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EVALUATION OF MICRO-TENSILE BOND STRENGTH OF BULK-FILL VERSUS NANOHYBRID COMPOSITE TO DENTIN

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ABSTRACT:
Purpose:to investigate the effect of placement technique whether it's bulk-fill or incremental on the microtensile bond strength(μTBS)of composite resins to dentin.
Materials&Methods:32 molars were divided into two groups(n=16)according to the type of composite used. Group A Tetric N-Ceram nano-hybrid incremental composite was used and Group B where Tetric EvoCeram bulk fill composite was used.
Then the teeth were sectioned into micro-bars and mounted in a universal testing machine and stressed until failure. Micro-tensile bond strength was expressed in MPa. The fractured surfaces were then examined using stereomicroscope to determine the mode of failure and representative specimens of each group were examined using Scanning electron microscope.
Results:Simple T-test was used ($P \leq 0.05$) and reported no significant difference between the two groups.
Clinical significance: Under the present situation of this study, it was recorded that Bulk-fill composite serves as an excellent substitute for incremental composite with no significant effect on the micro-tensile bond strength to dentin.

KEYWORDS: Bulk-fill composite, Self-etch adhesive, Microtensile bond strength, Dentin.

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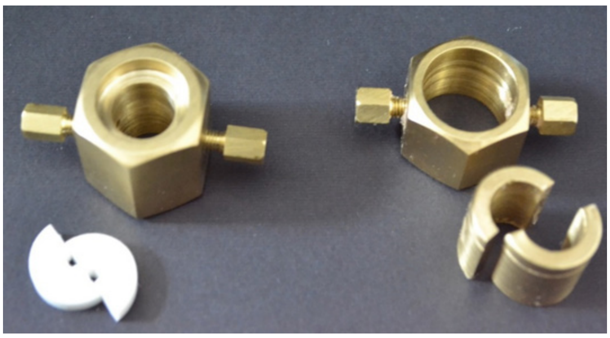
INTRODUCTION

With the increasing emphasis on aesthetics and advancements in bonding techniques, composite materials have become a popular choice for restoring both anterior and posterior teeth. While composites offer numerous advantages, their use also comes with certain limitations. These include the potential risk of allergic reactions, higher wear rates compared to metallic restorations, susceptibility to color changes over time, and challenges for dentists in handling and applying the material effectively.[1] Even today, one of the major disadvantages of composite materials is polymerization shrinkage and the associated stresses. This shrinkage can lead to the failure of the bond between the composite and the tooth, resulting in interfacial gaps, microleakage, marginal discoloration, and secondary caries. Additionally, the contraction stresses generated during polymerization can be transferred to the tooth structure, causing deformation, post-operative sensitivity, and potentially widening pre-existing enamel micro-cracks.[2,3] For years, the incremental technique has been widely used to prevent the formation of gaps caused by polymerization stress and to ensure strong adhesion between the composite material and the tooth structure. However, in recent times, bulk-fill composites have been introduced to simplify and speed up the restorative process while reducing costs. [4,5] Bulk-fill composites are designed to be applied in increments of 4 to 6 mm, with manufacturers claiming that these materials adapt well to cavity walls and help minimize cuspal deflection. [6-8] Several studies have explored the application of cavity restoration techniques using bulk-fill composites in deep and narrow cavities. However, the findings have been inconsistent due to differences in composite materials, to its versatility and consistency in in vitro studies. [13] However, this testing method is both time-intensive and technically challenging, demanding meticulous attention during the preparation and handling of specimens. Therefore, this study aims to examine the impact of placement techniques on the micro-tensile bond strength (μTBS) of various composite materials. [14] The method used for placing restorations plays a crucial role in managing shrinkage stress. Certain restorative techniques can help minimize the stress caused by constrained shrinkage. However, there is still no definitive consensus on the most effective technique for reducing shrinkage stress. To mitigate this issue, it is generally recommended to apply composite material in layers rather than using a bulk-fill approach. [12] So, the aim of this study was to investigate the effect of placement technique whether it's bulk-fill or incremental on the microtensile bond strength (μTBS) of composite resins to dentin.

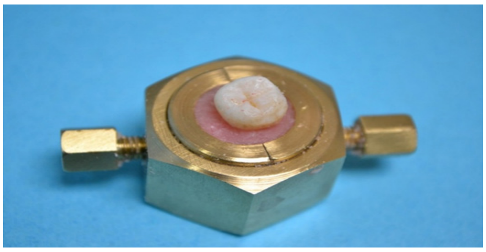
Materials and Methods:

1. Teeth Selection

Thirty-two freshly extracted, sound human molars from patients aged 40-55 years were used. Teeth were collected after obtaining patient consent. They were examined at 5x magnification to exclude structural defects.[15] Teeth were cleaned of debris and calculus using peridontal scaler , washed then stored in distilled water (changed daily), and used within one month.[16] Each tooth was mounted in self-cure acrylic resin up to the cemento-enamel junction (CEJ) using a pre-fabricated metallic mold (Fig.1,2), ensuring standardization (19 mm height, 14 mm diameter). Vaseline was applied to prevent sticking.



(Fig.1) Components of the split metalli mold (right) with attached specially made spli teflon mold (left)



(Fig.2) The molar embedded in the acrylic resin till its cemento-enamel junction using the metallic mold

(Fig.3) INSTRON Universal testing machine

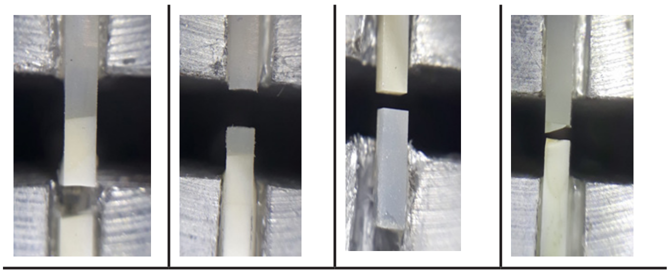
Results:

Microtensile Bond Strength (μTBS)

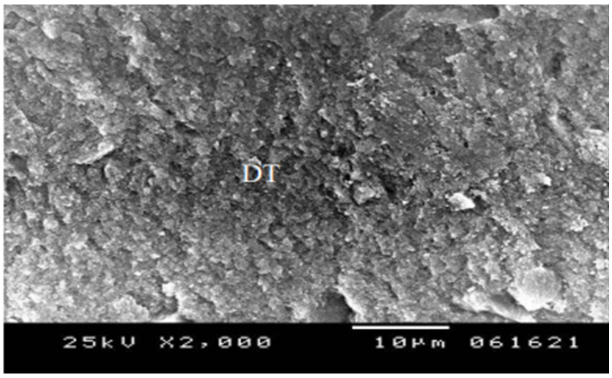
Data were statistically analyzed at a 95% significance level, with results expressed as mean ± standard deviation (SD) (Table II, III).

- No statistical difference between Groups A vs. B (P = 0.772).
- Mode of Failure
  - Pre-test failures (ptf's) were 0% in Groups A & B
  - Failure mode analysis was conducted using a stereomicroscope (50x magnification) (Fig. 4), (Table IV).
- SEM Examination

Scanning electron microscopy (SEM) confirmed failure modes observed under the stereomicroscope. Representative SEM images (Fig. 5) illustrate fracture patterns at 50x magnification.



(Fig.4) Different types of failure under light microscope



(Fig.5) Representative Fractured surface from group A showing cohesive failure in composite (SEM)

Table I: showing the groups and subgroups of the study.

	Group A	Group B
Placement technique	Group using Tetric N-Ceram n no-hybrid incremental composite	Group using Evo-Ceram Bulk-Fill composite

Table II: showing the mean and standard deviation of the microtensile bond strength of the groups.

	Group A	Group B
Range	3.253 - 42.373	4.003 - 38.417
Mean ±SD	22.813 ± 9.363	21.821 ± 10.709

Table III: showing a comparison between the microtensile bond strength (MPa) of Group A and Group B using simple T-test:

Mpa	Groups						T-Test	
	Group A			Group B			t	P-value
Range	3.253	-	3.253	4.003	-	38.417	-0.291	0.772
Mean ±SD	19.763	±	8.891	20.326	±	9.465		

Table IV: showing the frequency of each failure mode in the different test groups.

	Adhesive failure	Cohesive failure	Mixed failure
A	73.34%	23.34%	3.34%
B	68.34%	26.67%	6.67%

Discussion:

This in-vitro study aimed to examine how different placement techniques affect the microtensile bond strength (µTBS) of two composite types (Tetric N-Ceram Nano-hybrid incremental composite and Tetric EvoCeram Bulk-Fill composite) when bonded to dentin using thesame one-step universal adhesive (Tetric N-Bond Universal Adhesive) in self-etch mode. Although clinical trials are the most reliable method for evaluating den tal restorations, they cannot precisely identify the exact cause of failure due to the combined effects of various stresses acting on restorations in the challenging oral environment. Since this study specifically focused on assessing the impact of placement technique on µTBS, it was necessary to control for adhesive type aschol-based system, where alcohol facilitates penetration into the collapsed collagen network, ultimately leading to an increase in microtensile bond strength.[17] the sol uble phase, forming resin globules in water, which could compromise bond strength. Additionally, when deeper cavities are prepared, both the cavity configuration and dentin depth can further reduce bond strength at the cavity floor.[24] The Bulk-fill composite demonstrated microtensile bond strength (µTBS) values that were comparable to or even higher than those of the nano-hybrid incremental composite. This finding aligns with the study by Karatas et al., which concluded that bulk-fill flowable composites exhibit higher μTBS values compared to methacrylate-based flowable composites at a 4-mm thickness. The researchers attributed this to the unique monomer composition, surface energy, and wettability characteristics of bulk-fill composites, which surpass those of other composite materials. The elevated μTBS values observed in TetricEvoCeram Bulk-fill composite can be linked to its composition. According to the manufacturer, in addition to the standard camphorquinone/amine (CQ) initiator system, this composite contains an "initiator booster" known as Ivocerin. This germanium-based initiator has a similar absorption spectrum to CQ but exhibits greater photo-curing efficiency due to its enhanced absorption of visible light.[25] Although a strong correlation typically exists between filler content and the modulus of elasticity in resin-based composites (RBCs), TetricEvoCeram Bulk-fill deviates from this pattern. Despite having a high filler content, it exhibits only low to moderate elastic modulus values. This is partly because the composite includes pre-polymerized fillers (PPF) up to 50 μm in size, which consist of inorganic fillers such as barium glass and silica embedded in a pre-polymerized organic matrix. These PPFs are counted within the total filler content (which is 80% by weight, including 17% pre-polymers), meaning the proportion of inorganic fillers that contribute to increasing the modulus of elasticity is effectively lower.[26] A key feature of this composite is a patented filler that has been partially functionalized by silanes, acting as a shrinkage stress reliever. During polymerization, monomer chains attached to these fillers cross-link with the silanes, generating internal forces that impact the cavity walls. The shrinkage stress is influenced by both volumetric shrinkage and the composite's modulus of elasticity. Because TetricEvoCeram Bulk-fill has a low elastic modulus (10 GPa), its shrinkage stress reliever functions similarly to a spring, expanding slightly as the forces between the fillers increase. In contrast, standard glass fillers in the composite have a significantly higher elastic modulus of 71 GPa.[27] Moreover, the fillers in TetricEvoCeram Bulk-fill are more spherical in shape, which has been shown to improve translucency. This allows better light penetration into the deeper layers of the composite, promoting sufficient polymerization and enhancing its mechanical properties, including bond strength to tooth structures.[28] Tetric N-Ceram, on the other hand, incorporates nanotechnology. It contains targeted "nano additives," such as a rheological modifier, which plays a crucial role in determining the material's viscosity and workability, ensuring ease of application. Tetric EvoCeram Bulk-fill shares many properties with its conventional counterpart from the same manufacturer, with an elastic modulus of approximately 6–7 GPa this can explain why the insignificant differences between the μTBS values of the two composite types. [26-28]

Conclusion

Within the constraints of this study, the findings indicate that Bulk-fill composite serves as an excellent substitute for incremental composite.

REFERENCES

1. Manhart J, Garcia-Godoy F, Hickel R. Direct posterior restorations: clinical results and new developments. Dental clinics of North America. 2002;46(2):303-39.
2. Lutz F, Krejci I, Barbakow F. Quality and durability of marginal adaptation in bonded composite restorations. Dent Mater. 1991;7(2):107-13.
3. Singhal S, Gurtu A, Singhal A, Bansal R, Mohan S. Effect of Different Composite Restorations on the Cuspal Deflection of Premolars Restored with Different Insertion Techniques- An In vitro Study. J Clin Diagn Res. 2017;11(8):ZC67-ZC70.
4. Furness A, Tadros MY, Looney SW, Rueggeberg FA. Effect of bulk/incremental fill on internal gap formation of bulk-fill composites. J Dent. 2014;42:439-49.
5. Van Ende A, De Munck J, Van Landuyt KL, Poitevin A, Peumans M, Van Meerbeek B. Bulk-filling of high C-factor posterior cavities: effect on adhesion to cavity-bottom dentin. J Dent Mater. 2013;29:269-77.
6. F F, Ar D, Z H. The Effect of Bulk Depth and Irradiation Time on the Surface Hardness and Degree of Cure of Bulk-Fill Composites. Journal of dental biomaterials. 2016;3:284-91.

7. Moorthy A, Hogg CH, Dowling AH, Grufferty BF, Benetti AR, Fleming GJ. Cuspal deflection and microleakage in premolar teeth restored with bulk-fill flowable resin-based composite base materials. J Dent. 2012;40:500-5.

8. 8. Armstrong SR, Keller JC, Boyer DB. The influence of water storage and C-factor on the dentin-resin composite microtensile bond strength and debond pathway utilizing a filled and unfilled adhesive resin. J Dent Mater. 2001;17:268-76.

9. 9. Furness A, Tadros MY, Looney SW, Rueggeberg FA. Effect of bulk/incremental fill on internal gap formation of bulk-fill composites. J Dent. 2014;42:439-49.

10. 10. F F, Ar D, Z H. The Effect of Bulk Depth and Irradiation Time on the Surface Hardness and Degree of Cure of Bulk-Fill Composites. Journal of dental biomaterials. 2016;3:284-91.

11. 11. Flury S, Peutzfeldt A, Lussi A. Influence of increment thickness on microhardness and dentin bond strength of Bulk-Fill resin composites. Dental materials : official publication of the Academy of Dental Materials. 2014;30:1104-12.

12. 12. Betamar N, Cardew G, Van Noort R. Influence of specimen designs on the microtensile bond strength to dentin. J Adhes Dent. 2007;9:159-68.

13. 13. Betamar N, Cardew G, Van Noort R. Influence of specimen designs on the microtensile bond strength to dentin. J Adhes Dent. 2007;9(2):159-68.

14. Kumagai RY, Zeidan LC, Rodrigues JA, Reis AF, Roulet JF. Bond Strength of a Flowable Bulk-fill Resin Composite in Class II MOD Cavities. J Adhes Dent. 2015;17(5):427-32.

15. Pashley DH, Carvalho RM, Sano H, Nakajima M, Yoshiyama M, Shono Y, et al. The microtensile bond test: a review. J Adhes Dent. 1999;1(4):299-309.

16. Peutzfeldt A. Resin composites in dentistry: the monomer systems. Eur J Oral Sci. 1997;105(2):97-116.

17. Randolph LD, Palin WM, Leprince JG. Developing a More Appropriate Classification System for Modern Resin-Based Composite Technologies. Dental Composite Materials for Direct Restorations: Springer; 2018. p. 89-96.

18. Labella R, Lambrechts P, Van Meerbeek B, Vanherle G. Polymerization shrinkage and elasticity of flowable composites and filled adhesives. Dent Mater. 1999;15(2):128-37.

19. Lung CY, Matinlinna JP. Aspects of silane coupling agents and surface conditioning in dentistry: an overview. Dent Mater. 2012;28(5):467-77.

20. Goncalves F, Kawano Y, Pfeifer C, Stansbury JW, Braga RR. Influence of BisGMA, TEGDMA, and BisEMA contents on viscosity, conversion, and flexural strength of experimental resins and composites. Eur J Oral Sci. 2009;117(4):442-6.

21. Xu HH. Dental composite resins containing silica-fused ceramic single-crystalline whiskers with various filler levels. J Dent Res. 1999;78(7):1304-11.

22. Li S, Meng Lin M, Toprak MS, Kim DK, Muhammed M. Nanocomposites of polymer and inorganic nanoparticles for optical and magnetic applications. Nano Rev. 2010;1.

23. Lutz F, Phillips RW. A classification and evaluation of composite resin systems. J Prosthet Dent. 1983;50(4):480-8.

24. Nandini S. Indirect resin composites. J Conserv Dent. 2010;13(4):184-94.

25. Agarwal RS, Hiremath H, Agarwal J, Garg A. Evaluation of cervical marginal and internal adaptation using newer Bulk-Fill composites: An in vitro study. Journal of conservative dentistry: JCD. 2015;18(1):56.

26. Christensen GJ. Advantages and challenges of bulk-fill resins. Clinicians Report. 2012;5(1):1-2.

27. Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater. 2005;21(1):36-42.

28. Ozturk N, Usumez A, Usumez S, Ozturk B. Degree of conversion and surface hardness of resin cement cured with different curing units. Quintessence Int. 2005;36(10):771-7.