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EVALUATION OF THE CLEANLINESS OF ROOT CANALS AND THE ADAPTABILITY OF ROOT CANALS FILLING MATERIAL AFTER USING THE XP ENDO FINISHER AND PASSIVE ULTRASONIC IRRIGATION DURING RETREATMENT

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ABSTRACT

Objective: This study evaluated the cleanliness of root canals and the adaptability of root canals filling material after using the XP Endo finisher (XP-F) and passive ultrasonic irrigation (PUI) during retreatment. **Methods**: 53 recently extracted mandibular premolars were used that were instrumented to a size 50 then blocks were grouped into; **G1**: Cleanliness (Cl) group and **G2**: Adaptability (Ad) group. The blocks in Cl group were sectioned longitudinally then reassembled and reinstrumented to a size 50. Then the canals in Cl & Ad groups were obturated then the root filling material was removed and canals were cleaned with XP-F or PUI. Furthermore, specimens in Cl group were evaluated using a digital microscope to image the remnants while canals in Ad group were reobturated and sectioned horizontally that were examined using push out test to evaluate adaptability and data were statistically analyzed. **Results:** When compared cleanliness of canals from remnants, there was no significant difference between subgroups. Furthermore, the $Ad_{XP\text{-}F}$ and Ad_c subgroups had significantly higher values than Ad_{PUI} subgroup. **Conclusions:** Both XP-F and PUI perform the same with regards to removing of remnants. When using the XP-F instrument, the adaptability of the root canal filling material to the root canal walls improved.

INTRODUCTION

Although root canal treatment has demonstrated a success rate of higher than 90% when properly treated, failure may occur and are often associated with poorly treated canals [(1)]. In case of endodontic failure, retreatment becomes necessary. It can be done non-surgically or surgically. More recently with technologies like microscopy and ultrasonic, non-surgical retreatment has become more common. Non-surgical retreatment involves the removal of root canal filling material from the root canal system followed by cleaning and shaping and refilling of the canals to ensure a favorable outcome[(2)]. Several methods can be used to remove the root canal filling materials. Examples of instruments that can be used to remove gutta percha and sealer are stainless steel hand files, Ni-Ti rotary instruments, heat-bearing instruments[(3)] that are sometimes used in conjunction with an organic solvents to facilitate softening and removal of the gutta percha and sealer[(4)]. Another effective method for removal of gutta percha and sealer from the root canal is passive ultrasonic irrigation (PUI), which has been proven to minimize the amount of gutta percha and sealer remnants in the canal even from anatomic areas that are difficult to access[(5)]. Although the efficacy of different methods of removal varies, studies have shown that is almost impossible to remove gutta percha and sealer completely [(6-8)] especially in curved root canals [(7)]. This gutta percha and sealer remnants may result in reduced the adaptability of new root canal filling

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material to be placed after retreatment. Recently, a new cleaning instrument has been introduced in the dental market by FKG company called the XP Endo Finisher. The company advocates that it can be used to clean canals after conventional cleaning and shaping. According to the manufacturer, once activated, the curved instrument will clean canals and touch a higher percentage of root canal walls than conventional rotary instruments [9]. To date, there is no studies have been done to evaluate the efficacy of the XP Endo Finisher with regards to removal of gutta percha and sealer remnants during retreatment and also there is no studies have been done to evaluate the adaptability of root canal filling material to root canal walls after using the XP Endo Finisher during retreatment.

MATERIALS AND METHODS

Selection of the teeth

A total of 135 recently extracted single and straight rooted mandibular premolar teeth with apical foramen that opened apically were collected from patients aged between 20 and 40 years old. The selected teeth were cleaned of calculus and soft tissue remnants using a periodontal curette. They were evaluated using a dental operating microscope (DOM) (8x) and radiographs to exclude any external or internal defects respectively. The root length of the selected teeth were 13 or 14 mm in length. The selected teeth were immersed in 5.25% sodium hypochlorite (NaOCl) for 10 minutes for disinfection. After that, all teeth were stored in distilled water at room temperature until the time of use in the study.

Preparation of the teeth and construction of the blocks (n=53)

Resection of the crowns of the selected teeth was done at 13 mm from the apex. The mesiodistal and buccolingual dimensions of the canals were checked to be smaller than 0.98 mm on the resected root surface using a digital caliper. Canals with dimensions more than that were excluded from the study and replaced with another one. Prior to instrumentation, working length of the canal of the root portion was determined by introducing a size #10 k-file into the canal till it appeared at the apical foramen then subtracting 1 mm from this length. A circular plastic mold (12 cm in diameter and 1.3 cm in thickness) containing 10 square shape holes (1.4 cm in width and length) was fabricated for construction of an acrylic blocks containing root portions in their centers.

Cleaning and instrumentation of the canals (n=53)

Cleaning and instrumentation were done using i-Race rotary nickel titanium files with a sequence R1 (size 15 taper 0.06), R2 (size 25 taper 0.04), R3 (size 30 taper 0.04) then the canals were enlarged using bio-Race files with a sequence size 35 taper 0.04, size 40 taper 0.04, size 45 taper 0.02 and finally using size 50 taper 0.04. The canals were irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl) in between each file. After completion of cleaning and instrumentation, the canals were irrigated with 2 ml of 17% EDTA and left for 1 minute and subsequently rinsed with 2 ml of distilled water. The canals were dried with paper points size 50 taper 0.02.

Grouping of the blocks

After cleaning and instrumentation of the canals were done, the blocks were divided into two main groups according to the evaluation method used as follow;

Cleanliness group (Cl): (n=14) the canals in this group were evaluated for the cleanliness. This group was subdivided into two subgroups according to the cleaning method of the root canals as follows:

- **$Cl_{XP\text{-}F}$ subgroup: (n=7)** the canals in this subgroup were cleaned using the XP Endo Finisher instrument (XP-F).

- **Cl_{PUI} subgroup: (n=7)** the canals in this subgroup were cleaned using the passive ultrasonic irrigation (PUI).

Adaptability group (Ad): (n=39) the canals in this group were evaluated for the adaptability of the root canal filling material to the root canal walls. This group was subdivided into three subgroups according to the cleaning method of the root canals as follows:

- **Ad_{XP-F} subgroup: (n=13)** the canals in this subgroup were cleaned using the XP-F.
- **Ad_{PUI} subgroup: (n=13)** the canals in this subgroup were cleaned using the PUI.
- **Ad_{C} subgroup: (n=13)** the canals in this subgroup had no retreatment procedures representing a positive control group.

Cleanliness study

Sectioning and reassembling of the blocks (n=14) (ClXP-F and ClPUI subgroups)

After cleaning and instrumentation of the canals were done, the blocks in ClXP-F and ClPUI subgroups were sectioned longitudinally in buccolingual direction at the center of the canal to create two halves using isomet 4000. The two halves of the block were reassembled using a small amount of glue at the periphery of each half and quickly mounted the reassembled block in the rectangular copper mold to achieve the most adaptation.

Reinstrumentation of the canals (n = 14)

After mounting the reassembled block in the rectangular copper mold, the canal was reinstrumented to enlarge again to a master apical file size 50 taper 0.04**.** The canal was reinsrumented as mentioned previously.

Obturation of the canals (n = 14)

Obturation was accomplished using a master gutta percha cone size 50, taper 0.02 coated with Adseal sealer. Lateral compaction technique was done using a spreader size 50 for master cone and a spreader size 25, taper 0.02 for accessory gutta percha cones size 25, taper 0.02. Excess coronal gutta percha was removed with a heated plugger. The blocks were then stored in an incubator at 37°C and 100% humidity for 4 weeks to allow for the complete setting of the sealer. Canals cleaning, instrumentation and obturation were performed by a single operator to avoid interoperator variability.

Bulk removal of gutta percha and sealer (n = 14)

After complete setting of the sealer, the bulk of gutta percha and sealer was removed from the canal using the D-RaCe retreatment instruments with a sequence: DR1 (size 30, taper 0.1 at 1000 rpm and 1.5 Ncm) , DR2 (size 25, taper 0.04 at 600 rpm and 1.5 Ncm) then instrumentation of the canals was done using the bio-Race instruments with a sequence: size 30 taper 0.04, size 35 taper 0.04, size 40 taper 0.04, size 45 taper 0.02 and finally using size 50 taper 0.04. The canal was irrigated with 2 ml 5.25% NaOCl in between each file.

Cleaning of the canals (n = 14)

After removal the bulk of gutta percha and sealer from the canals, the canals were further cleaned using the XP-F instrument for Cl_{XP-F} subgroup (n = 7) or using irrisafe ultrasonic tip for Cl_{PUI} subgroup (n = 7). The root canals were filled with warmed 5.25% NaOCl at 37°C. The two instruments were operated in the canal up to the full working length. The reassembled blocks were placed in a water bath at 37°C to intimate the clinical setting. They were applied for 30 seconds within the canal in a slow up and down motion, the canals were then flushed with 3 ml of warmed 5.25% NaOCl and they were applied again for 30 s using the same method with flushing another 3ml of warmed 5.25% NaOCl. A total of 6 ml of warmed 5.25% NaOCl was used and the total activation time was 1 min then paper points (size 50, taper 0.02) were used to dry the canals.

Evaluation of cleanliness (n=14)

Prior to evaluation, each block in these subgroups was separated manually into the previous two halves. An image of each root half was captured at 30x using a digital microscope, and the amount of remnants in the canal was quantified using the NIH Image J V1.56 software program. The remnants were expressed as a percentage of the canal lumen area.

Adaptability study

Obturation of the canals (n = 39) (all Ad subgroups)

Obturation was accomplished as previously mentioned in cleanliness study using a master gutta percha cone size 50, taper 0.02 coated with sealer using lateral compaction technique and accessory gutta percha cones size 25, taper 0.02. The blocks were then stored in an incubator at 37°C and 100% humidity for 4 weeks to allow for the complete setting of the sealer.

Bulk removal of gutta percha and sealer (n=26) (AdXP-F and AdPUI subgroups)

After complete setting of the sealer, the bulk of gutta percha and sealer was removed from the canal using the D-RaCe retreatment instruments and Bio-Race files as previously mentioned in cleanliness study.

Cleaning of the canals (n=26) (AdXP-F and AdPUI subgroups)

After removal the bulk of gutta percha and sealer from the canals, the canals were further cleaned using XP-F instrument for $Ad_{XP\text{-}F}$ subgroup (n = 13) or using irrisafe ultrasonic tip for Ad_{PUI} subgroup (n = 13) as previously mentioned in cleanliness study.

Reobturation of the canals (n=26) (AdXP-F and AdPUI subgroups)

After cleaning of the canals, they were reobturated with a master gutta percha cone size 50, taper 0.02 that was coated with sealer using lateral compaction technique and accessory gutta percha cones size 25, taper 0.02 as previously mentioned.

Evaluation of the adaptability(n=39) (all Ad subgroups)

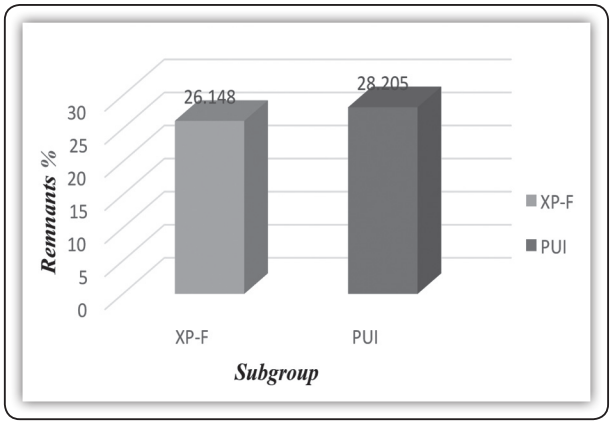
After complete setting of the sealer, the blocks were prepared to evaluate the adaptability of the root filling material to the root canal walls using the push out bond strength test. They were sectioned using isomet 4000. After sectioning, the specimen slice was subjected to compressive loading via a computer controlled materials testing machine with a load cell of 5kN and data were recorded using computer software and loaded at a crosshead speed of 0.5 mm/min.

Statistical analysis of the data

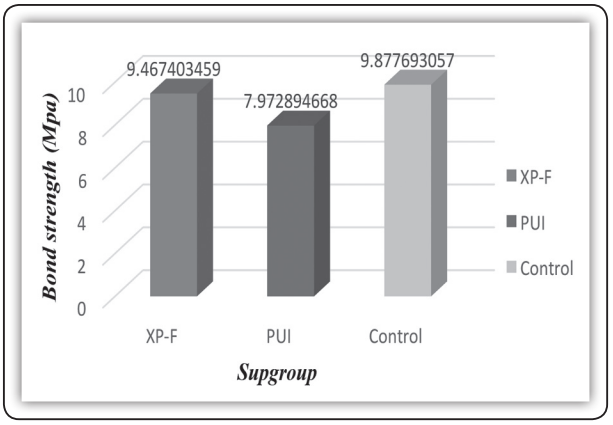
Data analysis was performed in several steps. Initially, descriptive statistics for each subgroup results. One way ANOVA followed by pair-wise Tukey's post-hoc tests were performed to detect significance between main subgroups (in push out bond strength test results) and root thirds. Student t-test was done between main subgroups in cleanliness test results. Two-way ANOVA was done to detect effect of each variable (Subgroup & thirds) using Microsoft excel. Statistical analysis was performed using Grapg-Pad Instat statistics software for Windows (www.graphpad.com). P values < 0.05 are considered to be statistically significant in all tests.

RESULTS

Firstly, for cleanliness study, the data was statistically analyzed using student t-test to compare the cleanliness of canals from gutta percha and sealer remnants after using the XP-F and PUI in percentage. There was no significant difference between $Cl_{XP\text{-}F}$ subgroup (26.148±1.133 %) and Cl_{PUI} subgroup (28.205±3.094 %) (P value =0.3473 > 0.05) (Histogram 1).



Histogram (1) showing the total mean values of percentage of gutta percha and sealer remnants for different cleaning methods subgroups through whole root canal length



Histogram (2) showing the total mean values of bond strength for different adaptability subgroups through whole root canal length

Secondly, for adaptability study, One way ANOVA test was used for analysis of the treatment modalities with regards to bond strength in megaPascals that showed the $Ad_{XP\text{-}F}$ (9.467±1.731 MPa) and Ad_{C} (9.878±1.647 MPa) subgroups had significantly higher values than Ad_{PUI} subgroup (7.793±1.387 MPa) (P value = 0.0086 < 0.05) while there was no statistical significant difference between $Ad_{XP\text{-}F}$ and Ad_{C} subgroups (P value > 0.05) (Histogram 2).

DISCUSSION

Mandibular premolars were selected in this study for ease of standardization because they commonly have a single straight canal in a bulky root. This is similar to other research done in this field [10,11]. The teeth were collected from patients with ages ranging between 20 and 40 years to minimize variation in dentin nature as a result of secondary and sclerotic dentin deposition [12]. The crowns of the premolars were removed to standardize the reference point and to facilitate the instrumentation of the canals. The root portions were adjusted to be 13 mm in length for standardization the working length. The mesiodistal and buccolingual dimensions of the canal lumen were measured on the resected root surface with a digital caliper. Root portions with canal lumens with dimensions larger than 0.98 mm were excluded from the study and replaced with other ones. This dimension (0.98 mm) is equal to the diameter of the master apical file at D12.

Canals were enlarged to a size #50 taper 0.04 because during specimen sectioning, a lumen size smaller than this would have resulted in complete obliteration of the canal space. Furthermore, this diameter was chosen so that the apical part of the canal was enlarged enough to correspond to the available plunger size during evaluation of the adaptability. When preparing specimens for cleanliness evaluation, sectioning and reassembling of the blocks was done before application of the different treatment modalities. This is unlike most research done in this field, in which sectioning is done after application of the treatment modalities [13,14,15] which has disadvantages such as contamination of the specimens or displacement of the gutta percha and sealer remnants during sectioning [16]. The former has the advantage of avoiding these disadvantages. The longitudinal sectioning method was chosen for cleanliness evaluation because it enables a direct examination of the root canal space and it is also cheap and available. The canals were obturated using the lateral compaction method because it is a common technique for obturation that has been used in many similar studies [10,15,17]. After obturation,

the blocks were left for 4 weeks at 37°C in 100% humidity to ensure the sealer setting[18]. The ultrasonic tip was activated for 1 minute. This is similar to other studies done in this field [13,19]. In the present study when evaluating cleanliness, neither the XP-F nor PUI were capable of entirely removing gutta percha and sealer remnants from the root canals. When comparing between the Cl_{XP-F} and Cl_{PUI} subgroups totally with regards to cleanliness, there was no statistically significant difference between them. This finding is similar to the results of other studies done to evaluate the efficacy of XP-F and PUI with regards to cleanliness of the root canals [20,21]. When evaluating the post retreatment adaptability using the push out bond strength test it was found that the Ad_C & Ad_{XP-F} subgroups had significantly higher values of bond strength when compared to the Ad_{PUI} subgroup. The control subgroup was a positive control that was used to simulate optimum adaptability of the root canal filling materials to the root canal walls. This is reflected very clearly in the results of the study. The reason why the Ad_{XP-F} subgroup had a higher average bond strength value than the Ad_{PUI} subgroup may be attributed to the fact that it may be more efficient in cleaning the canals as mentioned previously [13]. To date there is no research available in which post retreatment obturation bond strength has been evaluated after using the XP-F instrument.

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