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Assessing the Impact of Immediate and Delayed Dentin Sealing on Microleakage of Ceramic Onlays: An In-Vitro Study

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Research Article

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ABSTRACT

Objectives: The pursuit of enhanced bond strength between ceramic restorations and dentin has led to the development of immediate dentin sealing (IDS) as a promising technique. However, it is crucial to assess the effect of IDS on microleakage to ensure the long-term success and durability of these restorations. This study aimed to compare the microleakage of ceramic onlays bonded using IDS and delayed dentin sealing (DDS) protocols.

Materials and Methods: Twenty recently extracted human maxillary premolars were randomly allocated into two groups (n = 10 each) based on the dentin sealing technique employed. The first group received immediate dentin sealing (IDS), whereas the second group underwent delayed dentin sealing (DDS). Standardized cavities were prepared, and the dentin surfaces were sealed or left unsealed accordingly. Impressions were taken, and temporary restorations were fabricated. The wax patterns were milled, and the onlays were fabricated by heat-pressing technique using lithium disilicate glass-ceramic. The restorations were bonded, thermocycled, and immersed in methylene blue solution. Microleakage was evaluated by examining the degree of dye penetration using a stereomicroscope.

Results: The Mann-Whitney U test revealed no significant differences in microleakage between the two groups at the occlusal, palatal, and proximal margins.

Conclusions: Within the limitations of this in vitro study, the findings suggest that the IDS technique does not significantly influence the microleakage of ceramic onlays compared to the DDS protocol.

Keywords: Ceramic onlay, immediate dentin sealing, micro-leakage

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Introduction

When it comes to restoring teeth in the posterior region, partial coverage ceramic restorations have proven to be an excellent choice, offering a harmonious balance between aesthetics and functionality while preserving a significant amount of dental tissue. Long-term clinical studies have consistently demonstrated high survival rates for these restorations.[1] Among the various materials used for fabricating partial coverage restorations, heat-pressed lithium disilicate glass-ceramic stands out for its exceptional properties, including high fracture strength and excellent aesthetic capabilities.

In an effort to enhance the bonding of restorations to dentin, immediate dentin sealing (IDS) was first proposed in the early 1990s by Dr. Shigehisa Inokoshi, involving the application of resin materials to seal and protect the dentin and pulp after preparation and before impression, as recommended by Inokoshi.[2] This technique has been referred to by various terms, including "pre-hybridization," "dual bonding technique," and "resin coating technique." The IDS technique is believed to provide a layer of protection to the underlying hybrid layer, thereby preserving the dentin seal. According to Magne,[3] the IDS technique offers significant advantages in cases where tooth preparation for an indirect restoration exposes a substantial area of dentin.

The advantages of the IDS technique are multifaceted, including the potential to improve bonding strength,[4,5] and fracture strength.[6] Additionally, several studies have reported that the IDS technique can significantly reduce hypersensitivity.[7]

Microleakage, defined as the penetration of bacteria, fluids, ions, or molecules between the restoration and preparation walls, remains a significant concern in restorative dentistry. It can occur due to the destruction of the tooth-restoration interface caused by thermal expansion differences between the tooth and restoration or polymerization shrinkage of resin materials, leading to marginal gap formation. The consequences of microleakage are far-reaching, including degradation of bonding materials, post-operative sensitivity, and potential harm to pulp vitality. Therefore, it is crucial to investigate materials and techniques that can mitigate or prevent microleakage.

The main goal of this study was to assess the microleakage of lithium disilicate ceramic onlays in conjunction with the immediate dentin sealing technique (IDS) and compare it to delayed dentin sealing (DDS). The null hypothesis was that the immediate dentin sealing technique would not have a significant impact on the microleakage of ceramic restorations.

Materials and Methods

Specimen Preparation

Twenty maxillary premolars were selected for restoration with heat-pressed lithium disilicate glass-ceramic onlays, bonded using either the IDS or DDS technique. Initially, twenty sound maxillary premolars (N = 20) were extracted for orthodontic purposes and utilized for this in vitro study. To remove calculus and soft tissue residues, hand scalers and dental curettes were employed. The teeth were then preserved in an aqueous solution of 0.05% thymol at room temperature until the commencement of the study. During the working period, they were stored in an aqueous solution of 0.9% sodium chloride. The teeth were randomly divided into two groups according to the dentin sealing technique: Group 1 (n = 10) for the IDS technique and Group 2 (n = 10) for the DDS technique. Prior to preparation, cuboid molds were created using putty condensation silicone (18 × 18 × 13 mm^3). The roots of the teeth were embedded in transparent self-cured acrylic resin (Orthocryl®, Dentaurum, Ispringen, Germany) with the occlusal surface parallel to the horizontal plane and 1 mm below the cemento-enamel junction (CEJ). To facilitate the final impression, twenty perforated custom trays were fabricated using self-cured acrylic resin (RESPAL® NF, SPD, Mulazzano (LO), Italy). A silicon guide was created for each tooth to control the preparation dimensions.

Teeth Preparation

All preparations were performed by a single operator. Standardized mesio-occluso-distal (MOD) cavities with reduction of the palatal cusp were prepared using a high-speed handpiece (NSK®, Japan) and a set of burs for ceramic inlays and partial crowns (Expert Set 4562; Komet Dental, Gebr. Brasseler GmbH&Co. KG, Lemgo, Germany). The preparation dimensions were as follows: the occlusal isthmus was 2 mm in width, the pulpal depth was 2 mm, the axial reduction in proximal boxes was 1 mm mesio-distally, and 2 mm occluso-gingivally. The palatal cusp reduction was 2 mm with a 45° bevel relative to the longitudinal axis of the tooth. The finish line at the external slope of the palatal cusp was a rounded shoulder with a depth of 1 mm, performed 2 mm away from the tip of the cusp. The divergent axial walls were at an angle of 10°, and all angles were rounded. The preparation dimensions were measured using a silicone guide, a periodontal probe, and an Iwanson caliper. All surfaces were smoothened with fine and extra fine diamond burs.

Immediate Dentin Sealing

Following the preparation of the first group, the immediate dentin sealing technique was employed prior to taking the final impression. To initiate the process, the dentin was etched with phosphoric acid (UNI-ETCH®, 32%, BISCO, Inc., IL, USA) for 15 s, extending the application 1 mm towards the enamel margins. The etched surface was then thoroughly rinsed and dried. Subsequently, a layer of dual-cured universal dental adhesive system (ALL-BOND 3®, BISCO, Inc., IL, USA) was applied to the etched surfaces and air-dried. The adhesive layer was light-cured for 10 s, using an LED curing light (LEDition, Ivoclar Vivadent AG, Schaan, Liechtenstein). A thin layer of filled bonding resin (ALL-BOND 3® RESIN, BISCO) was then applied and light-cured for 10 s. Additionally, a thin layer of flowable composite resin (Te-Econom Flow, Ivoclar Vivadent AG) was applied and light-cured for 20 s. The oxygen-inhibited layer (OIL) was treated by wiping it with an alcohol-moistened cotton ball. The sealed surface was then covered with glycerin gel and light polymerized for 20 s. Finally, the preparation was redefined, and the enamel margins were re-beveled using fine diamond burs and rubber polishing discs for finishing and polishing.

Impression Making

A total of 20 perforated custom trays were utilized for making impressions of the 20 prepared premolars. In the first group, the impression was taken after completing the immediate dentin sealing technique, whereas in the second group, it was taken immediately after the preparation was completed. A condensation silicone putty and light body were used following the putty-wash one-step technique (zetaplus/oranwash L/indurent gel, Zhermack SpA, Italy).

Temporary Restoration

Prior to temporary restoration, the preparation surface was coated with a layer of separating material (PRO-V COAT®, BISCO, Inc., IL, USA) and air-dried for 15 s. Subsequently, the temporary restoration was built using a light-cured provisional packable composite (PRO-V FILL®, BISCO, Inc.) and light-cured for 10 s. A layer of low viscosity liquid polish (BisCover™ LV, BISCO, Inc.) was then applied to the entire surface of the provisional restoration and light-cured for 30 s. To simulate oral conditions, a storage period of 14 days under controlled conditions of 37°C and 100% relative humidity was implemented for all specimens. During this time, they were placed in a dry heat sterilization unit (TS TAU STERIL 2000 Automatic, Fino Mornasco, Italy).

Laboratory Procedures

A dental stone type IV (ISO 6873, Type 4: Die Stone Premium, South Korea) was employed for casting impressions. Subsequently, the gypsum master cast was digitally scanned using the SMART (Big) Optical 3D Scanner (Open Technologies, Italy). The Exocad DentalCAD software (Exocad GmbH, Germany) was utilized to design the restoration, taking into account the type and material specifications. A cement thickness of 20 µm was predetermined, with a 1 mm margin from the preparation margins. The wax patterns were then milled into a full anatomic form using a wax molding disc (Shenzhen Vasden Bioceramics Co., Ltd., China) through an in-lab CAD/CAM system (Roland DWX-51D, Roland DGA Corporation, CA, USA). Furthermore, glass-ceramic (IPS e.max Press, Ivoclar Vivadent AG, Schaan, Liechtenstein) was used to fabricate the ceramic onlays via the heat-pressed technique, strictly adhering to the manufacturer's guidelines. The wax patterns were invested using Maruvest Speed (Megadental GmbH, Germany), and the IPS e.max ingots (HO1 color) were heated and pressed in the investment mold following the wax burnout process.

Cementation Protocol

The try-in of ceramic onlays was facilitated using a precision probe and a condensation silicone wash (Speedex Light Body/Universal Activator, Coltène/Whaledent AG, Altstätten, Switzerland). To ensure optimal bonding, the ceramic onlay was disinfected with ethyl alcohol, followed by a thorough cleaning of the internal surface with phosphoric acid (H_3PO_4) (ETCH-37™ (37%), Bisco Inc., IL, U.S.A) for 30 s. Subsequently, the ceramic surface was etched using 9% hydrofluoric acid (Porcelain Etch, Ultradent Products Inc., UT, USA) for 20 s, rinsed, and dried.

Next, the onlay was immersed in an ultrasonic cleaner (Clean-02; Ultrasonic cleaner; Runyes Medical Instrument Co., Ltd., Ningbo, China) to remove any residual debris, followed by hot air drying (Calor Moveling 1400W; Sèche-cheveux; PRC) to eliminate excess moisture. Two layers of silane coupling agent (Silane, Ultradent Products Inc., UT, USA) were then applied and left for 60 s. A layer of universal adhesive system (All-Bond 3®) was subsequently applied, but not light-cured.

To prepare the teeth for cementation, the abutments were cleaned with a polishing paste containing fluoride-free pumice powder. For the abutments in the DDS group, the cavity was etched with phosphoric acid (UNI-ETCH® ,32%) for 15 s, rinsed, and dried. A coat of dental adhesive system (All-Bond 3®) was then applied and light-cured for 10 s. In contrast, the abutments in the IDS group underwent sandblasting (CoJetTM Prep, 3M ESPE AG, Seefeld, Germany) with 30 µm silica-coated particles for 3 s at 30 psi, from a distance of 10 mm and an angle of 45°. Following this, the enamel margins were etched, and the sealed surfaces were cleaned with phosphoric acid (UNI-ETCH® ,32%) for 15 s. A coat of silane (ESPETM Sil, CoJet™ System; 3M ESPE AG) was applied over the entire sealed surface and gently air dried. Next, two layers of a dental adhesive system (All-Bond 3®) were applied over the entire preparation, gently air dried, and left without curing.

For cementation: micro-hybrid composite (Enamel plus HRi Micerium, Italy) was used by preheating in a composite heater (Ena Heat Micerium, Italy) 68°C for 15 min. The onlay was seated in the cavity and subjected to a pressure of 1.5 N for 4 s, using sonic tips (SF1981/SF12; Komet Dental, Gebr. Brasseler GmbH&Co. KG) with a hand-piece (AS2000 M4; NSK Nakanishi Inc., Tochigi, Japan). The composite was initially light-cured for 5 s, followed by thorough cleaning of the margins, and finally light-cured for 40 s from all sides. The margins were finished and polished using rubber flame-shaped tips, cones, and discs.

Thermal Cycling

Thermal cycling was performed for 500 cycles (5°C/55°C) with a 15 s dwell time, to simulate the thermal stresses encountered in the oral environment.

Microleakage Measurement

To assess the microleakage of the onlay restorations, the entire surface of each tooth, excluding the restoration and a 0.5 mm surrounding margin, was coated with a single layer of nail varnish. The specimens were then immersed in a 0.5% methylene blue dye solution for 12 h to facilitate the detection of microleakage. After the dye incubation period, the specimens were thoroughly rinsed with running water and allowed to dry. Subsequently, each group of microleakage was divided into two equal sub-groups (n = 5) based on the sectioning direction: the mesio-distal section group (MD: 1-5/11-15) and the bucco-palatal section group (BP: 6-10/16-20).

To facilitate the sectioning process, an apico-occlusal division line was identified on each tooth surface and acrylic base using a permanent marking pen. The specimens were then cut vertically along the specified separation line into two equal parts, with the cutting direction parallel to the longitudinal axis of the premolar. For the mesio-distal section group, the cutting was performed in the middle of the buccal-palatal distance, while for the bucco-palatal section group, the cutting was performed in the middle of the mesio-distal distance. The cutting surfaces were then polished with sandpapers and rubber discs to remove any debris or scratches.

Microleakage was evaluated by assessing the extent of dye penetration between the inner surface of the ceramic restoration and the preparation surfaces of the abutment using a stereo microscope (Model SKT 41323; Meiji Stereo Microscope, MEIJI TECHNO Co., Ltd., Saitama, Japan) at a total magnification of 20x, with an objective lens of 2x. Four evaluation points were examined for each premolar cut in the mesio-distal direction, and four others for each one cut in the bucco-palatal direction. Each cutting surface had two points for assessing the marginal leakage (Figures 1 and 2), which were evaluated using an ordinal scale scale from 0 to 3 (Tables 1, 2, and 3). Therefore, the total number of points examined for microleakage was four points for each abutment, and eighty points for all the specimens in the study.

Statistical Analysis

The data were analyzed using IBM SPSS Statistics v.25 software (IBM Corp., Chicago, IL, USA) with a significance level set at 0.05. The non-parametric Mann-Whitney U test was selected to compare the microleakage scores between the two groups because the data were measured on an ordinal scale (0-3), which violates the distributional assumptions of parametric tests. This test was used to evaluate the effect of the dentin sealing technique on the microleakage level.

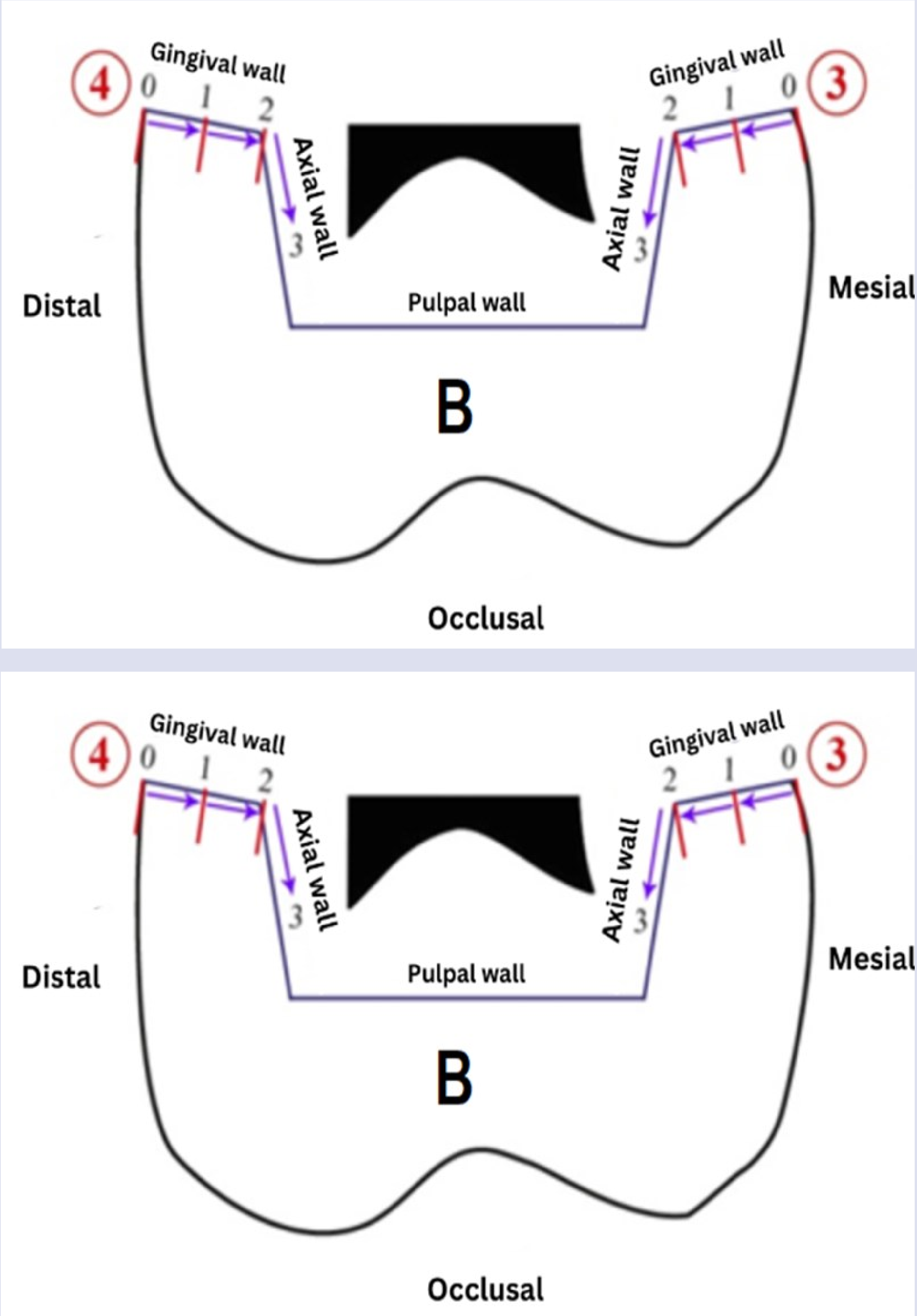

Figure 1. Reference points for microleakage evaluation in the mesio-distal section. (A) The first mesio-distal cutting surface showing the evaluation points at the mesial (①) and distal (②) margins. (B) The opposing half of the same tooth section showing the corresponding evaluation points at the mesial (③) and distal (④) margins.

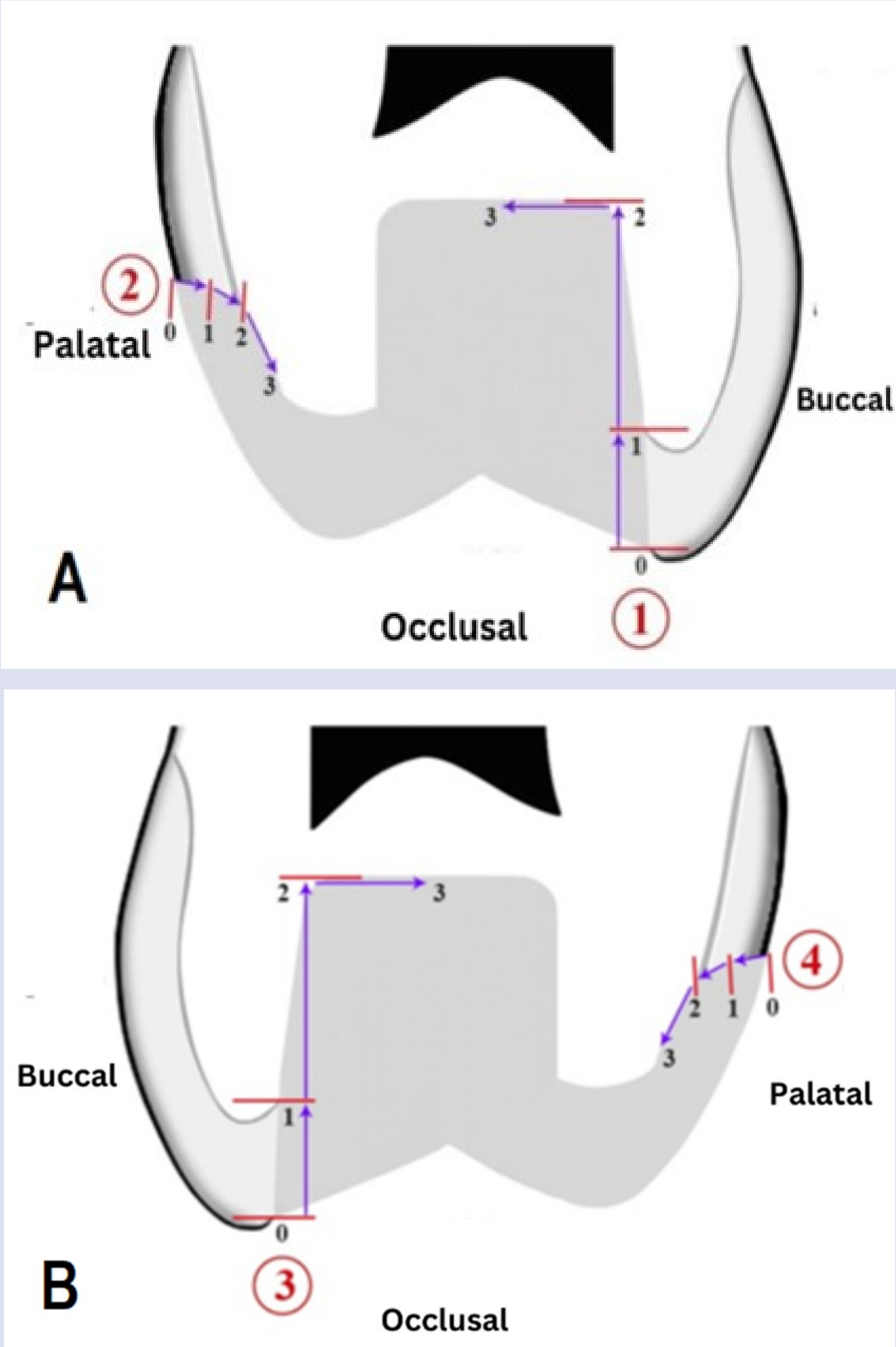

Figure 2. Reference points for microleakage evaluation in the bucco-palatal section. (A) The first bucco-palatal cutting surface showing the evaluation points at the occlusal (①) and palatal (②) margins. (B) The opposing half of the same tooth section showing the corresponding evaluation points at the occlusal (③) and palatal (④) margins.

Table 1. Evaluation of the microleakage in the mesial and distal margins

	Score	Description
Microleakage degree	0	no microleakage
	1	to half of the gingival wall
	2	along the gingival wall
	3	extended into the axial wall

Table 2. Evaluation of the microleakage in the occlusal margin

	Score	Description
Microleakage degree	0	no microleakage
	1	within the enamel
	2	extended the dentin enamel junction
	3	reaching the pulpal wall

Table 3. Evaluation of the microleakage in the palatal margin

	Score	Description
Microleakage degree	0	no microleakage
	1	up to the middle of the palatal wall
	2	along the palatal wall
	3	extended into the axial wall

Table 4. Effect of dentin sealing technique on microleakage at different tooth margins (Mann-Whitney U test)

The margin	Dye penetration	IDS		DDS		p
		frequency	%	frequency	%	
Proximal (Mesial and Distal)	no penetration	10	50	7	35	0.143
	to the half of the gingival wall	5	25	5	25	
	along the gingival wall	3	15	5	25	
	extended into the axial wall	2	10	3	15	
Occlusal	no penetration	6	60	4	40	0.272
	within enamel	1	10	3	30	
	extended the dentin enamel junction	3	30	1	10	
	reaching the pulp wall	0	0	2	20	
Palatal	no penetration	10	100	8	80	0.065
	up to the middle of the palatal wall	0	0	1	10	
	along the palatal wall	0	0	1	10	
	extended into the axial wall	0	0	0	0	

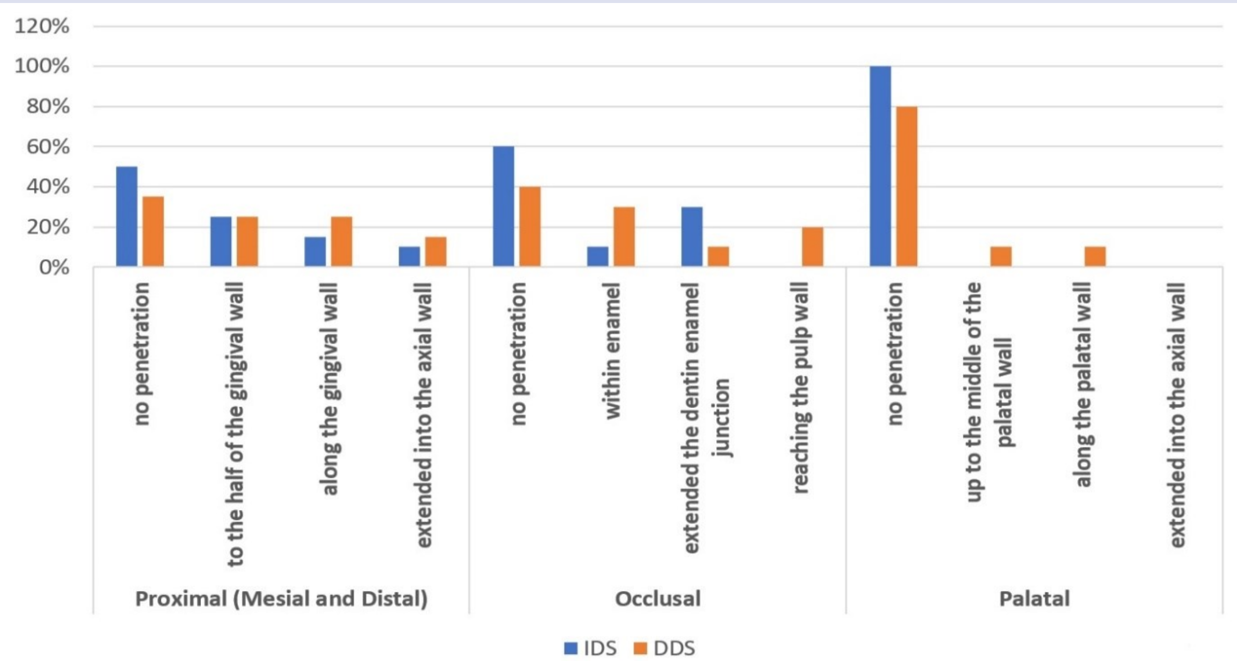

Figure 3. Comparison of microleakage scores between the immediate dentin sealing (IDS) and delayed dentin sealing (DDS) groups across different margin locations.

Figure 4. Stereomicroscopic evaluation of microleakage (dye penetration) at the restoration margin in a bucco-palatal section of a ceramic onlay.

Results

In proximal margins (mesial and distal) in the IDS group, the percentage of onlays with no microleakage was 50%, while microleakage occurred up to the half of the gingival wall was 25%, along the gingival wall 15%, and extended into the axial wall 10%. In the DDS group, there was no microleakage in 35% of onlays, up to the middle of the gingival wall 25%, along the gingival wall 25%, and extended into the axial wall 15%. There were no statistically significant differences in the degree of microleakage between the two groups in proximal margins ($p = 0.143$; Table 4 and Figure 3).

In occlusal margins, in the IDS group, the percentage of onlays with no microleakage was 60%, while microleakage within enamel occurred in 10%, and extended the dentin enamel junction 30%. In the DDS group, there was no microleakage in 40% of onlays, microleakage within the enamel 30%, extended the dentin enamel junction 10%, and reaching the pulpal wall 20%. There were no statistically significant differences in the degree of microleakage between the two groups in occlusal margins ($p = 0.272$; Table 4 and Figure 3).

In palatal margins, in the IDS group, there was no microleakage in all restorations. In the DDS group, there was no microleakage in 80% of onlays, up to the middle of the palatal wall 10%, and along the palatal wall 10%. There were no statistically significant differences in the degree of microleakage between the two groups in palatal margins ($p = 0.065$; Table 4 and Figure 3).

Microleakage in onlay under a stereomicroscope is shown in Figure 4.

Discussion

The marginal seal is a crucial aspect of clinical decision-making in indirect restorations success, as microleakage can lead to a multitude of problems that compromise their survival. In an effort to enhance the bonding of restorations to dentin, some researchers have advocated for the bonding agent application to freshly exposed dentin immediately after tooth preparation and before impression making, a technique referred to as immediate dentin sealing (IDS).[4] Given the significance of investigating materials and methods that prevent or reduce microleakage, the primary objective of this investigation was to evaluate and compare the microleakage of glass-ceramic onlays when using the IDS technique versus delayed dentin sealing (DDS). The null hypothesis posited that the IDS technique would not have a significant impact on the microleakage of ceramic onlays.

Human upper premolars were selected due to their ready availability, intact condition, and propensity for dentin exposure during preparation procedures. They provide a more accurate representation of the bonding between dentin and resin material compared to acrylic or metal teeth.

In the present study, the etch and rinse technique was employed, as initially described by Magne, who introduced the concept of immediate dentin sealing using a three-step bonding system.[3] The application of flowable composite (Te-Econom Flow) following the bonding agent serves to absorb stresses, protect the dentin-resin adhesive interface, and ultimately enhance bond strength.[8]

In the IDS group, a specialized intraoral microblasting unit (CoJet™ Prep) was utilized during the final cementation appointment to promote chemical bonding between the IDS layer and resin materials through tribochemical anchoring. This approach also enhances micromechanical bonding by increasing the bonding surfaces.[9]

Several dye solutions have been utilized in previous studies to determine the extent of dye penetration. Microleakage was assessed using methylene blue dye, a widely adopted tracer in dental research for this purpose. The dye penetration assay offers several advantages over other techniques, including its high feasibility and ease of reproducibility.[10]

A preheated composite was used in this study for the final cementation of onlays, because this material ensured greater stability during the efficient removal of excess material following restoration placement.[11] Moreover, the preheated composite improves the fracture resistance of indirect overlay restorations.[12] Better sealing was observed for composite restorations bonded with preheated composite when compared with resin cement.[13]

The occurrence of microleakage in both groups of the current study can be attributed to thermal cycling-induced degradation of the bonding system due to differential thermal expansion at adhesive interfaces,[14] prolonged exposure to 37°C for 14 days under humid conditions during provisional restoration (affecting the IDS group). Additionally, post-cementation immersion in 0.9% NaCl. Polymerization shrinkage stresses from high C-factor Class II cavity configurations exacerbated bond failure, with more pronounced effects in DDS group specimens.

The disparity in microleakage degrees observed in this study compared to previous investigations may be attributed to various factors, including the thickness of resin materials employed in the IDS technique, preparation margin variations in enamel or dentin, and differences in the direction of enamel rods and dentin tubules at the interface, which can impact bond strength and, consequently, microleakage.[15]

The null hypothesis was accepted, indicating that immediate dentin sealing (IDS) did not significantly affect the microleakage of ceramic restorations. Thus, no difference was found in microleakage whether dentin was sealed immediately after preparation or during the final cementation phase. These findings may be attributed to the use of similar materials, including modern resin materials and bonding agents, in both groups. The use of a fourth-generation etch-and-rinse adhesive system (ALL-BOND 3®), which uses separate primer and bonding agent bottles (A and B), likely contributed to these results. This two-bottle system is known to provide superior dentin sealing compared to single-bottle adhesives[16] due to its hydrophobic nature, which enhances bond strength. The improved adhesion likely provided symmetrical protection against water degradation in both groups, resulting in no statistically significant differences in microleakage.

The previous findings are in agreement with several studies. Duarte et al.[17] similarly reported no significant improvement in microleakage with IDS. Additionally, a study by Abo-Alazm and Safy[18] found no difference in dentin permeability reduction between immediate and delayed sealing of dentin. Ashy et al.,[19] likewise observed comparable marginal gap volumes between immediate and conventional dentin sealing groups following thermal cycling. These results are further supported by Spohr et al.,[20] who documented similar findings.

While the current study found no significant advantage of the IDS technique on microleakage, this contrasts with previous research reporting smaller marginal gaps with IDS,[15,21-23] improved marginal sealing via resin coating,[24,25] and reduced provisional-phase microleakage using bonding agents after preparation.[26] Discrepancies may stem from methodological variations in dye solutions, leakage assessment techniques, or sealing materials. Notably, AlGhamdi[27] observed an increase in leakage in delayed sealing groups for crowns bonded with different resin cements except for Panavia SA. The use of ammoniacal silver nitrate in the previous study to evaluate microleakage using scanning electron microscope (SEM) likely explains the difference. The small sample size may have limited the ability to detect potential differences between the groups that could occur in larger studies.

A recent study by Abo-ELsouood et al.,[28] demonstrated that the IDS with an adhesive system is superior in occluding dentinal tubules in a biomimetic manner based on its filler content, as a filled resin adhesive can produce a thick layer that is a significant contributor to the success of the IDS technique. Kitayama et al.,[29] demonstrated that flowable composite linings with high filler content (65%) improve marginal sealing, while lower filler ratios (42%) show no such benefit. Although the current study used a similar filler ratio (62%) in (Te-Econom Flow), no sealing improvement was observed with IDS. This discrepancy may stem from methodological differences in dye solutions, preparation design, or restoration materials. The technical complexity of IDS, involving multiple materials and procedural steps, may also introduce variability. Future research should standardize IDS protocols, materials, and experimental conditions to reduce variability and enhance result reliability.

Kitayama et al.[30] found that resin coating with a dentin bonding agent enhanced resin cement-dentin bond strength but failed to prevent dentin interface microleakage, while actually increasing enamel interface microleakage. This contrasts with the current findings and may be explained by the bonding system used: Malacarne et al.,[31] reported that solvated adhesives show greater water absorption than non-solvated types, potentially expanding the adhesive mass due to their highly polar acidic functional groups. In contrast, in the present study, the filled bonding resin (ALL-BOND 3® RESIN) was applied over the (water-free ethanol-based) bonding agent (ALL-BOND 3®) in the IDS group, which was HEMA-free hydrophobic monomers and had the ability to reduce the microleakage.[32]

While no significant differences were observed between the sealing groups, palatal margins demonstrated a notable tendency toward microleakage degree 0 (no penetration) and complete absence of degree 3 (axial wall penetration). This finding aligns with the study by Peixoto et al.,[33] where near-vertical prism cutting at palatal margins optimized bonding efficacy. In contrast, compromised adhesion occurred at: (1) proximal regions with thin enamel layers (gingival margins) and (2) steep buccal cusps where parallel prism cutting occurred, leading to increased microleakage. These results corroborate Krifka et al.,[34] who reported 37.3% vs. 20.1% interfacial penetration for buccal versus palatal cusps in ceramic restorations, confirming the critical role of enamel prism orientation in marginal integrity. Furthermore, a study by Thainimit et al.,[35] demonstrated that the resin cement thickness in the palatal margin was significantly lower compared to the proximal margin (and lower compared to the occlusal margin, although not statistically significant) for ceramic onlays, suggesting that increased resin cement thickness may lead to increased stresses and microleakage.

Generally, this study found significantly lower microleakage (degree 2-3) in restorations, as preparation margins entirely within enamel. Enamel's robust bonding capacity effectively resists polymerization shrinkage stresses, minimizing marginal gap formation and enhancing bacterial sealing. Margin placement in enamel is critical for optimal adhesive performance and microleakage prevention.

Limitations of the Study

The laboratory conditions employed in this study may not accurately replicate the complex oral environment, which may impact the generalizability of the results. Furthermore, the thermal cycling process used to simulate aging may not truly reflect the dynamic and multifaceted nature of the oral environment. Additionally, the microleakage assessment in this study relied on ordinal data, which provides a relative ranking of microleakage scores but does not provide a precise quantification of the extent of microleakage.[36]

The sample size (n = 10/group) was based on previous in-vitro microleakage studies. While this is common for researches, we acknowledge the lack of a priori power analysis as a limitation, as the non-significant results may reflect limited power. Future studies should include power analysis for more definitive conclusions.

Conclusions

In conclusion, this study aimed to investigate the effectiveness of the immediate dentin sealing (IDS) technique in minimizing microleakage in lithium disilicate glass-ceramic onlays. The results suggest that the IDS technique did not significantly impact the microleakage of ceramic restorations. The findings of this study underscore the need for further research on the marginal sealing properties of the IDS technique using larger sample sizes and different resin materials.

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None.

Conflicts of Interest Statement

The authors deny any possible conflict of interest related to this study.

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