reach the inaccessible canal areas[17,25]. In addition, the extreme flexibility of the XPS and the working end with 6 cutting edges (with minimal torque) ensure efficient cleaning of all canal walls and the apical segment. The formed dentine micro derbis is easily removed due to the pronounced "turbulence" of irrigants during instrument rotation in the canal[1,15,16,21].

The application of XPS in the chemo- mechanical canal preparation provides the necessary and sufficient diameter of the apical preparation (30/04), which is also a precondition that facilitates cleaning of this part of the canal[1,11,15]. Diameter of the apical preparation formed in this way allows the tip of the needle to easily reach the apical terminus, which also improves the efficiency of the irrigant in the removal of the smear layer[2,9]. One of the problems of such deep application of irrigation needles in clinical conditions can be the conveyance of irrigant (NaOCl) into periapex, which can cause adverse effects on periapical structures[26].

The results comparison of various studies on the effects of cleansing the apical third is quite complicated because of both, the different techniques of instrumentation and irrigation, and different evaluation methods[2]. In this study, a 2% NaOCl solution was used as an irrigant with two final irrigation protocols.

The largest number of researchers agree that the quality of the cleaning of the canal system depends largely on irrigants, its quantities, irrigation techniques and the time of exposure of the canal walls to the irrigants solution[1,3,9,10]. The fact is that the solution for irrigation, quantity and time of action were identical in both groups, nonetheless, better results could be obtained primarily in the final irrigation protocol.

An intermittent final irrigation protocol (in 3 steps) has shown somewhat better results than the conventional irrigation protocol. During the conventional protocol, the irrigation solution is mixed with the remains of the smear layer and debris, which significantly reduces the efficiency, while the fresh solution during each cycle provides better canal cleaning[1,16]. It has also been confirmed that 3 cycles of fresh NaOCl solution increase its cumulative efficiency as well as efficacy in canal cleaning quality[28].

A smaller amount of the smear layer in the apex part of the canal could be due to the fact that XPS due to the specific working part of the instrument and higher speeds during the canal treatment, leads to considerably less transport of the cut dentine into the apex part of the canal[29].

Efficient cleaning of the apical third and clean walls without smear layer were also observed after the application of the specific self-adjusting file (SAF-Self Adjusting File) in the canal instrumentation. The irrigation solution flows through the SAF file to provide a permanent freshness which is additionally activated by the movements of the file[2].

What is interesting in this study is the fact that the chemo-mechanical preparation of the canal was done with only one instrument and thus confirmed that the efficacy of cleaning does not depend on the number of used instruments[30], but above all from the diameter of apical preparation[1,15,24] or from type, volume, concentration, and irrigation protocol[11,31].

The results of this study indicated that the apical segment of the canal was clean and without a smear layer in a high percentage, although only 2% NaOCl solution was used for irrigation. These findings are inconsistent with the findings of the authors who suggest that the removal of the smear layer from the canal walls is mainly dependent on the usage of chelating agents[6,8,19,20].

Conclusions

Within the limitations of this study, it can be concluded that the chemo–mechanical instrumentation of root canal using XPS and 2% NaOCl solution provides efficient cleaning of the apical canal segment, primarily due to the adequate diameter of the apex preparation and the specific effect of the new instrument during canal preparation. The intermittent final irrigation protocol in three cycles improves the removal of the smear layer in the apical part of the canal.

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