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Debris extrusion during retreatment using continuous rotation motion of canal obturated with gutta-percha and bioceramic sealer using three different obturation techniques (An in vitro study)

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Aim: To evaluate the debris extrusion during retreatment using continuous rotation motion of canal obturated with gutta-percha and bioceramic sealer using three different obturation techniques.

Materials and methods: A total of forty-two extracted mandibular premolar single canals were used in this study. All teeth were divided into three groups according to obturation techniques (n=14 each); Group (A) using single cone technique (SCT), Group (B) using warm vertical compaction technique (WVC), and Group (C) using lateral condensation technique (CLC). During Retreatment, gutta-percha was removed using ProTaper Universal system retreatment files in continuous rotation motion. Debris extrusion during root canal filling removal was assessed using the microbalance.

Results: The highest mean weight of apical Debris extrusion was recorded with WVC technique followed by CLC while the least debris extrusion was recorded in SCT obturation technique. There was a statistically significant difference between group WVC and the other two groups, while there was no significant difference between group SCT and group CLC

Conclusion: Retreatment of canal obturated using single cone obturation technique and Bioceramics sealer extruded minimal amount of debris.

Keywords: Single cone technique; Warm vertical compaction technique; Lateral compaction technique; Bioceramics; Pro Taper Universal retreatment files.

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Introduction

Retreatment is a conservative, common procedure when failure occur in the initial root canal therapy, more challenging and takes more time than primary root canal therapy. The clinical challenge in retreatment is to know which tooth should be retreated and which should be extracted, know the cause of failure and identify solutions to repair pathological or iatrogenic defect in origin. Retreatment aims to bring the tooth to normal function by removing all remnants of necrotic tissue, removal of root canal filling materials(sealer and gutta percha)completely, proper root canal disinfection, minimizing post-operative pain, and reobturate root canal by obtaining proper apical seal to preserve the tooth and reach a high success rate. [1,2,3]

The root filling material's removal difficulty is based on on several aspects, including the root canal anatomy, the prior root filling technique, and the materials used.[4] Several obturation techniques have been advocated as the lateral compaction technique was used due to it is regarded as the gold standard, most studied and used technique; however, time consuming. In place of the lateral compaction filling approach, it was proven that warm vertical compaction technique provides larger amount of gutta-percha-filled area and is more efficient than cold lateral compaction technique, while there's a great need for an efficient and simple obturation method which will increase optimum management and decrease stress for clinician and patient, the single cone obturation technique with matched gutta-percha is fast and easier. [5]

Nowadays Bioceramics sealer have been recognized in modern practice due to their biological and physicochemical properties which have excellent sealing and filling to the canals.[6] The application of a single-cone with Bioceramics sealer is a recent technological advancement. Removal of a single cone is straightforward; however, may be more challenging to remove due to the greater amount of sealer used. The removal of bioceramic materials is a concern to clinicians because they penetrate deeper into dentinal tubules and harden after setting. [7,8]

Multiple techniques have been advocated to eliminate root canal filling material including manual endodontic files, mechanical nickel-titanium (NiTi) rotary instruments, reciprocation files, heated instruments, gates glidden, ultrasonic, and laser with adjunctive usage with or without solvent. Ni-Ti rotary retreatment kits were created since the conventional removal of a root canal filling with hand files can take a long time, particularly if the filling is densely packed. Rotary instruments make it easier to remove filling material.

During performing endodontic retreatment, apical debris extrusion produced during retreatment as an irrigation solution, residual vital or necrotic pulp tissue, pulp remnants, and microorganisms is unavoidable.[9] But needs to be minimal to avoid post-operative pain and inflammation for successful endodontic treatment. The amount of apical debris extrusion can be influenced by many factors as obturation techniques and instruments used. Up to this date, all techniques and instruments achieved apical debris extrusion.[10,11]

Previous studies generally examined how various retreatment materials and procedures affected the amount of debris extruded during retreatment. [12,13,14] After reviewing the literature, it has been determined how efficient the use of rotation motion using ProTaper universal retreatment files has been thoroughly investigated in several studies. [15,16] According to our knowledge there has been little research on the evaluation of the influence of different obturation techniques using Bioceramics sealer on apical debris

extrusion filling materials during endodontic retreatment were evaluated. [11]

Therefore, evaluation of apical debris extrusion after using the single cone technique, warm vertical technique, and cold lateral technique with bioceramic sealer was thought to be considered.

Materials and Methods

Sample Size calculation

A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there is no significant difference in the amount of debris extrusion during retreatment of root canal treated teeth obturated with three different obturation techniques using continuous rotation motion. By adopting an alpha level of (0.05) a beta of (0.2) i.e., power=80% and an effect size (f) of (0.498) calculated dependent on the results of a prior study 17; the predicted sample size (n) was found to be a total of (42) samples (i.e., 14 samples each group). Sample size calculation was performed using G*Power version 3.1.9.7 2.

Ethical consideration

The institutional ethical commission of Misr International University's Department of dentistry submitted this work as an in vitro study (registration no: MIU-IRB-2122-155). Written informed consent was obtained from patient attending MIU Dental clinic complex to use their extracted tooth. The teeth were de-identified for confidentiality. The data was saved in a secure database. printed and saved in a secure locker to be shared with supervisors for reviewing and then to the biostatistician for statistical analysis. The teeth were carried in a hazardous waste container and once the required tests were finished the teeth were incinerated

Inclusion Criteria: Extracted Single rooted with a single canal in mandibular premolars with oval-shaped root canals

Exclusion Criteria: Multi-rooted teeth, root fracture, external and internal resorption and open apex.

Sample preparation

A total of forty-two mandibular single-rooted premolars with oval-shaped root canals were used in this study. The teeth were radiographed digitally by shifts to exclude the presence of more than the single canal, calcifications, external or internal root resorption, pulp stones and to confirm the exitance of a straight single canal with full root development. K-file # 10 (Mani Inc., Tochigi, Japan) verified apical patency up until the apex was violated. Following that, the working length was adjusted to 1 mm less than the length at which the apical foramen of k-file size 15 was visible.

Sample instrumentation and obturation

Preparation of root canals was done in crown- down method using Universal ProTaper rotary files (PTUR) enlarged up to size #F4-File (#40, /06 taper) were reached (Dentsply Maillefer, Ballagaiues, Switzerland). The Endo Mate Endo motor of NSK was used (Nakanishi Inc., Tochigi, Japan). Sodium hypochlorite 5ml of 2.6% (NaOCL) was used for irrigation of the canals during the preparatory step, followed by regular saline. Subsequently, 2 min was used for applying a 17% ethylene diamine tetra-acetic acid (EDTA) solution, followed by a final flush with normal saline. Dryness of canals using paper point size #F4 to accommodate with size of gutta percha master cone. All canals were obturated using bioceramic sealer and gutta-percha (Sure-endo, Gyeonggi-do, South Korea). The specimens were grouped based on the type of obturation technique used (n= 14 each), i.e.

Group A: Single cone obturation technique, using gutta-percha master cone (0.06/40) that

corresponds with the last instrumentation of file used for preparation.

Group B: Warm vertical compaction, greater taper gutta-percha cone (0.06/40 gutta percha) corresponding to the last size of instrumentation, the coronal end of the cone cut off with a heated instrument, system B seared the canal to the orifice level, then pressed inside the gutta-percha to the binding point 5-7mm from the working length then vertical pressure with plugger of suitable size forced the plasticized material apically. The needle was inserted into the binding point in the backfill space then the space was filled up incrementally until reaching the expected level.

Group C: lateral compaction technique, using a master cone (0.06/ 40 gutta-percha) that matches the final file used for preparation. Then a size 30 NiTi finger spreader was introduced to WL, 2 mm short. For lateral compaction, 0.02/25 auxiliary cones coated with sealer were utilized.

Then temporary filling was utilized for sealing the access cavity of each sample. The quality of the obturation and the root canal filling's apical extent was evaluated by radiographing the teeth. Then for two weeks, the samples were kept at 37°C and 100% humidity to allow the sealer to completely set.

Sample retreatment

Retreatment was carried out on the crown down approach sequentially until the working length by using the ProTaper Universal system retreatment files (PTUR) (Dentsply Maillefer, Ballagaiues, Switzerland). The filling material in the coronal third of the root canal was removed using a D1 ProTaper file (30/.09 taper). The coronal two-thirds of the root canal was treated with a D2 ProTaper file (#25 /.08 taper). Light gentle apical pressure was applied by the D3 ProTaper file (#20 /.07 taper) until the working length was obtained. Then ProTaper Universal Rotary finishing file (F4) same as the master apical file of the initial endodontic treatment, re-prepared each sample for refining according to the manufacturer's instruction to accurately represent the debris extrusion associated with each obturation technique used. Irrigation of the root canal was done by 5ml of 2.6% NaOCL will be used as an irrigant between each file introduced through a 27-gauge needle and then with normal saline. Later on, 17% of EDTA was used for 2min to remove the smear layer, followed by a final flush with normal saline.

Method of Evaluation

Apical debris extrusion was evaluated following the removal of the root canal filling which is carried out using rotating techniques. According to the experimental model described by Myers and Montgomery 12 was used in this study. The empty Eppendorf tubes were weighed by placing them in microbalance weighing machine with an accuracy of ±0.001g (Chyo MJ-500, Kyoto, Japan). For each Eppendorf tube, the mean reading for each tube was calculated by taking three consecutive readings. After the tooth was prepared, the Eppendorf cap was taken from another Eppendorf tube and modified by drilling holes to fit the sample that was being tested for each tube group was recorded.

Each sample was firmly placed inside the modified cap until the cement-enamel junction. Then to maintain a balance between the internal and external air pressure, a 30-gauge needle was inserted inside the hole beside the sample before measurement. The gaps between the needle, sample, and hole were plugged with cyanoacrylate to avoid the leakage of irrigation solution through the hole. The Eppendorf tube was then filled with the adjusted cap containing the needle and tooth, allowing the root to hang inside without coming into contact with the tube. 18

In addition, the Eppendorf tube with the attached tooth was placed into a glass vial covered with white tape to avoid bias during the instrumentation procedure and to prevent the operator from directly touching the tube.

After the retreatment procedure was completed, the modified cap with the needle and the attached sample was partially removed from the Eppendorf tube. Then the debris that had stuck to the tooth's root apex was washed off with distilled water inside the tube. The Eppendorf tube was removed from the glass vial which was then weighed again using the same electronic weighting machine after incubation at 37°C for 15 days for evaporation of the moisture. The mean value for each tube was then determined by recording three consecutive readings. Calculation of the weight of apically extruded debris was done by subtracting the weight of the empty tube from that of containing debris [17,19] then the mean value for each group was recorded.

Statistical Analysis

Numerical data were presented as mean and standard deviation (SD) values. They were examined for normality by checking the distribution of data and using Shapiro-Wilk test of normality. Data were analyzed by applying One way ANOVA to compare results followed by Post Hoc test for multiple comparisons between different groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed using the SPSS statistical package (version 25, IBM Co. USA).

Results

The apical debris extrusion

Warm vertical obturation technique achieved the highest mean weight of apical debris extrusion weight followed by lateral condensation technique, while single cone obturation technique achieved the lowest one. There was a significant difference between group B (WVC) and the other two groups, while there was no significant difference between group A(SCT) and group C (CLC). Also, the overall P-value was statistically highly significant. (Table 1)

TABLE (1): Mean ±SD and inter-group comparison of weight of apical debris extrusion in the three obturation technique

Groups / Apical debris Weight (mg)	Group A (Single cone)	Group B (Warm vertical)	Group C (Cold lateral condensation)	P-value*
	15.57±4.13B	33.36±13.74A	17.86±4.91B	< 0.001HS

*** Overall P-value for Inter-group comparison between the main groups (ANOVA test).**
-Capital letters for inter-group comparison (Tukey Post Hoc test) and the means with different superscripts are statistically significant different at P ≤ 0.05, HS= Highly significant at P ≤ 0.001

Discussion

Complete removal of preexisting obturation material is important for root canal retreatment since it permits instrumentation and the root canal system's redisinfection. The root-filling material's removal is based on several aspects, including as the type of sealer utilized, the anatomy of the root canal, and the previous root-filling technique used. [6,13] To minimize irritation and pain by selecting the most suitable retreatment technique to remove the preexisting filling material completely and quickly while minimizing apical debris extrusion.

Cold lateral compaction (CLC) was used in this study as gold standard, a widely used, studied technique, and newer obturation techniques are often compared to it. [20] Although the problem is that it mainly relies on a root canal sealer to achieve a fluid-tight seal in root canal. Another obturation technique used in the current study, which is the warm vertical compaction (WVC) has been found better than the lateral condensation technique as it shows better three-dimensional adaptation to the root canal walls and provides a greater amount of gutta-percha filled areas but effective removal of these obturating materials is challenging. [1] In the last decade, with the widespread of rotary NiTi

instruments, allowing to creation of a root canal space with comparatively standard geometry, the filling of the root canals with single cone technique with taper-matched gutta-percha points has started to be applied due to the efficient, fast and simple obturation method, relatively straight forward compared with canals filled with warm vertical and cold lateral compaction gutta-percha techniques, which will increase outcomes and optimum management, in addition, decrease stress for clinicians and patients. [7]

Recently new generation Bioceramics sealers (BCS) have been introduced to the market due to their biocompatibility and physicochemical properties which improved sealing ability. [21,22] Concerning these properties of bioceramic sealers, the data present in the literature show controversial results. According to some authors, bioceramic sealers are harder and more resilient compared to other sealers. [23] Other authors have found that the residual material is comparable.[24,25]

Previous articles reported that invincible to avoid apical debris extrusion irrespective of the technique used for root canal instrumentation.[26] The analyzed continuous rotation systems extrude less debris extrusion toward the periapical tissues than the reciprocating systems. It has been shown that the dynamic of the alternating movement, which is a very aggressive action that removes a large quantity of material in a short amount of time, may cause single-file reciprocating systems to extrude and push a greater amount of filling material and debris towards the apex. [27] On the other hand, coronal displacement of the filling material is made possible by continuous rotating movement.

In the present study, we used rotation motion with ProTaper universal retreatment (PTUR) in the crown-down technique as it removes a great amount of gutta-percha through spirals running around the instruments, which gives cutting and softening action. Using tip diameters and taper sizes of 30,0.09, 25,0.08, and 20,0.07, respectively, PTUR consists of three instruments: D1, D2, and D3. These instruments demonstrate a progressive increase in taper and length.[28]

Regarding the master apical file size that could be attained during retreatment, There's no agreement in general. In the present study, the master apical file reached during the initial endodontic treatment was F4 (#40, 0.06). During retreatment, the apical diameter of the D3 which is the last instrument of the PTUS retreatment file (size 20) was designed to reach the working length, but it prevents the proper cleaning action. Therefore we used in addition Universal ProTaper rotary finishing file size #F4-File (#40, /06 taper) during retreatment same as the master apical file reached during initial endodontic treatment for root canal refining, ensure great contact with the canal walls and to accurately represent the debris extrusion associated with each obturation technique used.[29] In the present study we used ProTaper universal retreatment files without the addition of solvent to prevent the forming of a thin layer of filling material that is adhered to the dentinal walls and difficult to remove.[20] However, there is some debate regarding the effectiveness of using a solvent to help remove the filling mass.[16]

In the current study for weighting the apical debris extruded, the method of Myers and Montgomery [12] was used during retreatment procedure since is preferred common and precise measurement technique to collect debris. The limitations of this study are that the condition of the periapical tissues, pulpal status as well as the pressure at the periapex cannot be mimicked. In order to replicate clinical condition, 2.6% sodium hypochlorite was used as an irrigant; however, this process can also result in the development of

sodium hypochlorite crystals, which raises the weight of the apical extruded debris that is collected. Alternate to use distilled water as an irrigant to avoid inaccurate weight measurement due to NaOCl crystallization.

According to the result of apical debris extrusion in the current study, WVC technique achieved the highest mean of apical debris weight while SCT achieved the lowest one. There was a significant difference between group WVC and the other two groups, while there was no significant difference between group SCT and group CLC. These findings are in agreement with Canaki et al [30] who reported that the amount of debris extrusion was significantly greater with WVC than CLC in the gutta-percha using rotation motion and AH sealer. This explained by the flow of plasticized gutta-percha in irregularities and lateral canals, greater mass of gutta percha in WVC, while the greater amount of sealer in CLC and spreader tract may reduce the adaptation of gutta-percha and homogenous obturation material.

On the contrary to our result in apical debris extrusion. Turker et al [13] who demonstrated that similar amounts of apically extruded debris were found in SCT and CLC, but larger amounts were found in the non-solvent groups compared to the solvent. This could explain why there was less extrusion because the solvent softens the filling material and leaves more gutta percha and sealer remnants inside dentinal tubules and on root canal walls.

Our result in debris extrusion in the current study may be explained that the more BC sealer penetrated inside dentinal tubules due to the strong chemical bond with root dentin and less gutta percha make more resistance to apical debris extrusion. Up to our Knowledge irrigation protocols, kinematics and all obturation techniques generated apical extrusion of debris.[30]

Conclusion

Considering the limitations of this in vitro study, it may be concluded that:

1- Apically extruded debris was detected during the retreatment of canals obturated using different compaction techniques, especially warm vertical compaction.

2- Retreatment of canal obturated using single cone obturation technique and Bioceramics sealer extruded a minimal amount of debris.

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This study was self-funded.

Conflicts of interest

Conflicts of interest related to this work are denied by the author

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