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Original Article

The Impact of Immediate Versus Delayed Dentin Sealing on the Microtensile Bond Strength of Ceramic Restorations

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Abstract

Introduction: While immediate dentin sealing enhances bond strength over delayed sealing, conflicting evidence exists regarding the efficacy of adjunctive techniques such as sandblasting and fiber reinforcement. This study aimed to compare the microtensile bond strength and failure modes of ceramic restorations bonded using immediate (IDS) versus delayed (DDS) dentin sealing methods.

Methods: Twenty human third molars were disinfected and randomly divided into control (DDS), IDS1 (with sandblasting), IDS2 (without sandblasting), and IDS3 (with fiber reinforcement) groups. After tooth preparation, the samples were stored in distilled water at 37°C for 7 days. Ceramic discs were treated with the 9.5% hydrofluoric acid and silane primer, then cemented to the prepared teeth. The samples were stored in distilled water at 37°C for 24 hours. Bar-shaped samples were sectioned, thermocycled, and stored for 72 hours in distilled water at 37°C before microtensile bond strength testing. Failure types were assessed using a stereomicroscope.

Results: The highest mean bond strength was observed in the IDS3 group (24.09 MPa), followed by IDS2 (21.38 MPa), IDS1 (21.08 MPa), and DDS (16.57 MPa). One-way analysis of variance (ANOVA) revealed a noticeable difference in bond strength between the groups ($P<0.001$). Tukey's post hoc test demonstrated that all three IDS groups had significantly higher bond strengths compared to the DDS group, while no significant differences were found between the IDS groups. Qualitative assessments of failure types showed that failures were primarily adhesive between cement and bond, particularly in the DDS and IDS1 groups. The IDS3 group exhibited more mixed failures, indicating a stronger bond.

Conclusion: Overall, immediate dentin sealing significantly improved bond strength compared to DDS, with no significant differences among the IDS techniques.

Keywords: Dental onlays, Dental resins, Dentin-bonding agents, Polyethylene, Dental restoration failure

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Introduction

Restoring posterior teeth poses a serious challenge for dental professionals, as restorations must not only meet aesthetic demands but also ensure proper function while preserving as much of the natural tooth structure as possible. Although direct composite restorations have been a common solution, they face limitations, especially in cases involving extensive cavities where durability and long-term performance are crucial. Indirect ceramic restorations have emerged as a superior alternative, offering enhanced durability, better resistance to wear, and improved aesthetics, particularly in larger cavities (1). Similarly, these restorations have proven superior to post-core crowns, allowing for the preservation of more natural tooth structure (2).

Traditional indirect restoration techniques typically require two separate sessions. In the first session, an impression is taken after tooth preparation, and a temporary restoration is placed. The second session involves the removal of the temporary restoration and the application of the final restoration (3,4). During this process, the dentin is treated with bonding agents and luting resins before cementing the ceramic restoration. This method, known as delayed dentin sealing (DDS), has notable drawbacks. The temporary restoration may leave residual cement on the dentin surface, and contamination

during the interval between sessions can impair the hybridization process. As a result, the bond strength may decrease because the final restoration is applied to a less-than-optimal dentin surface (5). In addition, DDS is associated with bacterial leakage and postoperative sensitivity, further affecting restoration success (6).

The concept of immediate dentin sealing (IDS) was introduced to address the shortcomings of DDS. IDS involves applying an adhesive agent to the freshly prepared dentin surface before placing the temporary restoration. This approach ensures that hybridization occurs on a clean, uncontaminated dentin surface, resulting in stronger and more reliable bonding (7-8). Further advancements in biomimetic dentistry have incorporated the use of polyethylene and glass fibers to reinforce restorations, especially in large cavities, where additional strength is necessary. These fibers improve fracture resistance, reduce microleakage, and act as a stress reliever (9,10). Additionally, surface conditioning methods, such as sandblasting (air abrasion with Al_2O_3 particles), have been explored to improve bond strength by increasing surface roughness and removing contamination, thereby enhancing mechanical adhesion (11).

Despite the promising developments in IDS and the use of advanced materials and techniques, there remains a lack of consensus regarding the most effective methods for conditioning dentin surfaces during the IDS process. There are conflicting reports on post-IDS air abrasion. Some studies show higher retention (12,13), while others report reduced bond strength (14,15); likewise, polyethylene-fiber reinforcement demonstrates pro results in some studies (16), but con findings in others (17). Given these uncertainties and the contradictory results in the literature, this study aims to investigate the microtensile bond strength of ceramic restorations to dentin, comparing the conventional DDS method with various IDS techniques, including the application of sandblasting and polyethylene fibers.

Materials and Methods

Study Design and Sample Preparation

This in vitro study was approved by the Ethics Committee of Mashhad University of Medical Sciences, Iran (protocol No. IR.MUMS.DENTISTRY.REC.1401.152) on March 11, 2023.

Twenty human third molars were extracted from patients referred to the Oral and Maxillofacial Surgery Department of Mashhad Dental School. The teeth were carefully examined under a stereomicroscope (Dino-Lite, 25X magnification) to ensure they were free of cracks. The teeth were then disinfected in a 0.5% chloramine solution and stored at 4 ˚C for 24 hours. Twenty IPS e.max Press HT cylindrical ceramic discs (Ivoclar, Switzerland) with a 4 mm height and a 13 mm diameter were prepared. According to the cementing technique, both discs and teeth were randomly divided into control (DDS), IDS1 (with sandblasting), IDS2 (without sandblasting), and IDS3 (with fiber reinforcement) groups (n = 5 per group).

To remove the occlusal enamel, the occlusal surfaces were flattened using a trimmer (MESTRA, Spain) and polished with silicon-carbide abrasive papers of 800, 1000, and 1200 grit (Starcke, Germany) suspended in water to ensure a smooth dentin surface. The root ends were cut flat to facilitate the mounting procedure.

Cementation Procedure

Delayed Dentin Sealing Group Preparation

The prepared teeth were kept in distilled water at 37 ˚C for seven days. Ceramic discs were etched using 9.5% hydrofluoric acid (Porcelain Etchant, Bisco Inc., USA) for 90 seconds, rinsed, dried, and primed with silane primer (BIS-Silane, Bisco Inc., USA) as per the manufacturer's instructions. In addition, the tooth surface was cleaned with an alcohol-soaked swab, washed, air-dried, and treated with a two-step 6th generation adhesive (Clearfil SE Bond, Kuraray, Japan). The primer was applied actively for 20 seconds, followed by gentle airflow for 5 seconds to remove the solvent. Bonding was applied in the same manner and polymerized for 20 seconds using a light-curing unit (DBA, LUX VI, Woodpecker, China).

The prepared ceramic disc was cemented to the tooth using DUO-LINK UNIVERSAL (BISCO, USA). Furthermore, a 300-g load was applied to ensure uniform seating. Excess cement was removed and cured for 20 seconds on each surface (buccal, lingual, mesial, distal, and occlusal from beyond the disc). Moreover, an oxygen-inhibiting layer (Oxyguard, Kuraray; Tokyo, Japan) was applied at the interface of the ceramic disc and the tooth. Finally, the prepared samples were incubated (Nemo Fanavaran Pars, Iran) in distilled water at 37 ˚C for 24 hours.

Immediate Dentin Sealing (With Sandblasting) Group Preparation

The IDS1 group followed the same bonding and cementation steps as the DDS group. Additionally, a 1-mm layer of flowable composite (everX Flow, GC, Japan) was applied to the tooth surface and polymerized for 40 seconds. The surface was then treated with 90 µm aluminum oxide sandblasting (Westcode, China) for 10 seconds, followed by ultrasonic cleaning for 5 minutes to remove excess particles. After washing and air drying, the ceramic discs were cemented, and the samples were stored in distilled water at 37 ˚C for 24 hours.

Immediate Dentin Sealing (Without Sandblasting) Group Preparation

The IDS2 group performed the same cementing steps as the IDS1 group while not conducting sandblasting.

Immediate Dentin Sealing (With Fiber Reinforcement) Group Preparation

A 1-mm layer of flowable composite (G-aenial Universal Flo, GC, Japan) was applied and left unpolymerized. In

addition, a single polyethylene fiber bundle (Ribbond-THM, USA) measuring 6×4 mm was pre-wetted with unfilled bonding resin, blotted, then positioned flat, centrally, and parallel to the occlusal plane, slightly short of margins. The ribbon was gently adapted into the uncured composite to ensure complete impregnation and no voids. Next, the assembly was held at 65 ˚C for 5 minutes. Further, the fiber was fully covered with a thin second layer of the same flowable composite and light-cured for 40 seconds. The specimens were stored in distilled water at 37 ˚C for 7 days; ceramic preparation and cementation proceeded as for other groups.

Pre-Test Preparations

The samples were mounted in self-curing acrylic (Acropars, Iran) and sectioned into bar-shaped specimens using a diamond blade (Nemo Fanavaran Pars, Iran) with 100-µm precision and water cooling. The first cut of each block was excluded to avoid irregularities from excess or missing cement. Furthermore, bar-shaped samples with a cross-sectional area of 1.0 ± 0.1 mm² were prepared from each group (IDS1, IDS2, IDS3, and DDS). After 72 hours of storage at 37˚C in distilled water, the samples underwent 2,000 thermal cycles (5–55 ˚C; 20 seconds of dwell in water and 10 seconds of transfer). Ultimately, the samples were prepared for microtensile bond strength testing.

Microtensile Bond Strength Assessment

Each sample was mounted in a universal testing machine (Santam, model STM-20, Tehran, Iran) with the longitudinal axis aligned to minimize bending stress. Bond strength was measured at a rate of 1 mm/min until failure, and the results were calculated in megapascals. Failure types were examined under a stereomicroscope at 25X magnification.

Statistical Analysis

The obtained data were analyzed using SPSS, version 25 (IBM, USA). Mean microtensile bond strength was estimated, and the normality of the data was tested using the Kolmogorov-Smirnov test. Moreover, a one-way analysis of variance (ANOVA) was used to compare the microtensile bond strength between the groups, followed by Tukey's post hoc test for pairwise comparisons. The significance level in the study was considered to be $P<0.05$.

Results

Microtensile Bond Strength

In this in vitro study, 20 teeth in four groups were examined for the microtensile bond strength of cemented ceramic discs. The mean ± standard deviation microtensile bond strength of the groups is provided in Table 1.

The normality of the data was evaluated in all parameters, and in all of them, the normal distribution of the data was confirmed by Kolmogorov-Smirnov statistics ($P>0.05$). One-way ANOVA analysis showed a significant difference between groups ($P<0.001$). Therefore, Tukey's post hoc test was used for pairwise comparisons. Tukey's post hoc test revealed that the control group (DDS) had significantly lower microtensile bond strength than the other groups ($P<0.05$). The graph in Figure 1 was drawn to better understand the difference in microtensile bond strength between groups.

Table 1. Mean Microtensile Bond Strength for All Groups

Groups	Mean ± SD*
DDS	16.56 ± 2.54[a]
IDS1	21.08 ± 3.77[b]
IDS2	21.37 ± 3.39[b]
IDS3	24.08 ± 3.05[b]

Note. SD: Standard deviation. *Different superscripted letters denote statistically significant differences between groups at $P<0.05$.

Failure Type

Figure 2 shows the frequency of failure types in different groups. The most frequent failure mode was adhesive at the composite-adhesive interface. Adhesive failures between the composite and ceramic were also found in IDS1 and IDS3, and mixed failures were observed only in IDS3. Moreover, some failures taken by a stereomicroscope at 25x magnification are displayed in Figures 2 and 3.

Discussion

The conventional approach for cementing indirect restorations (DDS) involves tooth preparation and sealing the dentin during restoration delivery. However, DDS often fails to meet optimal bonding expectations. IDS has been shown to address the disadvantages of DDS by reducing post-cementation dentin sensitivity and bacterial leakage while improving pulp survival.

Evidence on post-IDS air abrasion/tribochemical coating is contradictory. It can increase retention on the resin-coated surface (12,13), but aggressive abrasion or a thin adhesive layer may expose or damage the hybrid layer and reduce bond strength (14,15). On the other hand, polyethylene-fiber reinforcement can decrease polymerization-shrinkage stress and shift failures to more favorable modes, especially in high C-factor or deep dentin (16), but the benefit is inconsistent; poor fiber placement, inadequate resin wetting, or incompatibility with the adhesive/cement system can negate microtensile bond strength gains (17). Overall, IDS outcomes are technique-sensitive and depend on adhesive film thickness, fiber handling, and bonding-system chemistry.

In this study, IDS demonstrated significantly higher bond strength compared to DDS, with no significant differences among the IDS techniques, which aligns with the findings of previous studies, highlighting the superiority of IDS over DDS (18,19). Hardan et al (18) reported improved dentin bond strength with IDS, which is consistent with our results. Their study used two adhesive types, etch-and-rinse and self-etch, without

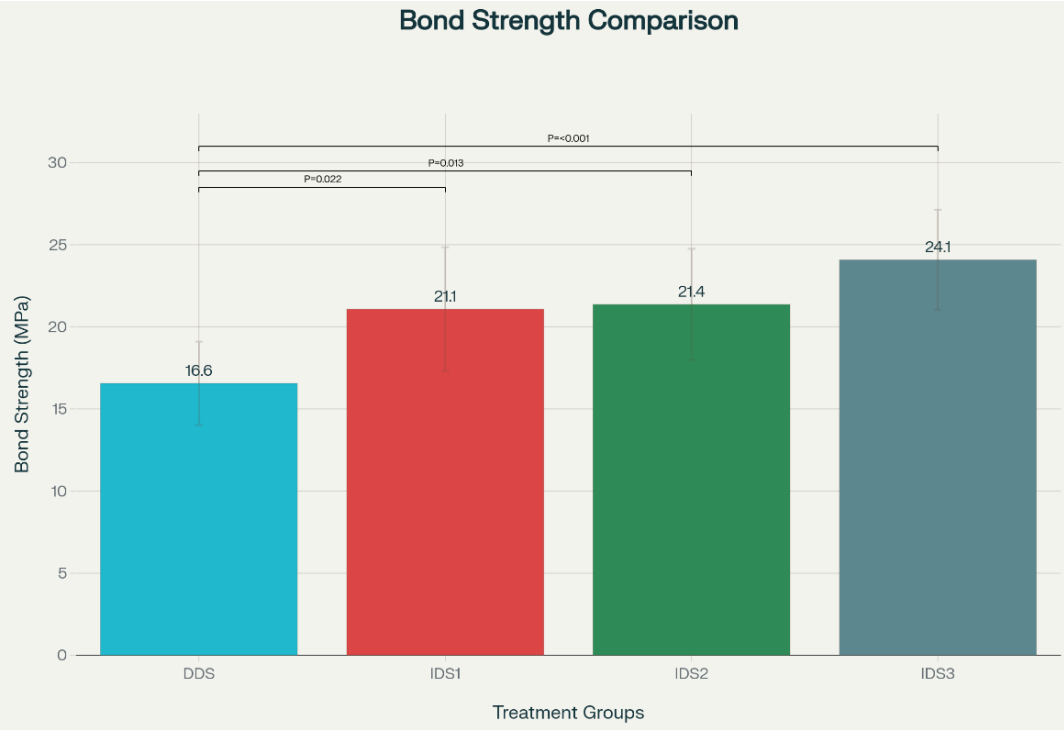

Figure 1. Microtensile Bond Strengths in All Groups

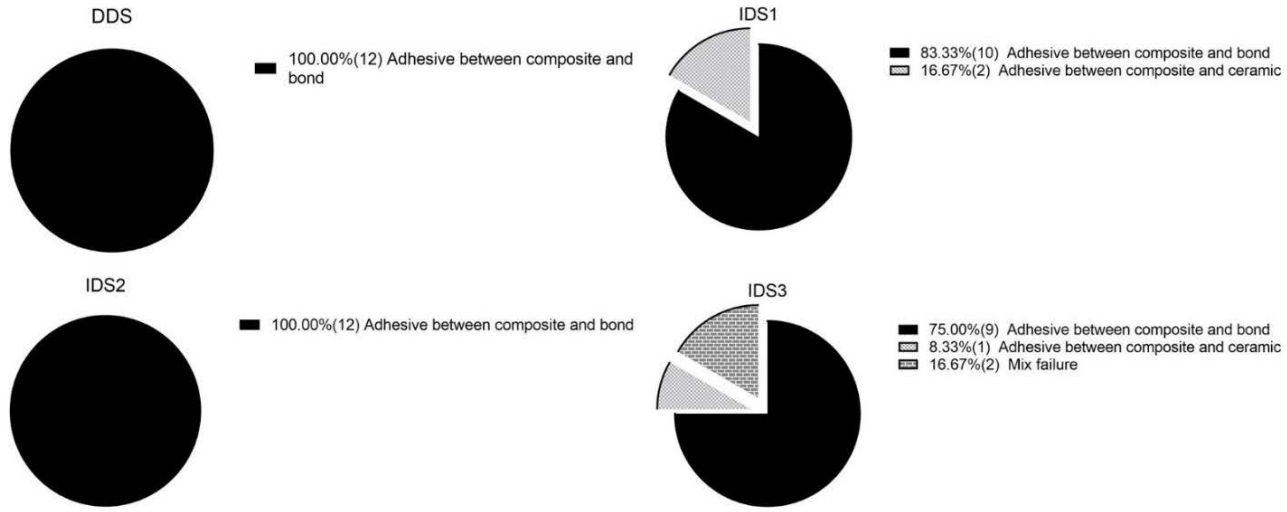

Figure 2. Failure-Mode Distribution

finding significant differences between them. Similarly, de Carvalho et al (20) found that IDS enhanced bond strength across all the studied adhesives, particularly when a flowable composite layer was applied. In our study, Clearfil SE Bond, a self-etch adhesive, combined with a flowable composite layer, yielded robust results.

Some review studies (21,22) have consistently emphasized the positive impact of IDS on reducing microleakage and postoperative sensitivity while improving the longevity of indirect restorations, which does not match the results of all studies. Falkensammer et al (13) concluded that IDS was less effective than DDS, possibly due to their use of eugenol-free cement. Their application of silica-coated aluminum oxide improved bond strength in both DDS and IDS groups, likely due to better removal of cement particles and enhanced chemical bonding. In contrast, our results revealed that sandblasting in the IDS1 group did not significantly improve bond strength, possibly due to storage conditions in distilled water rather than saliva, which may better replicate oral environments. Our finding that sandblasting (IDS1) did not further increase bond strength is compatible with reports that tribochemical silica coating/air abrasion may partially remove a thin IDS layer and thereby compromise the IDS benefit unless a sufficiently thick resin coat is protected, underscoring the technique sensitivity of post-IDS surface conditioning (12).

Failure analysis in our study revealed that most failures

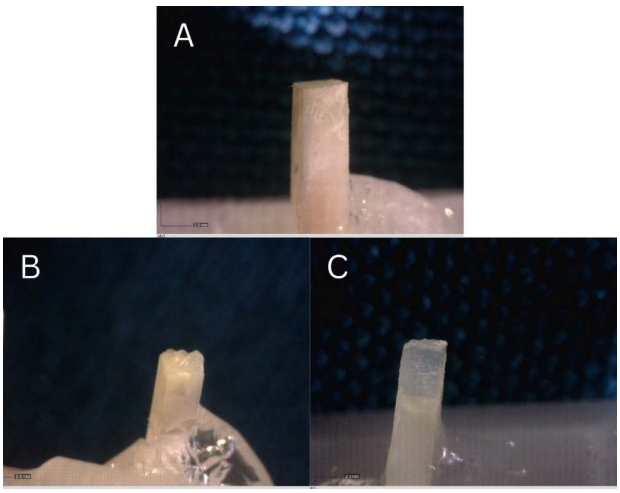

Figure 3. Representative Failure Surfaces (Stereomicroscope, 25×)

were adhesive between the composite and the bond, particularly in the DDS and IDS1 groups. IDS3 showed more mixed failures, indicating a stronger bond, likely due to polyethylene fibers. However, these findings are qualitative and have not been assessed quantitatively. Similarly, Falkensammer et al (13) found adhesive failures to dominate in IDS groups, while DDS displayed more mixed failures, a trend partially consistent with our results.

The use of polyethylene fibers in IDS3 did not significantly outperform other IDS methods, which conforms to the results of Belli et al (23), demonstrating that polyethylene fibers enhanced bond strength only in high C-factor cavities. In low C-factor scenarios (e.g., smooth dentin surfaces), they had no effect. The results in IDS3 likely stem from the IDS technique itself rather than the fibers. Additionally, the everX Flow composite used in the IDS1 and IDS2 groups, known for its short fiber reinforcement and thixotropic viscosity, likely contributed to the bond strength improvement.

Clearfil SE Bond (two-step self-etch) has been selected for this study because it contains 10-MDP, which forms stable MDP–Ca bonds with hydroxyapatite and supports durable resin-dentin interfaces (24). Among self-etch systems, Clearfil SE Bond is widely regarded as a benchmark ("gold standard") with strong short-term and long-term performance (25), including randomized clinical data (26). Its frequent use in IDS protocols reflects this chemistry-driven reliability and corroborates the evidence that IDS improves μTBS versus DDS (4,14).

While comparing IDS methods, no prior studies have mirrored our experimental design in terms of adhesive layers, flowable composite use, or sandblasting techniques. Further research is needed to evaluate these variables systematically.

The findings of this study, based on an in vitro design, may not be fully generalizable to clinical practices. The omission of impression-taking and temporary restoration, both of which could influence outcomes, is a limitation of this study. Future studies should focus on simulating oral conditions and evaluating bond strength over time to provide more clinically relevant insights.

Conclusion

IDS significantly improved bond strength compared to DDS, whether applied with a high-filler flowable composite, with or without sandblasting, or combined with polyethylene fibers. However, no significant differences were observed among the IDS techniques. Further studies are required under conditions replicating the oral environment.

Authors' Contribution

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Supervision: Alireza Borouzi Niat.
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Writing - review & editing: Reza Shakiba.

Competing Interests

The authors declare they have no conflict of interests.

Consent for Publication

Not applicable.

Data Availability Statement

The data of the current study are available upon reasonable request from the corresponding author.

Ethical Approval

The protocol of this in vitro study was approved by the Research Ethics Committee of Mashhad University of Medical Sciences (IR.MUMS.DENTISTRY.REC.1401.152).

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References

1. Saadeddin N, Al-Khalil MA, Al-Adel O. Effect of immediate dentin sealing on the fracture strength of lithium disilicate ceramic onlays. Swiss Dent J. 2022;132(7-8):482-9. doi: 10.61872/sdj-2022-07-08-01
2. Hu SN, Li JW, Zhang XX, Wei R, Liang YH. Outcome of chairside CAD/CAM ceramic restorations on endodontically treated posterior teeth: a prospective study. BMC Oral Health. 2024;24(1):51. doi: 10.1186/s12903-023-03812-3
3. Swift EJ Jr. Critical appraisal: immediate dentin sealing for indirect bonded restorations. J Esthet Restor Dent. 2009;21(1):62-7. doi: 10.1111/j.1708-8240.2008.00232.x
4. Samimi P, Iranmanesh P, Khoroushi M, Kafi MH, Jafari N. Bond strength evaluation of ceramic restorations with immediate dentin sealing: a systematic review and meta-analysis. J Dent (Shiraz). 2024;25(3):192-202. doi: 10.30476/dentjods.2023.97057.1986
5. Pérez-Soto E, Bourgi R, Hardan L, Cuevas-Suarez CE, Monjáras-Ávila AJ, Fernández-Barrera M, et al. Bonding to demineralized dentin: impact of immediate and delayed

dentin sealing over time. Dent J (Basel). 2025;13(8):354. doi: 10.3390/dj13080354
6. Abdulsattar YH, Kadhim AJ. Effect of immediate dentin sealing on the fracture strength of indirect overlay restorations using different types of luting agents (a comparative in vitro study). J Conserv Dent Endod. 2023;26(4):434-40. doi: 10.4103/jcd.jcd_226_23
7. Alleman DS, Nejad MA, Alleman DS. The protocols of biomimetic restorative dentistry: 2002 to 2017. Inside Dentistry. 2017;13(6):64-73.
8. Kovalsky T, Voborna I, Ingr T, Morozova Y, Misova E, Hepova M. Immediate dentin sealing: effect of sandblasting on the layer thickness. Bratisl Lek Listy. 2022;123(2):87-91. doi: 10.4149/bll_2022_015
9. Mangoush E, Garoushi S, Lassila L, Vallittu PK, Säilynoja E. Effect of fiber reinforcement type on the performance of large posterior restorations: a review of in vitro studies. Polymers (Basel). 2021;13(21):3682. doi: 10.3390/polym13213682
10. Selvaraj H, Krithikadatta J, Shrivastava D, Alonazi MA, Algarni HA, Munaga S, et al. Systematic review fracture resistance of endodontically treated posterior teeth restored with fiber reinforced composites- a systematic review. BMC Oral Health. 2023;23(1):566. doi: 10.1186/s12903-023-03217-2
11. Gailani HFA, Benavides-Reyes C, Bolaños-Carmona MV, Rosel-Gallardo E, González-Villafranca P, González-López S. Effect of two immediate dentin sealing approaches on bond strength of lava™ CAD/CAM indirect restoration. Materials (Basel). 2021;14(7):1629. doi: 10.3390/ma14071629
12. van den Breemer C, Özcan M, Cune MS, Ayres AA, Van Meerbeek B, Gresnigt M. Effect of immediate dentin sealing and surface conditioning on the microtensile bond strength of resin-based composite to dentin. Oper Dent. 2019;44(6):E289-98. doi: 10.2341/18-052-l
13. Falkensammer F, Arnetzl GV, Wildburger A, Krall C, Freudenthaler J. Influence of different conditioning methods on immediate and delayed dentin sealing. J Prosthet Dent. 2014;112(2):204-10. doi: 10.1016/j.prosdent.2013.10.028
14. Ozer F, Batu Eken Z, Hao J, Tuloglu N, Blatz MB. Effect of immediate dentin sealing on the bonding performance of indirect restorations: a systematic review. Biomimetics (Basel). 2024;9(3):182. doi: 10.3390/biomimetics9030182
15. do Nascimento Santos JV, Almeida HN, Diniz LBN, de Andrade Nogueira M, Junior JF, Özcan M, et al. Effectiveness of dentin cleaning using air abrasion with aluminum oxide particles on the bond strength of resin-based cements: a systematic review and meta-analysis. J Dent. 2025;161:105950. doi: 10.1016/j.jdent.2025.105950
16. Sadr A, Bakhtiari B, Hayashi J, Luong MN, Chen YW, Chyz G, et al. Effects of fiber reinforcement on adaptation and bond strength of a bulk-fill composite in deep preparations. Dent Mater. 2020;36(4):527-34. doi: 10.1016/j.dental.2020.01.007
17. Pimentel M, Kantovitz KR, Turssi CP, do Amaral F, Basting RT, de Moura Martins L, et al. Impact of polyethylene fiber-reinforced composite resin and thermomechanical cycling on dentin bond strength. Braz Oral Res. 2025;39:e13. doi: 10.1590/1807-3107bor-2025.vol39.013
18. Hardan L, Devoto W, Bourgi R, Cuevas-Suárez CE, Lukomska-Szymanska M, Fernández-Barrera M, et al. Immediate dentin sealing for adhesive cementation of indirect restorations: a systematic review and meta-analysis. Gels. 2022;8(3):175. doi: 10.3390/gels8030175
19. Magne P, Kim TH, Cascione D, Donovan TE. Immediate dentin sealing improves bond strength of indirect restorations. J Prosthet Dent. 2005;94(6):511-9. doi: 10.1016/j.prosdent.2005.10.010
20. de Carvalho MA, Lazari-Carvalho PC, Polonial IF, de Souza JB, Magne P. Significance of immediate dentin sealing and flowable resin coating reinforcement for unfilled/lightly filled adhesive systems. J Esthet Restor Dent. 2021;33(1):88-98. doi: 10.1111/jerd.12700
21. Samartzi TK, Papalexopoulos D, Sarafianou A, Kourtis S. Immediate dentin sealing: a literature review. Clin Cosmet Investig Dent. 2021;13:233-56. doi: 10.2147/ccide.S307939
22. Qanungo A, Aras MA, Chitre V, Mysore A, Amin B, Daswani SR. Immediate dentin sealing for indirect bonded restorations. J Prosthodont Res. 2016;60(4):240-9. doi: 10.1016/j.jpor.2016.04.001
23. Belli S, Dönmez N, Eskitaşcioğlu G. The effect of c-factor and flowable resin or fiber use at the interface on microtensile bond strength to dentin. J Adhes Dent. 2006;8(4):247-53.
24. Carrilho E, Cardoso M, Marques Ferreira M, Marto CM, Paula A, Coelho AS. 10-MDP based dental adhesives: adhesive interface characterization and adhesive stability-a systematic review. Materials (Basel). 2019;12(5):790. doi: 10.3390/ma12050790
25. Tuncer S, Tekce N, Pashaev D, Demirci M, Baydemir C. Short- and long-term bond strengths of a gold standard two-step self-etch adhesive system to dentin: a preliminary study. J Istanb Univ Fac Dent. 2015;49(2):1-7. doi: 10.17096/jiufd.60136
26. Peumans M, De Munck J, Van Landuyt K, Van Meerbeek B. Thirteen-year randomized controlled clinical trial of a two-step self-etch adhesive in non-carious cervical lesions. Dent Mater. 2015;31(3):308-14. doi: 10.1016/j.dental.2015.01.005