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Research Article

Assessment Of Micro-Shear Bond Strength Of Biodentine To Various Restorative Materials After Aging: An In - Vitro Study

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ABSTRACT:

Objective: This study aimed to determine the perfect timing for restoratives installations of the micro-shear bond strength (µSBS) of Biodentine with various restorative materials. **Materials and Methods:** Sixty Biodentine specimens were prepared and categorized into two groups based on aging periods: one week and two weeks. Each group was further divided into three subgroups according to the restorative material used—Short Fiber-Reinforced Composite, Zirconomer, and Cention N—with ten specimens in each subgroup. A self-etch adhesive bonding technique was applied before placing the restorative materials. The micro-shear bond strength (µSBS) was evaluated using a universal testing machine, and data analysis was conducted using a paired t-test, considering $p < 0.05$ as statistically significant. **Results:** The bond strength was influenced by both the aging period and the type of restorative material. After two weeks of Biodentine aging, Short Fiber Composite and Cention N showed a notable increase in µSBS ($p < 0.05$), with Zirconomer also displaying a statistically significant but smaller increase. Among the materials tested, Short Fiber Composite demonstrated the greatest improvement in bond strength, followed by Cention N, while Zirconomer showed the least enhancement. **Conclusion:** The bond strength of Biodentine improves as it matures, especially with restorative materials like Short Fiber Composite and Cention N. Delaying the placement of the final restoration for a minimum of two weeks can enhance adhesion and durability.

Keywords: Biodentine, bond strength, aging, Short Fiber Composite, Cention N, Zirconomer.

INTRODUCTION:

Vital pulp therapy (VPT) produces procedures to save dental pulp vitality through solutions including indirect pulp capping along with direct pulp capping followed by pulpotomy procedures [(1)]. The first step of VPT includes precise removal of extensive dental decay to prevent pulp exposure before applying biocompatible materials as protective layers [(2)]. The biomaterials used in procedures need to demonstrate several critical traits including compatibility with tissue, vitality preservation and powerful bonding with nearby dental structures and strengthening against everyday functional stress.

The dentistry industry employs Mineral trioxide aggregate (MTA) as a widely approved calcium silicate cement for endodontic procedures because it possesses excellent biocompatibility linked to effective tissue sealing and the ability to trigger tissue regeneration [3]. MTA material exhibits drawbacks because it takes a lengthy time to set and demands special instruments during placement and shows problematic handling comfort and may cause tooth discoloration [4; 5].

The cement Biodentine presents similar chemical elements to MTA while offering specific unique clinical benefits. The cement consists of tricalcium silicate together with dicalcium silicate and calcium carbonate and iron oxide and zirconium oxide [6]. Biodentine demonstrates shorter setting periods and stronger physical characteristics than MTA thereby qualifying itself as a dentin replacement material for permanent use [7; 8]. The clinical application of Biodentine is improved through its enhanced practicality which makes it better suited for urgent restorative procedures.

The dental restoration market received EverX Posterior as an innovative short fiber-reinforced composite for posterior restorations. The composition of these materials includes resin as the base substance with E-glass fibers scattering throughout and inorganic fillers blended into both structures. Bis-GMA and TEGDMA crosslinked monomers together with PMMA form the resin matrix of this material [9]. These restorative materials demonstrate exceptional fracture toughness with efficient stress distribution features because they provide promising longevity for dental restorations.

The newly developed Cention N restoration material belongs to the "alkasite" category. The material contains alkaline glass components that emit fluoride and calcium together with hydroxide ions. The dentition of pediatric patients benefits from caries prevention because of these ions. The incorporation of Barium aluminum silicate together with ytterbium trifluoride and isofillers within Cention N minimizes polymerization shrinkage and microleakage for extended restoration durability according to studies [10].

Zirconia-reinforced glass ionomer cement (Zirconomer) represents a new material technology designed to increase mechanical properties and enhance durability against regular wear. The material combines zirconium oxide with alumino-fluoro-silicate glass powder as well as tartaric acid and polyacrylic acid [11]. Zirconium oxide addition enhances durability which qualifies zirconium as an alternative material suitable for stress-bearing restorations.

The success potential of dental restorations depends heavily on the quality of adhesion between Biodentine and upper restorative materials [12]. The bond strength directly affects how well the restoration resists functional stresses along with preventing microleakage. Few investigations exist about Biodentine's bond with advanced materials such as Cention N, Zirconomer, and short fiber-reinforced composites through their aging process.

Since few studies have studied the micro-shear bond strength of Biodentine with short fiber-reinforced composite, Zirconomer, and Cention N at different substrate aging intervals (1 week and 2 weeks) this research gaps motivated the current study. Researchers conduct this study to determine the perfect timing for restoratives installations which ensures both optimal bond strength and extended clinical success.

MATERIAL AND METHOD:

Materials Used:

The materials and their compositions used in this study are outlined below:

Material	Manufacturer	Composition
Biodentine	Biodentine™ (Septodont, St. Maure des Fosses, France)	Powder: Tricalcium silicate, dicalcium silicate, calcium carbonate, oxide filler, iron oxide, zirconium oxide (radiopacifier) [6]. Liquid: Calcium chloride (accelerator), hydrosoluble polymer (water-reducing agent).
Zirconomer GIC	Zirconomer Improved (Shofu Inc.)	Powder:Alumino-fluoro-silicate, zirconium oxide, tartaric acid [11]. Liquid: Polyacrylic acid, deionized water.
Short Fiber-Reinforced Composite	EverX Posterior (GC Corp, Tokyo, Japan)	Consists of a resin matrix (Bis-GMA, TEGDMA), discontinuous E-glass fibers, inorganic particulate fillers, and PMMA.
Cention N	Cention N (IvoclarVivadent)	Powder: Barium aluminum silicate, ytterbium trifluoride, isofiller, calcium fluorosilicate glass fillers [10]. Liquid: Dimethacrylates and initiators.
Self-etch adhesive	ScotchbondTM Universal, 3M, ESPE, USA	MDP phosphate monomer, Dimethacrylate resins, HEMA, VitrebondTM Copolymer, filler, ethanol, water initiators, silane

Sample Preparation:

Sixty acrylic cylindrical molds received central holes with 5 mm diameter and 2 mm depth through the use of copper molds. Biodentine received its recommended mixture before dentists applied it into these cavities. A glass slab applied gentle pressure onto the mold for obtaining a glossy finish.

The researchers implemented a storage period of 72 hours at 37°C with 100% relative humidity to ensure proper setting of the samples by covering them with moist cotton pellets. The smooth and even surfaces of the specimens developed through an aqueous polishing process that included silicon carbide paper of 600, 800, and 1000 grams. The researchers applied distilled water followed by ventilated dry conditions to the specimens.

Experimental Grouping:

The research divided the specimens into two major groups containing thirty test samples each with one and two-week aging periods for Biodentine. The research groups included three subgroups containing ten specimens each based on the restorative material selection.

Group I:Biodentine aged for 1 week

- Sub-group I-a (n = 10):Biodentine + Short Fiber-Reinforced Composite

- Sub-group I-b (n = 10):Biodentine + Zirconomer
- Sub-group I-c (n = 10):Biodentine + Cention N

Group II: Biodentine aged for 2 weeks

- Sub-group II-a (n = 10):Biodentine + Short Fiber-Reinforced Composite
- Sub-group II-b (n = 10):Biodentine + Zirconomer
- Sub-group II-c (n = 10):Biodentine + Cention N

Restorative Procedure:

The self-etch adhesive procedure served for restoration bonding purposes. The authors placed restorative materials inside cylindrical plastic tubes with a 0.75 mm internal diameter and 1 mm height in the exact center of Biodentine surfaces.

- A set of adhesive resin (short fiber composite) received application on Biodentine through a self-etch approach.
- The restorative polymers received 20-second LED light-curing after being gradually placed into the mold cavities.
- The specimens received preservation through storage in distilled water at 37°C during a 24-hour period to match oral environment conditions before testing.

Micro-Shear Bond Strength Testing:

A universal testing machine conducted the measurements for micro-shear bond strength (μSBS). The test applied 1.0 mm/min shear force until the material failed from the bonding interface. The tensile strength measurement involved using this formula:

The formula was used to calculate micro-shear shear bond strength (t) in MPa.

$t = F/(\pi R2)$,

Where: [t = Micro-shear bond strength (MPa); F = Load at failure (N), R = Radius of the resin composite cylinder (mm)]

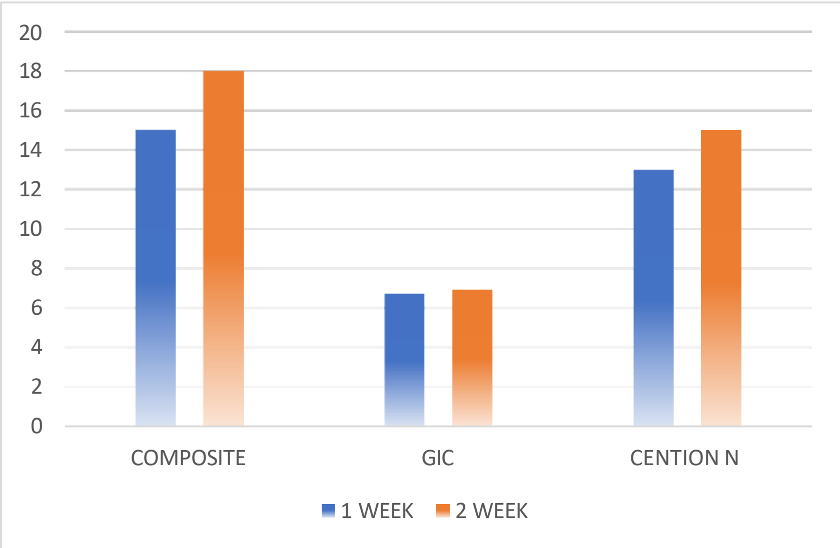
The established method created uniform standards for assessing how different dental restorative materials bonded with Biodentine at changing periods of time. A paired t-test analysis revealed statistical differences through its results. The paired t-test evaluated mean comparisons between 1st and 2nd weeks for each parameter and delivered significant results with p-values below 0.05.

RESULT:

TABLE 1 :- Micro shear bond strength of biodentine with different restorative material at different time interval

Restorative Material	1-Week Aging (Mean ± SD)	2-Week Aging (Mean ± SD)	Mean Difference	p-value (paired t-test)
Short Fiber Composite	13.20 ± 1.32 (a)	18.40 ± 1.26 (b)	**5.20**	**P < 0.05 (0.000003)**
Zirconomer	7.70 ± 0.95 (a)	8.90 ± 0.88 (a)	**1.20**	**P < 0.05 (0.023856)**

Cention N	10.00 ± 1.33 (a)	15.00 ± 0.82 (b)	**5.00**	**P < 0.05 (0.000007)**



Bond strength measurements between Biodentine and various restoratives were conducted based on 1 week and 2 week aging conditions for µSBS evaluation. The research study revealed important findings that depended on both restorative material choice and aging time duration.

Short Fiber Composite together with Cention N reached a substantial improvement in bond strength after 2-weeks of Biodentine aging when compared to 1-week aging which displayed statistical significance ($P < 0.05$).

The bond strength increase of Zirconomer was statistically significant but the change was more minimal in comparison to other restoratives.

The results demonstrate that Biodentine aging for two weeks leads to stronger bond strength with Short Fiber Composite and Cention N.

Biodentine maturation throughout a period of two weeks enhances the bond strength that different restorative materials can develop.

The tested materials showed Short Fiber Composite had the strongest bond strength increase followed by Cention N although Zirconomer had the lowest enhancement rate.

A minimum two-week waiting period for Biodentine can improve its bond strength based on the current findings.

DISCUSSION:

The material Biodentine possesses characteristics that closely match those of mineral trioxide aggregate (MTA) yet stands as a calcium silicate cement intended for fast-setting restoratives that preserve biocompatibility [13]. Studies show that Biodentine maintains low mechanical strength during its early period which lasts for about 12 minutes despite its quick initial setting time [14]. The placement of ultimate restorative materials should be delayed for two weeks to enable material maturation which results in improved mechanical properties.

The success rate of restorations depends on achieving strong bonds between Biodentine material and top restorative materials. Bond strength needs to be sufficient to counteract the contraction forces which composite restorations create in order to avoid marginal gaps forming. The maintenance of a durable interface throughout time requires bond strength which should be between 17–20 MPa [15].

Biodentine was combined with distinct restorative materials under two aging periods of one and two weeks to measure their micro-shear bond strength (µSBS). The used restorative materials produced varying bond strength levels which became evident through the results. Short Fiber Composite secured the peak µSBS measurement but Cention N achieved better results than Zirconomer did. Material composition together with contact with Biodentine determines the strong bond outcomes.

Biodentine experienced two-week aging that enhanced the µSBS value in Short Fiber Composite and Cention N. This study established that bond strength values of these materials became progressively stronger during extended aging periods ($P < 0.05$) thus proving that extended aging duration improves adhesive capabilities. Such results are consistent with research which demonstrates how Biodentine progressively strengthens through the process of hydration and mineral crystal development [16;17]. Biodentine shows improved mechanical stability through delayed placement because the product becomes more resistant and self-adhesive in its development process. The notable increase in µSBS for Short Fiber Composite and Cention N with extended Biodentine aging can be attributed to material-specific properties. Short fiber composites are known for their high fracture toughness and ability to distribute stresses effectively, which may facilitate a stronger bond with matured Biodentine [18; 19]. Similarly, Cention N exhibits a dual-curing mechanism and ion-releasing properties, which may contribute to enhanced chemical adhesion with aged Biodentine [20].

Conversely, the bond strength of Zirconomer remained relatively unchanged between the one- and two-week aging intervals. While a small increase was observed ($P < 0.05$), it was significantly lower compared to the other materials. This could be due to its limited chemical interaction with Biodentine or a lower adaptability to the material’s evolving surface characteristics over time [21]. As a result, Zirconomer may not be the ideal restorative choice when Biodentine is used as a base material, particularly when bond strength is a primary concern.

These findings underscore the importance of considering the aging period of Biodentine before placing the final restoration. While materials like Short Fiber Composite and Cention N benefit from extended maturation time, others, such as Zirconomer, may not exhibit significant improvement. Further in-vitro and clinical studies are needed to explore the long-term effects of Biodentine aging on the performance of various restorative materials and their clinical outcomes.

CONCLUSION:

This study examines how the aging of Biodentine affects its micro-shear bond strength (µSBS) with various restorative materials. The results indicate that prolonged aging improves its bond strength with short fiber-reinforced composites and Cention N, whereas Zirconomer shows limited enhancement. These findings suggest that allowing Biodentine to mature for approximately two weeks before placing definitive restorations can optimize bond strength and restoration stability. Further in-vitro and clinical studies are needed to confirm these findings and assess the long-term impact of Biodentine aging on restorative performance.

Ethical Clearance: Approved by the Institutional Ethical Committee

Authors Contributorship: Equally contributed.

Conflict of interest: Nil.

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