EFFECT OF PASSIVE ULTRASONIC IRRIGATION ON THE REMOVAL OF ROOT CANAL FILLING DURING RETREATMENT PROCEDURES

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Abstract

The aim of this in vitro study was to evaluate the efficacy of passive ultrasonic irrigation used as adjunct during endodontic retreatment and its effect on the removal of obturation material from canal walls.

Thirty-six extracted human single-rooted teeth were instrumented and obturated with gutta-percha and zinc oxide-eugenol-based sealer using the lateral condensation technique. Teeth were stored at 37ºC in a humid environment for four weeks. The removal of root canal filling was performed using ProTaper™ universal retreatment rotary files without solvent. Teeth were then divided into three groups of 12 specimens each based on the irrigation technique: group 1) syringe irrigation technique with 5.25% NaOCl solution applied as a final irrigation; group 2) passive ultrasonic irrigation technique using # 25 stainless steel files and ultrasonic activation for one minute; group 3) passive ultrasonic irrigation technique applied three times of one minute each. The teeth were longitudinally split in half and photographed. The amount of residual filling material was evaluated according to Hülsmann's scoring system. Mann-Whitney U test revealed that the amount of residual filling material in group 3 was significantly lower than those of groups 1 and 2. PUI enhanced the removal of filling material from root canal walls during endodontic retreatment.

Keywords: Retreatment - passive ultrasonic irrigation – gutta-percha.

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EFFET DE L'IRRIGATION PASSIVE PAR ULTRASONS SUR LA DÉSOBTURATION CANALAIRE PENDANT LES PROCÉDURES DE RETRAITEMENT

Résumé

Le but de cette étude réalisée *in vitro* était d'évaluer l'efficacité de l'irrigation passive aux ultrasons, utilisée en complément au cours des reprises de traitement endodontique, sur l'élimination de matériaux d'obturation des parois canalaires. Trente-six dents humaines monoradiculées extraites ont été instrumentées et obturées avec de la gutta-percha et un ciment de scellement à base d'oxyde de zinc-eugénol en utilisant la technique de condensation latérale. Les dents ont été conservées à 37°C dans un environnement humide pendant quatre semaines. La désobturation du canal radiculaire a été effectuée à l'aide des limes rotatives ProTaper™ sans solvant. Par la suite, les dents ont été divisées en trois groupes de 12 dents chacun : groupe 1) irrigation finale à la seringue avec du NaOCl à 5,25% ; groupe 2) irrigation passive en utilisant des limes en acier inoxydable # 25 et activation aux ultrasons pendant une minute; groupe 3) irrigation passive aux ultrasons pendant une minute répétée trois fois. Les dents ont été sectionnées longitudinalement en deux moitiés et photographiées. La quantité de matériau d'obturation résiduel a été évaluée selon le score de « Hülsmann ». Le test Mann-Whitney U a révélé que la quantité de matériau d'obturation résiduelle dans le groupe 3 était significativement plus réduite que celle obtenue dans les groupes 1 et 2.

L'irrigation passive aux ultrasons a amélioré l'élimination du matériau d'obturation des parois lors des reprises de traitement endodontique.

Mots-clés: reprise du traitement canalaire – irrigation canalaire - gutta percha.

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Introduction

Proper sealing of the root canal system is required to maintain the disinfection obtained after cleaning and shaping, in order to facilitate the repair process of the periapical tissues. Correct preparation of the root canal system and a hermetic obturation are prerequisite to prevent recontamination and to ensure the success of the endodontic therapy [1].

Despite the high success rates of the endodontic treatment, the clinician should be prepared to retreat the root canal system if endodontic treatment fails [2]. Unfortunately, conventional root canal retreatment is one of greatest technical difficulties that endodontists face, since filling materials represent a mechanical barrier and their removal can be time- and effort-consuming [3].

Endodontic retreatment requires regaining access to the root canal system by removal of the original filling with endodontic hand files, heat instruments, ultrasonic instruments or engine-driven rotary files followed by cleaning, shaping and re-obturation [4, 5]. Several studies have shown that rotary instruments remove more filling materials during endodontic retreatment than manual instruments [6- 8].

Gutta-percha has been the material of choice for obturation since 1867. Even though it is easily removed, some *in vitro* studies have demonstrated the persistence of gutta-percha residues on the canal walls, especially in the apical third of the root canal, regardless of the sealer used and the retreatment method. These authors have suggested that the residual material can be minimized if the canal enlargement during retreatment exceeds that achieved prior to the initial root filling [9-11].

The nickel-titanium (NiTi) rotary instruments for root filling removal and root canal retreatment have been widely investigated [3, 6, 7, 12-17]. Their use allows the removal of the gutta-percha with no solvents [12], thus preventing the formation of a thin film of gutta-percha on the walls of the root canal [13]. Such film might reduce the action of intra-canal medicaments and the adhesion of the root canal sealer to the canal walls during the retreatment therapy.

Studies have reported that it is essential to remove all root canal filling material from anatomic ramifications and dentinal tubules to ensure cleaner root canal walls [4]. This facilitates the obturation of all of the root canal ramifications and decreases the residual microbial population [4, 18-20].

Irrigation of root canals with antibacterial solutions is an essential part of the chemo-mechanical preparation prior to canals obturation [21].

Irrigation is complementary to instrumentation in facilitating removal of bacteria, debris and necrotic tissue [22], especially from areas of the root canal that have been left unprepared by mechanical instruments [23]. The currently available evidence strongly favors NaOCl as the main endodontic irrigant [24].

The penetration of the irrigant and the flushing action created by irrigation are dependent not only on the anatomy of the root canal system, but also on the delivery system, the depth of placement, the volume of the irrigant and its fluid properties [23, 25-28].

Conventional irrigation with syringe and needle remains widely accepted [29, 30]. Classical endodontic handbooks refer to hand irrigation as a simple procedure [29] and provide general guidelines in order to maximize irrigation efficiency and avoid diffusion of the irrigant into the periapical tissue [31, 32].

The first use of ultrasonics in endodontic practice was described by Richman [33]. Martin et al. [34] demonstrated ultrasonically activated K files' ability to cut dentin. However, the uncontrolled movement of the file during ultrasonic preparation restrains their use in root canal shaping [35]. Also, it has been shown that ultrasonically driven files are effective in the "irrigation" of root canals [36]. Therefore, their use has evolved from primary instrumentation to a passive cleaning technique.

Passive ultrasonic irrigation (PUI) was first described by Weller et al. [37]. The "passive activation" refers to the fact that the instrument inserted inside the canal does not touch its walls. During PUI, a small file or smooth wire (e.g., file # 15) placed at the center of the root canal after shaping is ultrasonically activated. An "acoustic streaming" is generated [36], which will create small, intense, circular fluid movement (i.e., eddy flow) around the instruments. The eddying occurs closer to the tip than to the coronal end of the file, with an apically directed flow at the tip [38]. Since the root canal is enlarged, the file or wire can vibrate freely to enable acoustic streaming [36]. This latter increases the cleaning effect of the irrigant inside the canal by means of hydrodynamic cutting power [39]. Various studies have shown that NaOCl used with PUI removes more dentin debris, planktonic bacteria and pulp tissue from the root canal than syringe irrigation [40, 41].

Recently, passive ultrasonic activation has been proved to improve canal debridement [42, 43], disinfection [44, 45] and sealing [46]. PUI also has been recommended for removing Ca(OH)2 from the root canal (47, 48). The purpose of this *in vitro* study was to evaluate the efficacy of passive ultrasonic irrigation as effective method during endodontic retreatment in removing the obturation material from canal walls.

Materials and Methods

Specimens' preparation

Thirty-six extracted human single-rooted teeth with mature apices were used in this study. Teeth with extremely large canals and open apices detected on the radiographs were excluded from the study. The teeth were cleaned from soft tissue remnants, stored in a 0.1 thymol solution and washed with saline at the moment of use. Teeth were sectioned to provide remaining roots measuring 20 ± 0.05 mm in length.

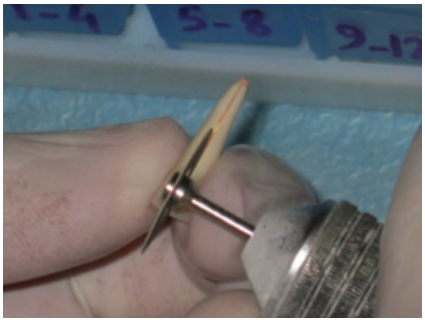

Fig. 1: Preparing the longitudinal groove on lingual surface.

Hulsmann score: Score I

Hulsmann score: Score II.

Hulsmann score: Score III.

Hulsmann score: Score IV.

Hulsmann score: Score V.

Hulsmann score: Score VI.

Root canals preparation

Access cavities were prepared using high-speed diamonds and water spray. Initially, apical patency was established by inserting a K file # 10 to 1 mm beyond the apex; the working length was established when the tip of the file was visible at the apex. The root canals were prepared using K3 rotary files (Kerr, Sybron Endo, California, USA). The instruments were used in a crown-down approach in the following sequence: 25 0.10, 25 0.08, 40 0.06, 35 0.06, 30 0.06 and 25 0.06. During instrumentation, canals were irrigated with 5.25% NaOCl solution using a syringe and a 26-gauge needle (Softec; Hwajin Medical, Chungnam, Korea). Final apical enlargement was done with 30 0.06.

Root canals filling technique

The canals were dried with paper points and then filled with gutta-percha and a zinc oxide-eugenol-based sealer (Sealite™ Regular; Acteon, Pierre Rolland, France) using lateral condensation. A # 30 master cone was fitted in each canal with a tug-back at the working length. The sealer was placed into the canal by means of the master cone and the root filling was laterally condensed with accessory cones using a # 25 finger spreader. Excess gutta-percha was removed at the canal entrance with heated instruments, before vertical compaction was used to condense gutta-percha at the coronal third of the root. The adequacy of the root canal filling was radiographically confirmed. Access cavities were sealed with Cavit (ESPE Dental, Medizin, Germany) and stored at 37° C in a humid environment for 4 weeks to allow complete setting of the sealer.

Retreatment Techniques

The obturation was removed from the canals using ProTaper™ Universal Retreatment rotary files (Dentsply Maillefer, Ballaigues, Orbe, Switzerland). These files were used in a crown-down approach in combination with a torque-controlled engine (NSK, Japan) at 500 rpm, according to the manufacturer's instructions. The root canal filling material was gradually removed using light apical pressure until the pre-established working length was reached. The D1 instrument (9% taper, size 30) was first used to cre-

Amount of residual filling material	Assigned value
I	1
II	2
III	3
IV	4
V	5
VI	6

Table 1: Assigned values for the different scores of the Hülsmann' system.

Amount of residual filling material	Syringe irrigation		Syringe irrigation + PUI for 1 minute		Syringe irrigation + PUI for 3 minutes	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
I	2	18.2	1	8.3	8	66.7
II	1	9.1	5	41.7	2	16.7
III	1	9.1	2	16.7	0	0
IV	1	9.1	2	16.7	1	8.3
V	2	18.2	1	8.3	1	8.3
VI	4	36.4	1	8.3	0	0
Total	11	100	12	100	12	100

Table 2: Amounts of residual filling material obtained in the three groups.

ate a pilot hole into the filling material; the D2 instrument (8% taper, size 25) was used in the middle third of the root canal and the D3 instrument (7% taper, size 20) in its apical part. Apical enlargement was then performed with manual files until K file #35. During all retreatment procedures, flutes of the files were cleaned with piece of gauze after each use. One set of ProTaper™ Universal Retreatment rotary files was used for the retreatment of six root canals.

The teeth were randomly assigned to 3 groups of 12 specimens each based on the final irrigation technique:

Group 1 (control group)

The canal was irrigated with a 5.25% solution of NaOCl using a syringe and a 26-gauge needle (Sofjec, Hwajin Medical, Chungnam, Korea). The solution was left in the canal for a minute. This procedure was repeated three times resulting in a total irrigation time of three minutes. At the end of this period, canals were thoroughly dried with absorbent paper points.

Group 2

The root canal was filled with a 5.25% NaOCl solution using the same syringe and irrigation needle as in the control group but the solution was left in place for a minute. This procedure was repeated three times. In the last minute, PUI was applied through an electrical ultrasonic unit (NSK Varios 560, Nakanishi, Tochigi, Japan). A stainless steel instrument (# 25) (Varios U files) was inserted into the root canal 1 mm short of the working length, and the irrigant was ultrasonically activated for one minute.

Group 3

Root canal system was filled with 5.25% NaOCl solution, using the same syringe and irrigation needle used for the control group. PUI was performed for one minute. This procedure was repeated three times, resulting in a total PUI time of three minutes.

Evaluation of root canal cleanliness

Following retreatment, the canals were dried with paper points. Longitudinal grooves were prepared with diamond discs on both external buccal and lingual surfaces (Fig. 1), without reaching the root canal space. Then, the roots were split in half with a chisel. Photographs were taken with a digital camera (Power Shot S45, Canon, Japan), and the amount of residual filling material was scored using modified Hülsmann's scoring system [7, 49] which consists of six categories:

I: Obturating material completely removed.

II: One to three small (< 2 mm extension) isles of obturating material.

III: More than three small (< 2 mm extension) isles of obturating material.

IV: Large residues of obturating material (> 2 mm extension).

V: Obturating material covering more than 5 mm.

Studied variable	Final Irrigation Technique	N	Mean Rank	Chi square	d.f.	p-value
Amount of residual filling material	Syringe Irrigation	11	23.82	9.95	2	0.007*
	Syringe Irrigation + PUI for 1 minute	12	19.67			
	Syringe Irrigation + PUI for 3 minutes	12	11.00			
	Total	35				

*: Significant at p-value < 0.01.
Table 3: Significant differences in the amounts of residual filling material revealed by the Kruskal-Wallis test.

Group A	Group B	U Value	p-value
Syringe Irrigation	Syringe Irrigation + PUI for 1 minute	44.5	0.178
	Syringe Irrigation + PUI for 3 minutes	23.5	0.006**
Syringe Irrigation + PUI for 1 minute	Syringe Irrigation + PUI for 3 minutes	30.5	0.013*

*: Significant at p-value < 0.05; **: Significant at p-value < 0.01.
Table 4: Results of the Mann-Whitney U test.

VI: Several isles (> 2 mm extension) of obturating material.

Statistical analysis

The Kruskal-Wallis test and the Mann-Whitney U test were performed to statistically analyze the effect of passive ultrasonic irrigation on the amount of residual filling material. The alpha error was set at 0.05. Results were processed and analyzed using a software program (SPSS for Windows, version 11.0, Chicago, IL, USA).

Results

One of the ProTaper™ Universal Retreatment rotary files was fractured in the canal in the group 1.
The amount of residual filling material was observed in all groups. This variable had 6 ordinal categories; each one was assigned a level-corresponding numerical value (Table 1).
The amount of residual filling material obtained for the three groups is shown in the table 2.
The Kruskal-Wallis test revealed significant differences in the amounts of residual filling material between at least 2 of the 3 studied groups of teeth (Table 3).
To make a pairwise comparison between the three studied groups, a Mann-Whitney U test was applied (Table 4).
Better results were obtained with the group 3 compared to groups 1 and 2 in terms of elimination of the filling material since the amount of residual filling material detected was significantly lower. On the other hand, no significant differences were found between groups 1 and 2 in the amount of residual filling material.

Discussion

The success of endodontic retreatment depends on the complete removal of the obturation material [4, 40]. To date, it has been proven that complete removal of the filling material is not possible, regardless of the retreatment method or the root canal filling material [11, 13, 40].
Numerous studies showed that the use of rotary devices, heat or solvents in endodontic retreatment should be followed by thorough hand instrumentation to achieve optimal cleanliness of root canal walls [41].
The ProTaper™ Universal system has proven its effectiveness in removing gutta-percha from the root canal [5, 7, 42]. In the present study, rotary instruments D1, D2 and D3 from the ProTaper™ retreatment kit were used in accordance with the manufacturer's instructions, at 500 rpm and in a crown-down approach. The final instrumentation was performed with manual files until the K file #35 reached the working length.
Passive ultrasonic irrigation is the most efficient method of ultrasonic irrigation

[36]. It follows root canal preparation, irrespective of the preparation method used, up to the size of the master apical file. In this way the ultrasonic file can oscillate freely in the root canal and its cutting action reduced to a minimum. When the file oscillates freely, acoustic streaming and/or cavitation are more powerful [50].

Of all the known irrigants, none is as effective as 5.25% sodium hypochlorite solution [51]. Irrigation with NaOCl combined with ultrasound or a wave vibration system has the greatest antibacterial effect. It has been established that passive ultrasonic irrigation in combination with sodium hypochlorite (NaOCl) is more effective than conventional hand irrigation in removing dentine debris from the root canal [22]. The application of this combination improves the exchange of substances in the canal, permits heating of the irrigant and eliminates dentin debris and part of the waste layer, thereby achieving greater cleaning effect [52].

The significantly increased capacity of NaOCl to dissolve organic material when it is agitated by ultrasound [53] or when the temperature rises because of ultrasound energy [54] is well established. In general, the literature recommends between 30 seconds and 3 minutes of NaOCl irrigation, although there is no defined consensus on the exact length of time.

Testing the efficacy of a retreatment procedure requires assessing the cleanliness of root canal walls. Wilcox et al. [13] and Imura et al. [55] split the teeth longitudinally. In both studies, the specimens were photographed, magnified and traced.

Residual gutta-percha was assessed radiographically [6, 17] or measured using evaluation scales, e.g. severe, moderate, mild or no-retreatment debris [12, 56].

In the present study, the roots were split longitudinally and the residual filling material was measured linearly. When sectioning the roots, the filling debris can be displaced and the technique ends up being unpredictable. Furthermore, images viewed from just one direction will not indicate the thickness of debris.

Delineation of the remaining filling material using softwares is more precise than the utilization of scores [7, 8]. This precision is related to image magnification on the computer, providing better quality of images.

Conclusion

Passive ultrasonic irrigation used as a final irrigation technique decreased the amount of residual filling materials during endodontic retreatment procedures. These results might be explained by the effect of acoustic streaming inside the canal, which can agitate the irrigation solution throughout the canal.

However, mechanical rotary root canal preparation couldn't by itself remove the entire root filling material, even though this was accomplished in some of the samples.

Further studies, using microscopic evaluation are needed before generalizing the results of this study.

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