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Immediate and Delayed Micro Tensile Bond Strength of Different Bioactive Restorative Materials

Ahmed Tharwat Al Ammary[1], Saad ElSayed Abd ElNaby Nawaya[2], Amir Hussieny Abd El Hamid Ibrahim[3], Mahmoud Elsayed Fetouh[4], Hatem Abdul Monaem El bially[5], Ahmed Ali Ezzeldine[6], Ahmed Mohamed Abu siyam[7], Walaa Mohamed Ahmed Alsamoully[8], Ibrahim El Dossoky Basha[9], Ahmed Ali[10].

[1]Assistant Professor of Operative Dentistry Department, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email: ahmdalmary144@gmail.com
[2]Lecturer of Operative Dentistry Department, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email:dr.s.nawaia@gmail.com
[3]Lecturer of Operative Dentistry Department, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email: amirras1234@gmail.com
[4]Lecturer of Operative Dentistry Department, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email: mahmoudfetouh315@gmail.com
[5]Lecturer of Operative Dentistry Department, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email: hatemelbially1984@gmail.com
[6] Lecturer of Dental Biomaterial Department, Faculty of Oral and Dental Medicine, Al–Azhar University (Boys-Cairo), Egypt. Email: drahmedezzeldine76@gmail.com
[7] Lecturer of Dental Biomaterial Department, Faculty of Oral and Dental Medicine, Al–Azhar University (Boys-Cairo), Egypt. Email: ahmedsalem23193@gmail.com
[8]Assistant Professor of Operative Dentistry Department, Faculty of Oral and Dental Medicine, Al–Azhar University (Boys-Cairo). Email: Walaasamolly@gmail.com
[9] Assistant Professor of Operative Dentistry Department, Faculty of Oral and Dental Medicine, Al–Azhar University (Boys-Cairo). Email: ibrahim33.ib@gmail.com
[10] Assistant Professor, Department of Dental Biomaterials, Faculty of Dental Medicine Al-Azhar University (Assiut), Assiut Branch, Egypt. Email: drahmedelfeky@gmail.com

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ABSTRACT

Aim: The current research aimed to assess the immediate and delayed the micro tensile bond strength (μ-tbs) of three bioactive restorative materials (Surefil one, Cention forte, and Fuji II LC).

Method:60 human permanent lower molars were used in this study. The teeth have decoronated 4 mm coronal to cementoenamel junction. The pulp chamber of each tooth was accessed by taper stone bure with high-speed hand piece for making place for placing the tested filling materials.The Specimens were randomized divided into 3 main identical test groups with 20 teeth in each main group according to the kind of the tested restoration then every group was subdivided into 2 subgroups according to the time of evaluation with 10 teeth each (immediate and delayed). **Group 1**: Surefil one, **Group 2**: Cention forte, and **Group 3**: Fuji II LC. The teeth were prepared for the μ-TBS test to be assessed immediate after restoration and the other teeth after storage time 6 months. The immediate test samples were tested after 48 hours of filling the materials, while the delayed test samples were stored in artificial saliva for 6 months.

Results: In concerning the immediate test results: showed that the greatest μ-TBS was recorded in **group 3 Fuji II LC** 19.9 ± 4.6, then **Group 1 Surefil one** recorded 10 ± 3.2, while **group 2 Cention forte** recorded the lowest μ-TBS mean values 8.8 ± 2.8. Statistically, there was statistically insignificant variation across the groups 1&2 ($P > 0.05$). on other hand there was statistically significant difference in comparing group 3 with groups 1 & 2 ($P < 0.05$). While In concerning the delayed test results: showed in concerning the delayed test results: showed that the greatest μ-TBS was recorded in **Group 1 Surefil one** recorded 8.9 ± 2.8, then**group 2 Cention forte** 7.4 ± 2.9, while **group 3 Fuji II LC** recorded the lowest μ-TBS mean values 7 ± 1.9. Statistically, there was statistically insignificant variation across all groups 1,2, and 3 ($P > 0.05$). There was statistically insignificant variation when comparing between the results of Immediate versus Delayed results of groups 1&2 ($P > 0.05$). on other hand there was statistically significant difference in comparing the results of group 3 between the immediate and delayed results ($P < 0.05$).

Conclusion: The durability and good μ-TBS results of self-adhesive bulk-fill dental restoration make them the good choice for teeth restoration.

Keywords: Delayed, Bioactive, statistically, Micro

INTRODUCTION

The year 1964 watched the development of resin-based composite restorations which were among the most significant advancements in aesthetic dentistry. According to a number of investigations, the dental resin composite possesses outstanding mechanical qualities, such as greater hardness, increased resistance to wear, reduced water dissolution, and biological acceptability (1).

An important development in direct restorative treatments is the use of self-adhesive restorations (2). These materials provide a straightforward application method and may be able to solve issues related to intricate adhesive procedures (3). Additionally, by doing away with the pre-treatment adhesive phase, they lessen cumulative iatrogenic mistakes and reduce the chair-side period(4,5).

Conservative dentistry is highly recommended by utilizing bioactive 'ion-releasing' restorations. This refers to the material's ability to strategically release necessary ions to encourage biomineralization. The use of bioactive materials in dental restorations has several benefits, including increased interfacial adhesion, stimulation of dentin regeneration processes, and longer restoration lifetime. As a result, there is a marked decrease in the frequency of marginal microleakage and secondary decay (6).

The development of innovative hybrid materials, such as 'self-adhesive', 'bulk-fill', or 'ion-releasing' dental restorations, marks a substantial step forward in minimally invasive restorative dentistry. By doing away with the need for additional adhesives, these materials lower the risks of blood or saliva contamination. They also cover possible adhesive problems, like the post-filling hypersensitivity. Many of these restorations have ion-releasing properties, and the bulk-fill notion is an additional simplifying restoration system. Many investigations have demonstrated the benefits of ion-release capabilities in remineralizing and preventing dental caries (6,7).

One type of dental restoration that aims to create a possibly bioactive restorative substance is alkasite-based material. One type of hybrid tooth-colored dental restoration material is alkasite-based. It is produced by releasing hydroxyl, fluoride, and calcium ions, all of which have strong anti-cariogenic properties (4). This restoration combines the advantageous properties of resin-based composites with glass ionomer cement. Because of its dual-cure capabilities, bulk application is possible with or without an adhesive coating (8).

Bond strength tests, including the micro-tensile bond strength, are the most often used methods to assess the bonding efficacy of adhesive systems (9). The use of micro-tensile tests, which are more suitable for detecting bonding strength because of neck wedge flaws, has been the subject of several investigations (10–12).

So, the current research aimed to assess the immediate and delayed the micro tensile bond strength (μ-tbs) of three bioactive restorative materials (Surefil one, Cention forte, and Fuji II LC).

MATERIALS AND METHODS

Teeth selection

From the outpatient clinic of the Faculty of Dental Medicine at Al Azhar University, 60 recently extracted undamaged, caries-free, and free from restorations human permanent molars were gathered. Periodontal problems were the cause of the extraction. A hand scalar (Nordent, Ivory #2&3, USA) was utilized for eliminating calculus and soft-tissue debris. A rubber cup (Prophy rubber polishing cup, China) and fine pumice water slurry (PSP, Dylan Rd, Belvedere, England) were used to polish the molars, and they were then kept at ambient temperature in distilled water to avoid dehydration (13). All teeth were examined under a magnification lens to check for cracks.

Specimen preparation

All samples' roots were implanted up to 2 mm beneath the cemento-enamel junction in self-curing acrylic resin (Acro Stone, Heliopolis, Cairo, Egypt). A predefined thickness of coronal enamel and superficial dentin was removed from every molar to provide consistent mid-coronal dentin exposure. Utilizing preoperative radiographic evaluations, the mid-coronal dentin position was identified and indicated on the outside of the molar.

A slow-speed automated diamond saw (PICO 155 precision saw, Pace Technologies, Tucson, AZ, USA) was used for cutting every molar perpendicular to its longitudinal axis while lubricating it with water. Following that, a standard smear layer was created by rotating 600-grit silicon carbide paper (Micro Cut, Buehler, Lake Bluff, IL, USA) for 30 seconds while flowing water over the exposed dentin surfaces.

The roof of pulp chamber of each tooth was removed by taper stone bure with high-speed hand piece for making place for putting the tested filling materials.

Specimens' grouping

The Specimens were randomized divided into 3 main identical test groups (Figure 1) with 20 teeth in each main group according to the kind of the tested restoration then every main group was subdivided into 2 subgroups according to the time of evaluation with 10 teeth each (immediate and delayed).:

Group 1: Surefil one
It is a self-adhesive bulk-fill composite, Dentsply Sirona, USA.
Group 2: Cention forte
It is “Alkasite” bulk-fill resinous restorative material (IvoclarVivadent; Schaan, Liechtenstein) involves the release of ions during polymerization in an acidic environment
Group 3: Fuji II LC
It is a light-cured resin-reinforced glass ionomer restorative (Tokyo, Japan).
The filling steps and procedures were done in each group according to the manufacture recommendations, then evaluated for Micro Tensile Bond Strength Testing (µ-TBS) after:
Immediate; after 2 days.
Delayed; following six months of storage at 37 °C in an incubator containing synthetic saliva that was made at Al Azhar University's pharmacy faculty. Weekly changes were made to the synthetic saliva during the one-month period of storage.

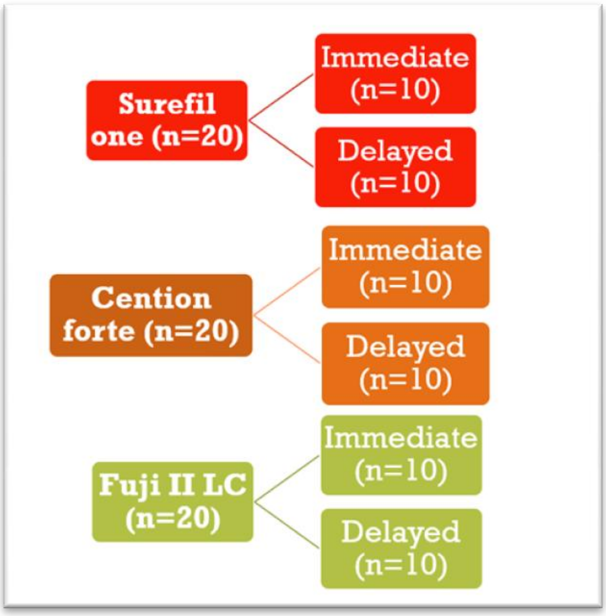

Figure 1: A Diagram showing the study design of the tested materials.

Preparing the specimens for Micro Tensile Bond Strength Testing (µ-TBS):
Micro Tensile Bond Strength Testing (µ-TBS) after:
Immediate; after 2 days.
Delayed; following six months of storage within a synthetic saliva.
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 extracted. Three rods were used for each tooth.
The samples for Immediate µTBS test were inspected optically and then assessed using Leica stereomicroscopy (model S8APO, LAS 3.4 software) at a magnification of 20×. 30 sticks from each group were selected with total of 90 sticks were selected from all groups for the µTBS test [(10)].
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 till debonding [(14)]. Bond strengths were computed by dividing the force applied till debonding by the cross-sectional bonding region. Mega Pascals were used to compute bond strength and were measured in Newtons.
These steps were repeated with the samples to be examined following six months of synthetic saliva storage for the tested materials with total of 90 sticks were selected from all groups for the µTBS test.

Statistical analysis
All test data collected from both time of evaluation were tabulated and Statistical analysis Using IBM, Chicago, IL, USA, SPSS software, an analysis of statistics was carried out. Tamhane's T2 post hoc tests and one-way

analysis of variance (ANOVA) were utilized to compare the micro tensile bond strength results. The chi-square test was utilized to analyse the failure mode distributions.

RESULTS

The means and standard deviations of micro tensile bond strength (μ-TBS) of immediate and delayed results were represented in Table (1) and illustrated in Figure(2).

In concerning the immediate test findings:

The tabulated findings of the present research displayed that the greatest μ-TBS was recorded in **group 3 Fuji II LC** 19.9 ± 4.6, then **Group 1 Surefil one** recorded 10 ± 3.2, while **group 2 Cention forte** recorded the lowest μ-TBS mean values 8.8 ± 2.8. Statistically, there was statistically insignificant variation across groups 1&2(P > 0.05). on other hand there was statistically significant variation in comparing group 3 with groups 1 & 2 (P < 0.05).

In concerning the delayed test findings:

The tabulated findings of the present research displayed that the greatest μ-TBS was recorded in **Group 1 Surefil one** recorded 8.9 ± 2.8, then**group 2 Cention forte** 7.4 ± 2.9, while **group 3 Fuji II LC** recorded the lowest μ-TBS mean values 7 ± 1.9. Statistically, there was statistically insignificant variation across all groups 1,2, and 3 (P > 0.05). There was statistically insignificant variation when comparing amongst the results of Immediate versus Delayed results of groups 1&2 (P > 0.05). on other hand there was statistically significant variation in comparing the results of group 3 between the immediate and delayed results (P < 0.05).

Table 1: Showing The immediate and delayed means of micro tensile bond strength (MPa) of the 3 tested groups.

Groups	Means ± standard deviations	
	Immediate	**Delayed**
Group 1: Surefil one	**10 ± 3.2^{B}**	**8.9 ± 2.8 ^{B}**
Group 2: Cention forte	**8.8 ± 2.8 ^{B}**	**7.4 ± 2.9 ^{B}**
Group 3: Fuji II LC	**19.9 ± 4.6^{A}**	**7 ± 1.9^{B}**
P value	**P < 0.05**	

Significant differences are indicated via various letters.

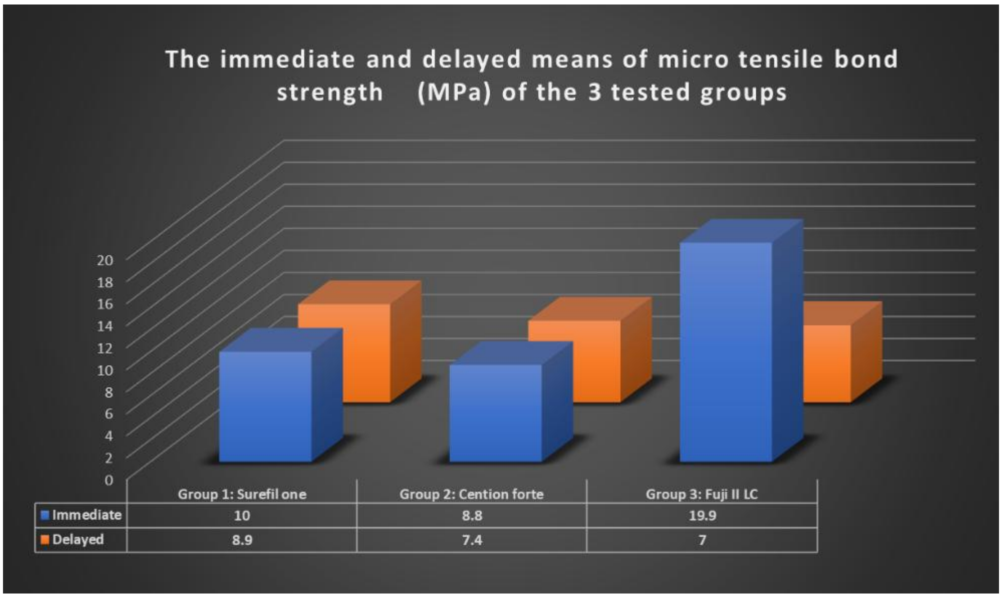

Figure 2: A chart showing the μ-TBS means values of the tested materials.

DISCUSSION

Natural look, biocompatibility, mechanical durability, bulk fill features, bioactivity, and quick, long-lasting adherence to tooth tissues are all desirable qualities in dental restoration materials. Self-adhesive bulk-fill hybrid resin composites with enhanced recommendations for direct restorations and purported bioactivity are examples of recent advancements [15].

In this direction, the current research aimed to assess the immediate and delayed the micro tensile bond strength (μ-tbs) of three bioactive restorative materials (Surefil one, Cention forte, and Fuji II LC).

Utilizing a diamond disc bur, each molar was sectioned to a 4 mm occlusal to cementoenamel junction for standardization and ensure that the pulp chamber wall was 3 mm above the pulp chamber floor.
In this research we used 3 types of Bulk Fill Restorative to put 4 mm single layer of composite and a reinforced glass ionomer restorative restoration because these materials are widely used.
The bulk application technique is simpler, it reduces the number of clinical steps, making the work easier and faster. Because bulk-fill composites could be positioned in 4mm increments, their bond strengths were comparable to those of traditional composites. In contrast, the traditional composite resin is polymerized in 2 mm increments, which keeps the bond strength from decreasing[16,17].
Because of its exceptional capacity to form chemical contact with the surfaces of dental hard tissues, the resin-modified glass ionomer (RMGI) has been chosen as the control restoration for the present research. This restoration has a remarkable bioactivity and ability to release and replenish fluoride ions have made it attractive despite a few minor drawbacks, including difficulty reaching the dentin surface and decreased bond strength [18].
Also, we used µTBS assessment due this test has become a cornerstone in dental materials research. This versatile and robust technique evaluates the bond strength between dental materials, especially adhesive systems, and dentin bonding agents. The µTBS test's strength lies in its ability to investigate various factors influencing bond strength, such as dentin type, chosen adhesive system, and the bonding protocol itself [19].
The results of µ-TBS of our study in concerning the immediate test results showed Statistically that there was no statistically significant difference between groups 1&2 (Group 1 Surefil, and group 2 Cention forte)P > 0.05. on other hand there was statistically significant variation in comparing group 3 (Fuji II LC) with groups 1 & 2 (P < 0.05).
The high µ-TBS of group 3 (Fuji II LC) in our results in comparing to the other Bulk-fill composites (Group 1 Surefil, and group 2 Cention forte)may be theRMGI possesses a strong chemical bonding affinity for the dental hard tissues [20].
While the decreased in µ-TBS within self-adhesive resin composite group (Group 1 Surefil, and group 2 Cention forte) would suggest that these restorations may not be capable to reach the dentin below it because of the denser smear layer. This may explain the restriction self-bonding abilities of self-adhesive bulk-fill resin composite and the inadequate self-adhesiveness of bio-active-based restoration material on untreated dentin which is like what reviewed by **Meerbeek*et al***. who questioned the capacity of acidic monomers by themselves to provide enough anchoring to dental hard tissues [21].
On contrary to our results**, Latta*et al.*** in his studies stated that contemporary self-adhesive bulk-fill resin composite restoration systems and RMGI displayed comparable degrees of self-adhesiveness to enamel and dentin [22,23].
On other hand the results of µ-TBS of our study in concerning the delayed test results showed Statistically, there was statistically insignificant variation across all groups 1,2, and 3 (P > 0.05). There was statistically insignificant variation when comparing amongst the results of Immediate versus Delayed results of groups 1&2 (P > 0.05). on other hand there was statistically significant variation in comparing the results of group 3 between the immediate and delayed results (P < 0.05).
These results may be explained by the water absorption and dissolution throughout storing are frequent occurrences that result in chemical alterations and a negative impact on the mechanical characteristics of polymeric materials, aging has a major impact. In addition to swelling brought on by aqueous solvent absorption, non-reacted ingredients are lost, the filler-matrix interface erodes, and plasticization occurs, resulting in a reduction in rigidity, toughness, wear resistance, and flexural strength. On other hand, the adhesive contact may have been directly impacted by glass ionomers' weak mechanical qualities, which are known to perform inadequately in stress-bearing locations [24].
According to our research, Surefil One and Cention forte have a remarkable ability to adhere to dentin, displaying a high µTBS, these results was similar to the results of **Lohbauer and Belli** [25].

CONCLUSION

The durability and good µ-TBS results of self-adhesive bulk-fill dental restoration make them the good choice for teeth restoration.

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