

Evaluation the efficiency of mechanical and/or chemical cleaning methods of endodontic sealer remanent of the pulp chamber dentine and its effect on the bond strength of composite restoration by micro tensile bond strength

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Abstract:

Aim: The current research intended to assess the efficiency of mechanical and/or chemical cleaning methods (Ultrasonic and/or Acetone) of endodontic sealer remanent on the pulp chamber dentine and its outcome on the bond strength with composite restoration to the pulp chamber by the micro tensile bond strength (μ -TBS), and its failure modes by stereomicroscopy. **Method:** 40 human permanent lower molars were selected to be used in this study. Every tooth has decoronated to 4 mm coronal to cementoenamel junction. The root canals were prepared via ProTaper Gold. ProTaper Gold obturators #F3 and AH Plus sealer were used for filling the canals.

2 mm apically of the occlusal gutta percha was removed to make a space for liner material. Glass ionomer restorative was used as liner material over the gutta percha to the level pulp chamber floor. The obturated teeth were then randomized divided into four identical test groups with 10 molars in every group. **Group 1 (Ultrasonic Cleaning)** the sealer remnant was cleaned by Ultrasonic tip ET 20D, **Group 2 (Acetone)** the sealer remnant was cleaned by Acetone. **Group 3 (Acetone / Ultrasonic)** the sealer remnant was cleaned by both Acetone / Ultrasonic, and the **Group 4 (Control)** was not comminated with the sealer. All teeth were received Bulk Fill Restorative composite to fill the pulp chamber, the preparing the teeth for the μ -TBS test and determining the types of failure modes. **Results: Group 1 (Ultrasonic Cleaning)** had the greatest reported μ -TBS (38.50 ± 7.91), while the least μ -TBS was reported in **Group 2 (Acetone)** 31.80 ± 7.42 with statistically significant different ($p = 0.007$). On other hand **Group 1 (Ultrasonic Cleaning), and Group 3 (Acetone / Ultrasonic)** showed results similar to the results of **Control Group with non-statistically significant different** ($P > 0.05$). In concerning the distribution of failure mode, showed that the mixed-type failure mode (54%) was the most common one seen in **Group 1 (Ultrasonic Cleaning)**, (51%) recorded in **Group 4 (Control)**, (50%) recorded in **Group 3 (Acetone / Ultrasonic)**, and the lowest was (39%) recorded in **Group 2 (Acetone)**. While the distribution of adhesive failure mode was (45%) recorded in groups **Group 2 (Acetone)**, (37%) recorded in **Group 3 (Acetone / Ultrasonic)**, and (30%) recorded in both **Group 1 (Ultrasonic Cleaning) & Group 4 (Control)**. **Conclusion:** Mechanical removal of resin sealer remanent by Ultrasonic Cleaning gives good condition for increasing the μ -TBS of composite restoration to the pulp chamber dentine of endodontically treated molars.

Introduction:

The coronal seal's integrity effect on the stability result of root canal therapy had been illustrated by many studies⁽¹⁻⁴⁾. Due to the incredible increasing in coronal filling restorations and its bonding technology that leads to immediately coronal sealing of teeth that have had endodontic treatment utilizing bonded restorative materials^(5,6). while root canal obturation procedures is done, some remanent of the sealer remain on the coronal dentin surface entering the dentin tubules⁽⁷⁾.

On other hand these sealer remnants will affect on the bond strength of the composite resin adhesion to the pulp chamber dentine and create a gap between the pulp chamber wall and the coronal filling that with time decrease the coronal sealing leading to failure⁽⁸⁾.

The residual presence of an epoxy resin-based endodontic sealer, AH Plus, greatly decreased the micro tensile bond strength between bonding agents and the coronal dentine. on other hand, it showed also tooth discoloration over 12 months^(9,10).

Root canal sealers contaminating the pulp chamber wall were removed using many techniques including ethanol, ethyl acetate acetone, chlorhexidine, isopropyl alcohol, dry cotton, and EndoSolv R⁽¹¹⁾.

So, the current research intended to assess the efficacy of mechanical and/or chemical cleaning methods (Ultrasonic and/or Acetone) of endodontic sealer remanent of the pulp chamber dentine and its effect on the bond strength of composite restoration by the micro tensile bond strength (μ -TBS), and its failure modes by stereomicroscopy.

Materials and methods:

For this investigation, 40 permanent mandibular molars that had just been extracted and showed no signs of decay or other flaws were chosen. The teeth were kept in distilled water at room temperature to avoid dehydration⁽¹²⁾. All teeth were examined under a magnification lens to check for cracks. To guarantee uniform pulp chamber shape, radiographs of every tooth were taken in the buccolingual and mesiodistal orientations.

The included criteria of the selected teeth:

The teeth were fully developed apex without interior resorption, decay, calcification of the canal, or history of endodontic therapy.

To standardize, every tooth has decoronated to 4 mm coronal to cementoenamel junction using diamond disc bur for standardization and making sure that the height of the pulp chambers wall is 3mm from pulp chamber floor.

To guarantee the apical patency of the canals, a K-file size 10 (Dentsply Maillefer, Switzerland) was transferred to the apex of each canal. The identical file was reinserted into the canal till it was observed through the apical foremen, at which point the working length (WL) was noted⁽¹³⁾.

ProTaper Gold (figure 1) rotary tools (Dentsply Maillefer, Ballaigues, Switzerland) were used for preparation the root canals, and 5,25% NaOCl was used as an irrigation solution. The final tool employed in the apical area was an F3 finishing file.



Figure (1): A photograph showing the ProTaper Gold rotary instruments.

Following preparation, 15% EDTA was used to cleanse the root canals (for removal of smear layer), 5,25% NaOCl, 0,9% NaCl, and paper points were used to dry them. ProTaper Gold obturators #F3 were employed in the root canal fillings, and the epoxy-resin based AH Plus sealer were used for filling the canals via the lateral condensation method. 2 mm apically of the coronal gutta percha was removed to make a space for liner material.

liner material placement:

Glass ionomer restorative (Ketac™ N100 Light-Curing Nano-Ionomer Restorative Refill (3M™, ESPE, U.S.A) shade A3) was used as liner material over the gutta percha to the level pulp chamber floor.

Teeth grouping:

The obturated teeth were then randomized divided into three identical test groups with 10 teeth in each group according to the method used for cleaning the endodontic sealer remanent from the pulp chamber dentine.

Utilizing a micro brush, uniformly apply a thin coating of newly mixed epoxy-resin AH Plus sealer to the dentine surfaces in each of the three intervention groups. Left the sealer undisturbed for 5 minutes. While the 4th group was a control group that had access cavity only without obturation and no contamination with the sealer.

Group 1: Ultrasonic Cleaning:

The contaminated dentin surface was accomplished utilizing an Acteon ET20D - Diamond Canal Prob. Use an ultrasonic tip (P5 Newtron, Satelec Acteon, Merignac, France) for 20 seconds, making pressure-free encountering the surface (figure 2).

Group 2: Acetone:

The contaminated dentin surface was removed by utilizing 99.5% acetone-saturated cotton pellets - Resin Cleaner (RPM Supplies Ltd: 46 Western Parkway Business Park, Lower Ballymount Road, Ballymount, Dublin 12, Republic of Ireland) for 20 seconds till a stereomicroscope image revealed no sealant on the dentine surface (figure 3).

Group 3: Acetone / Ultrasonic:

After using cotton pellets soaked in 99.5% acetone to cleanse the contaminated dentine surfaces, ultrasonic cleaning was performed as described method in group 1.

Group 4: Control:

Teeth that had access cavity only without obturation and no contamination with the sealer as well as the dentine surface of the pulp chamber was not cleaned.



Figure (2): A photograph showing Acteon ET20D - Diamond Canal Prob. Tip used in Group 1.



Figure (3): A photograph showing Acetone - Resin Cleaner used in Group 2.

Composite resin bonding to coronal pulpal dentine:

The pulp chamber of all teeth samples was washed with distilled water for 5 minutes and etched for fifteen seconds using a 37% phosphoric acid, then thoroughly rinsed using water and blot-dried.

The dentine surfaces were coated with a self-etch adhesive approach (3M ESPE, USA) in accordance with the directions provided by the supplier. A 3 mm Single-layer of composite resin 3M™ Filtek™ One Bulk Fill Restorative (3 M ESPE, St. Paul, MN, USA) were placed on the dentine surface and cured at ambient temperature. The composite was then exposed to light for 20 seconds utilizing a VALO (Ultradent) LED light-curing device (LCU) that had an irradiance of 1000 mW/cm². For a whole day, repaired molars were kept in water at 37°C (figure 4).



Figure (4): A photograph showing the composite used for pulp chamber restoration.

Preparing the specimens for Micro tensile bond strength testing:

The specimens were cut with the long access of each tooth to make 5 to 6 slices with 1-mm breadth, and these slices were cut utilizing a slow-speed diamonds blade such that they were perpendicular to the tooth buccal wall (adhesive contact). The molars were turned 90° and sliced to yield portions that were 1 ± 0.3 mm thickness. The portions were left connected to the remaining portion of the molar for additional division. From every molar, 3 to 5 slices were so extracted.

Three rods were used for each tooth. The samples were inspected optically and then assessed using Leica stereomicroscopy (model S8APO, LAS 3.4 software) at a magnification of 20×. Thirty sticks from each group were selected with total of 120 sticks were selected from all groups for the μ TBS test⁽¹⁴⁾ (figure 5).

Using cyanoacrylate adhesive, every sample was attached to a Geraldelli jig and tensioned (using a Micro-tensile tester from Isomet, USA) at a 1 mm/min crosshead speed until failure⁽¹⁵⁾. Bond strengths were computed by dividing the force applied until failure by the cross-sectional bonding region. Mega Pascals were used to compute bond strength and was measured in Newtons.



Figure (5): A photograph showing preparing a specimen to be measured by the Micro-tensile bond strength.

Using the stereomicroscopy at 40× magnification, the failure mechanisms were assessed and categorized into three categories as follows: (1) Cohesive (breakage along with the adhesive layer), (2) adhesive failure (failure

mode occurs when there is minimal adhesion on one or both sides of the bonding surface), and (3) mixed failure. Statistical analysis:

Using IBM, Chicago, IL, USA, SPSS software (version 22.0), an analysis of statistics was carried out. Tamhane's T2 post hoc tests and one-way analysis of variance (ANOVA) were used to compare the micro tensile bond strength results. The chi-square test was used to analyze the failure mode distributions.

Results:

The means and standard deviations of micro tensile bond strength were represented in Table (1) and illustrated in Figure (6) while the failure modes by (%) of different groups were represented in Table (2) and Figure (7).

Group 1 (Ultrasonic Cleaning) had the greatest reported μ -TBS (**38.50 ± 7.91**), while the lowest μ -TBS was reported in **Group 2 (Acetone)** **31.80 ± 7.42** with statistically significant different (p = 0.007).

On other hand **Group 1(Ultrasonic Cleaning), and Group 3 (Acetone / Ultrasonic)** showed results similar to the results of **Control Group with no** statistically significant different (P > 0.05).

Table (1) Showing the micro tensile bond strengths (MPa) of different groups.

Groups	means ± standard deviations
Group 1: Ultrasonic Cleaning	38.50 ± 7.91^A
Group 2: Acetone	31.80 ± 7.42^C
Group 3: Acetone / Ultrasonic:	35.95 ± 6.38^A
Group 4: Control:	33.91 ± 8.45^{AB}
P value	P = 0.007

Significant differences are indicated via various letters.

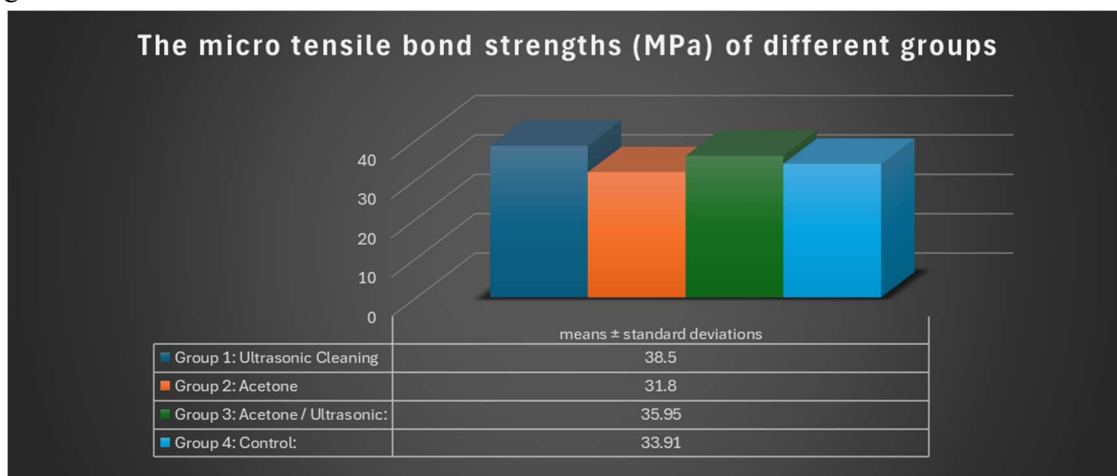
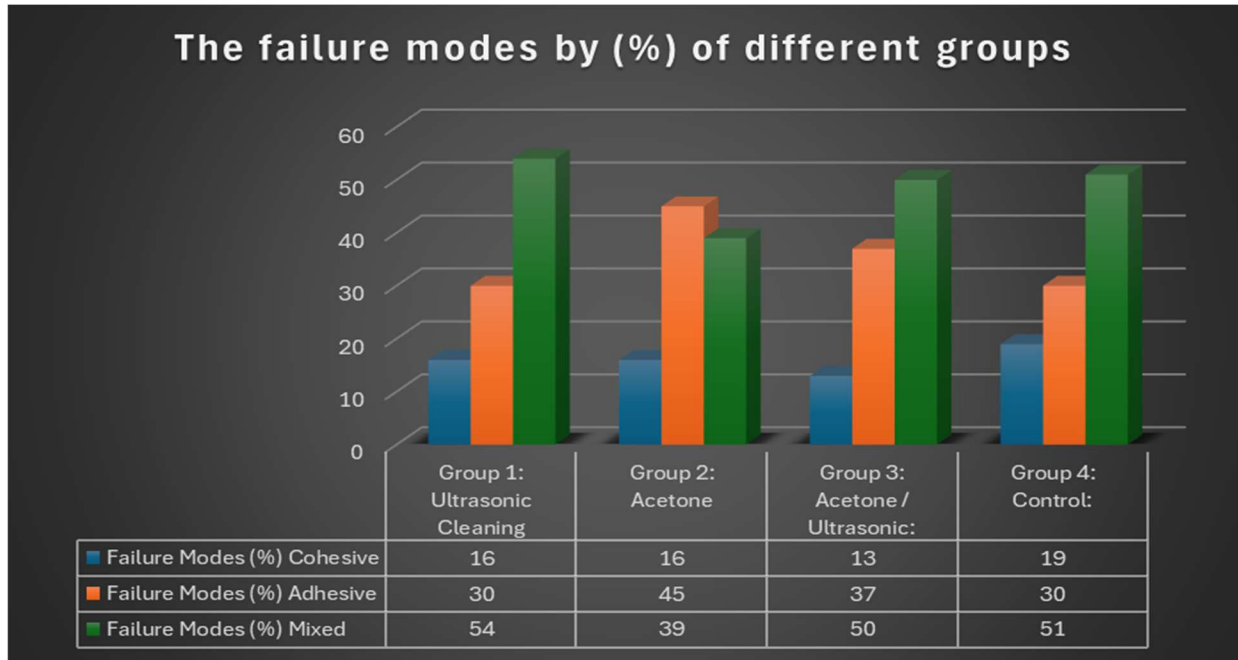


Figure (6): A photograph showing the μ -TBS means values

In concerning the distribution of failure mode, showed that the mixed-type failure mode (54%) was the most common one seen in **Group 1 (Ultrasonic Cleaning)**, (51%) recorded in **Group 4 (Control)**, (50%) recorded in **Group 3 (Acetone / Ultrasonic)**, and the lowest was (39%) recorded in **Group 2 (Acetone)**. While the distribution of adhesive failure mode was (45%) recorded in groups **Group 2 (Acetone)**, (37%) recorded in



Group 3 (Acetone / Ultrasonic), and (30%) recorded in both Group 1(Ultrasonic Cleaning) & Group 4 (Control).

Table (2) Showing the failure modes by (%) of different groups.

Groups	Failure Modes (%)		
	Cohesive	Adhesive	Mixed
Group 1: Ultrasonic Cleaning	16	30	54
Group 2: Acetone	16	45	39
Group 3: Acetone / Ultrasonic:	13	37	50
Group 4: Control:	19	30	51

Figure (7): A photograph showing the failure modes by (%) of different groups.

Discussion:

Preventing the coronal leak of microorganisms from the saliva oral cavity plays an important role in coronal sealing of root canal treated teeth ⁽¹⁶⁾. But in some times during the procedure of root canal thereby, the sealer used in obturation might have an impact on how materials and dentin interact, leading to undermining the development of a good coronal seal ⁽¹⁷⁾.

In this research the effectiveness of mechanical and/or chemical cleaning techniques (Ultrasonic and/or Acetone) of epoxy-resin based AH Plus sealer remnant removal from pulp chamber dentinal wall and how it affects the strength of the composite restoration to pulp chamber dentine by the μ -TBS, and its failure modes by scanning electron microscopic was compared.

All steps of root canal were done in natural teeth instead of using the tooth crown only for testing the bad effect of root canal sealer remanent on bulk-fill composite bonding to coronal tooth structures by μ -TBS evaluation to

mimic the clinical situation.

The few studies that had been published in the last years concerning after removing the sealer, several cleaning techniques were suggested, including using dried cotton pellets, and solvents were largely investigated. Mechanical drilling improvement, micro abrasion, and air polishing were the next steps ^(18,19).

To standardize, every tooth was decoronated to 4 mm coronal to cementoenamel junction using diamond disc bur for standardization and making sure that the height of the pulp chambers wall is 3mm from pulp chamber floor.

The current research employed the endodontic tip ET 20D because it is frequently utilized in root canal treatment for access preparation, calcified dentin removal, and orifice location. We used acetone to decontaminate the dentine with sealant and found that acetone produced a stronger binding than ethanol. ⁽²⁰⁾

In this research we used Bulk Fill Restorative to put 3 mm single layer of composite. Also, we used Micro-tensile bond strength evaluation due to the most commonly utilized tests for assessing adhesive solutions' bonding efficacy, is attributed to the bond strength assessment of very tiny samples (sectional widths < 1 mm²), and its homogenous strain and stress pattern is crucial in achieving the majority of the bond interfacial breakdown ⁽²¹⁾.

The outcomes of this research regarding the μ -TBS showed that the greatest μ -TBS was reported within **Group 1(Ultrasonic Cleaning) 38.50**, while the least μ -TBS was reported within **Group 2 (Acetone) 31.80** with statistically significant different ($p = 0.007$). On other hand **Group 1(Ultrasonic Cleaning), and Group 3 (Acetone / Ultrasonic)** showed results similar to the results of **Control Group with no** statistically significant different ($P > 0.05$).

These results may be due to the sealer residues were completely removed after using **Ultrasonic Cleaning** with ET 20D in medium wet mode producing sound cascading and swift microjet interaction that could remove any sealer residues from deep distance in the dentinal tubules, and additionally, the dentine surface's irregularity is encouraged by the ultrasonic endodontically tips enhancing the adhesion of resin to dentine and tubular penetration and in return increases the μ -TBS of composite resin to pulp chamber dentine ⁽²²⁾.

On other hand dentine primers include **Acetone**, which has a strong ability to remove water from the dentine surfaces. Because collagen fibres can collapse as a result of extensive acetone usage, the binding strength could be significantly affected ⁽²³⁾.

The results of this study was similar to **Hai-Ling et al** who stated that the μ -TBS might be maintained and endodontic sealer remnants removed using ultrasound alone or alongside acetone ⁽²⁴⁾, while our results was disagreement with **Peters et al** who stated that it doesn't seem that contamination with AH Plus sealer significantly affects the μ -TBS amongst dentin and an etch-and-rinse technique or bulk-fill composite ⁽²⁵⁾.

On other hand there was a study made by **Kolus et al** who advised to delay the application of adhesive restoration to other appropriate time after root canal treatment and with use of the effective sealer cleaning method to increase the bonding strength of the adhesive restoration to dentin ⁽²⁶⁾.

In concerning the outcomes of this research about the distribution of failure mode, showed that the mixed-type failure mode (54%) was the most common one seen in **Group 1 (Ultrasonic Cleaning)**, (51%) recorded in **Group 4 (Control)**, (50%) recorded in **Group 3 (Acetone / Ultrasonic)**, and the lowest was (39%) recorded in **Group 2 (Acetone)**. While the distribution of adhesive failure mode was (45%) recorded in groups **Group 2 (Acetone)**, (37%) recorded in **Group 3 (Acetone / Ultrasonic)**, and (30%) recorded in both **Group 1(Ultrasonic Cleaning) & Group 4 (Control)**.

This was explanted by the results of the Micro-tensile bond strength, when increasing the conditions for good

bond strength so, the adhesive failure modes will be decrease and the mixed failure modes will be increase ⁽²⁷⁾.

Conclusion:

Mechanical removal of resin sealer remanent by Ultrasonic Cleaning gives good condition for increasing the μ -TBS of composite restoration to the pulp chamber dentine of endodontically treated molars.

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