



THE IMPACT OF VARIOUS BIO CERAMIC ROOT CANAL SEALER REMOVAL TECHNIQUES ON THE STRENGTH OF THE BOND BETWEEN BULK FILL COMPOSITE RESIN AND SEALER-CONTAMINATED CORONAL DENTIN

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Abstract:

Aim: The current research directed to measure the efficacy of different bioceramic (**Total Fill BC**) root canal sealer removal methods on the bond strength between canal sealer-contaminated coronal dentin and Bulk Fill composite resin by the micro tensile bond strength (μ -TBS), and its failure modes by stereomicroscopy.

Method: Forty human permanent lower molars were selected to be used in this study. Each molar was decoronated cemento-enamel junction that is 4 mm occlusal. The root canals were prepared via Protaper Universal. Protaper Universal obturators #F3 and Total Fill BC Sealer were used for filling the canals. Following that, the obturated molars were randomly assigned to four equal experimental groups with 10 molars in every group. Group 1: Dry cotton, Group 2: Ultrasonic-15 seconds, Group 3: Ultrasonic-30 seconds, and Group 4: Control. the sealer remnant was cleaned as mentioned in each group. All teeth were received Bulk Fill Restorative composite to fill the pulp chamber, then preparing the teeth for the μ -TBS test. **Results:** Group 3 (Ultrasonic-30 seconds) had the greatest mean value

of μ -TBS 37.99 ± 5.87 , followed by **Group 4 (Control)** 36.89 ± 6.49 , then **Group 2 (Ultrasonic-15 seconds)** 34.57 ± 7.82 while the lowest μ -TBS was reported in **Group 1 (Dry cotton)** 18.28 ± 8.56 with statistically significant different ($p = 0.005$) between group 1 and the other groups, while there is no significant different in between groups 2,3, and 4 ($P > 0.05$).

Conclusion: In clinical settings, adding ultrasonic cleaning to endodontic procedures may significantly improve resin adherence and increase the efficacy of endodontic procedures.

Introduction:

Because they obstruct the pulp chamber and provide an extra barrier to the canal orifice, coronal restorations are crucial for improving the efficacy of root canal therapy because they prevent the entry of bacteria and toxin penetration from the occlusal direction ⁽¹⁻⁴⁾.

Due to its organic constituents and dentinal tubules that carry fluids and a range of compositions, bonding to typical dentin is naturally difficult. This problem is made worse by endodontic therapy because it alters the mechanical and physical characteristics of dentin or inhibits the polymerization of resin restorations ⁽⁵⁾.

Sealers, intracanal medications, and irrigations are essential components of endodontic therapy. Alterations in dentin, such as dryness or variations in the solubility of collagen and dentin, could result from irrigation. Additionally, sealers alter the dentin surface's reactivity and wetting ability. The remains of sealants or irrigation agents in dentin or dentinal tubules can weaken bonds and prevent adhesive polymerization ^(6,7).

The osteoinductive qualities, over time bactericidal impacts, and efficient sealing capabilities of bioceramic root canal sealers have drawn interest. In order to preserve a coronal seal, avoid reinfection, and guarantee an extended prognosis, an adequate restoration after root canal therapy is essential. Following root canal therapy, resin restorations are often utilized materials to both cosmetically and practically repair damaged tooth tissue. When binding strength is crucial, they may be used for occlusal sealing ⁽⁸⁻¹¹⁾.

Root canal sealers contaminating the pulp chamber wall were removed using many techniques including ethanol, ethyl acetate acetone, isopropyl alcohol, dry cotton, and EndoSolv R ⁽¹²⁾.

The integrity of composite bonding for post-endodontic restorations may be compromised by sealer contamination. So, the current research was directed to measure the efficacy of different bioceramic (**Total Fill BC**) root canal sealer removal methods on bond strength between canal sealer-contaminated coronal dentin and Bulk Fill composite resin by the micro tensile bond strength (μ -TBS), and its failure modes by stereomicroscopy.

Materials and methods:

Forty permanent mandibular molars that freshly extracted and displayed no indications of dental caries or other flaws were selected. 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 inclusion criteria of the chosen molars:

The molars had no evidence of endodontic treatment, internal resorption, caries, or canal calcification; they were fully grown apex.

Each molar has been sectioned to a 4 mm occlusal to cemento-enamel junction utilizing a diamond disc bur to ensure uniformity and that the pulp chamber wall is at least 3 mm above the pulp chamber floor.

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

Rotary files were used for the instrumentation of root canals (Protaper Universal, Dentsply, USA) till # F3. A torque control motor with a rotational speed of 250 rpm, the DENTA PORT ZX (J. MORITA

MFG. CORP. 680 HIGASHIHAMA, MINAMI-CHO) was used to complete the preparation. The irrigation used was 5.25 % sodium hypochlorite (Clorox, Egypt) after every file. After removing the smear layer with 10 ml of 17% EDTA (Meta Biomed, Korea), 3 ml of saline were used for the last rinse. With paper tips (Meta Biomed, Chungcheongbuk-do, Korea), all samples' canals were dried. F3 points (size 30) were used to obturate the canals in the samples. **Total Fill BC Sealer** on 0.04 ProTaper gutta-percha cones, via the lateral condensation method.

Teeth grouping:

Following obturation, the molars were randomly assigned to three equal experimental groups with 10 teeth in each group according to the method used for cleaning the endodontic sealer remanent from the pulp chamber dentine.

Using a micro brush, uniformly apply a thin coating of Total Fill BC Sealer to the dentine surfaces in each of the three groups. Left the sealer undisturbed for 5 minutes. While the 4th group was a control group that contaminated with the sealer but not cleaned.

Group 1: Dry cotton:

A dry cotton pellet was used for one minute to remove the leftover sealant from the cavity.

Group 2: Ultrasonic-15 seconds:

The residual sealer was removed by applying passive ultrasonic energy for 15 seconds while an endodontic ultrasonic tip (NSK Varios E4D; Nakanishi Inc., Tochigi, Japan) was connected to an ultrasonic instrument (NSK-Varios 750; Nakanishi Inc., Tochigi, Japan) at a 20–25-degree angle to the dentin surface lacking making contact.

Group 3: Ultrasonic-30 seconds:

The residual sealer within the root canals was passively removed using 30 seconds of ultrasonic energy, using the same protocol as the group that received 15 seconds of ultrasonic energy.

Group 4: Control:

The samples in the control group were filled with Bulk Fill composite resin, just like the other groups, and were not contaminated with root canal sealer.

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.

Following the supplier's instructions, the dentine surfaces were covered using a self-etch adhesive (3M ESPE, USA). 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 using a VALO LED light-curing tool (Ultradent) (LCU) that had an irradiance of 1000 m W/cm². For a whole day, repaired molars were kept in water at 37°C.

Preparing the samples for Microtensile 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 (figure 1). 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⁾.

Each specimen was affixed to a Geraldelli jig with cyanoacrylate glue, then tensioned at a crosshead speed of 1 mm/min utilizing an Isomet Microtensile tester (Isomet, USA) until failure as illustrated in figure 2 ⁽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 (1): A photograph showing selection of 3 rods from each sample to test the μ -TBS.



Figure (2): A photograph showing a rod sample was connected to a Geraldelli jig and tensioned from each sample Microtensile tester (C representing composite direction and D representing denting direction).

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.

Results:

The means and standard deviations of microtensile bond strength were summarised in Table (1) and illustrated in Figure (3).

Group 3 (Ultrasonic-30 seconds) had the greatest mean value of μ -TBS 37.99 ± 5.87 , followed by **Group 4 (Control)** 36.89 ± 6.49 , then **Group 2 (Ultrasonic-15 seconds)** 34.57 ± 7.82 while the lowest μ -TBS was reported in **Group 1 (Dry cotton)** 18.28 ± 8.56 with statistically significant different ($p = 0.005$) between group 1 and the other groups, while there is no significant different in between groups 2,3,and 4 ($P > 0.05$).

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

Groups	means $\pm$ standard deviations
Group 1: Dry cotton	18.28 $\pm$ 8.56 ^B
Group 2: Ultrasonic-15 seconds	34.57 $\pm$ 7.82 ^A
Group 3: Ultrasonic-30 seconds	37.99 $\pm$ 5.87 ^A
Group 4: Control	36.89 $\pm$ 6.49 ^A
P value	P = 0.005

Significant differences are indicated via various letters.

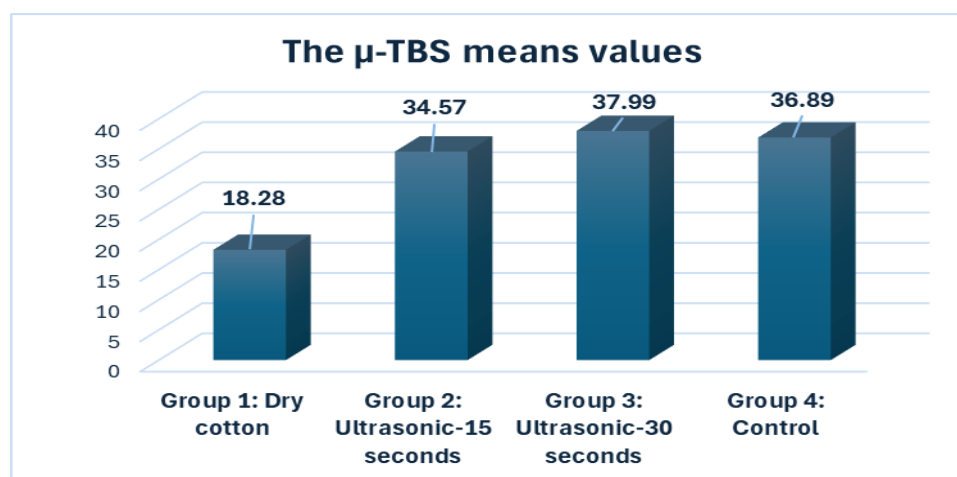


Figure (3): A photograph showing the μ -TBS means values

Discussion:

The floor and walls of the root canal access cavity get contaminated by the sealers employed throughout the obturation of root canals. For the bonding of dentin restorations to be effective and long-lasting, such contaminants must be eliminated. Water absorption and solubility are impacted by calcium hydroxide, which is produced by hydration in calcium silicate-based bioceramic sealers⁽¹⁶⁾. Sealer contamination may jeopardize the quality of composite bonding following root canal fillings. So, the goal of the current study was to evaluate the efficacy of various bioceramic (Total Fill BC) root canal sealer removal methods on bond strength between canal sealer-contaminated coronal dentin and Bulk Fill composite resin by the micro tensile bond strength (μ -TBS), and its failure modes by stereomicroscopy.

The removal procedures for contamination from calcium silicate-based Total Fill BC Sealer were assessed in this research. Dry cotton and all other water-based removal techniques were used to get rid of the sealant. Water absorption and solubility are impacted by calcium hydroxide, which is produced by hydration in calcium silicate-based bioceramic sealers. Because of their greater qualities, including osteo-inductive impacts, the capability to harden upon contact with of tissue liquids, over time antibacterial behavior, sealing ability, and the capacity to expand and hermetically fill root canals, bioceramic root canal sealers have become more and more popular in the field of root canal therapy⁽¹⁶⁾.

In order to assess the detrimental effects of root canal sealer residue on bulk-fill composite bonding to occlusal tooth structures, all root canal procedures were carried out on natural teeth rather than on dental crowns by μ -TBS evaluation to mimic the clinical situation.

The few studies were reported 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^(17,18).

Utilizing a diamond disc bur, each tooth was sectioned to a 4 mm occlusal to cemento-enamel junction in order to standardize and ensure that the pulp chamber wall was 3 mm above the pulp chamber floor.

In the current research we applied a 3 mm one-layer of composite using Bulk Fill Restorative. Additionally, we utilized microtensile bond strength assessment because it the most widely used methods for evaluating the adhesive solutions' bonding efficacy, is attributed to the bond strength assessment of very tiny samples (sectional widths $< 1 \text{ mm}^2$), and its homogenous strain and stress pattern is crucial in achieving most of the bond interfacial breakdown, however the microtensile bond strength (μTBS) test has become a cornerstone in dental materials research. This versatile and robust technique evaluates the bond strength amongst dental materials, especially adhesive systems, and dentin bonding agents. The μTBS test's strength lies in its ability to investigate various variables affecting the bond strength, such as dentin type, chosen adhesive system, and the bonding procedure itself⁽¹⁹⁾.

The results of this study concerning the $\mu\text{-TBS}$ showed that the greatest $\mu\text{-TBS}$ was reported within **Group 3 (Ultrasonic-30 seconds)** had the greatest mean value of $\mu\text{-TBS } 37.99 \pm 5.87$, followed by **Group 4 (Control) 36.89 ± 6.49** , then **Group 2 (Ultrasonic-15 seconds) 34.57 ± 7.82** while the lowest $\mu\text{-TBS}$ was reported in **Group 1 (Dry cotton) 18.28 ± 8.56** with statistically significant different ($p = 0.005$) between group 1 and the other groups, while there is no significant different in between groups 2,3, and 4 ($P > 0.05$).

The current research's findings showed that the resin bonding was affected differently by the various bioceramic root canal sealer removal methods (dry cotton, ultrasonic-15 seconds, ultrasonic-30 seconds, and control).

Due to its limits in efficiently eliminating residual sealer, the dry cotton cleaning procedure showed the least $\mu\text{-TBS}$ values as bioceramic sealers are water solvent. On other hand the effective bonding surface among resin and dentin might be decreased by the leftover calcium hydroxide, which can prevent resin sealers from penetrating dentinal tubules⁽²⁰⁾.

Also, in root canal treatment, ultrasonic therapy is utilized to improve treatment effectiveness⁽²¹⁾. Ultrasonic energy efficiently removes debris from dentinal tubules by using acoustic waves, physical vibrations, and cavitation processes in liquids⁽²²⁾. Ultrasonic oscillations in irrigating solutions cause cavitation, which produces microbubbles that burst and send forth strong shock waves. Even in deep and difficult-to-reach places within dentinal tubules, these shock waves make it easier to remove debris⁽²³⁾. Additionally, the acoustic streaming brought on by ultrasonic radiation improves irrigation mobility, encouraging deeper penetration into dentinal tubules and more efficient debris dislodging. In addition to helping to remove debris, the enhanced flow dynamics from acoustic streaming guarantee that the irrigation makes complete contact with all dentin surfaces⁽²⁴⁾.

Some studies agreed to our results which reported that the ultrasonic energy activation may produce cavitation bubbles and acoustic waves that can efficiently penetrate the dentinal tubules and eliminate residual sealer⁽²⁴⁻²⁶⁾.

Conversely to our study results, previous research found that there were no appreciable variations in binding strength between various cleaning methods (dry cotton) on a Class I molar model contaminated with bioceramic root canal sealer. air-water spray, moist cotton, and a 5-second ultrasonic activation (dry cotton, wet cotton, and air-water spray), including 5-sec ultrasonic activation⁽²⁷⁾. This inconsistency might be due to variations in dentin surface properties and ultrasonic treatment duration.

Conclusion:

Within the clinical practice, integrating ultrasonic cleaning into endodontic protocols, may significantly improve resin adherence and help endodontic procedures be successful.

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