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# Influence of Dentin Sealing Technique on the Shear Bond Strength between Lithium Disilicate Ceramics and Try-In-Paste-Contaminated Dentin

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**Abstract:** This study aimed to evaluate the effect of try-in paste contamination on the bond strength of lithium disilicate glass–ceramic to dentin treated with immediate (IDS) or delayed (DDS) dentin sealing techniques. Occlusal halves of 33 molars were decapitated and divided into three groups (n = 10). Lithium disilicate discs (3 × 5 mm) were prepared. For Group A, the provisional crown was applied over dentin and was soaked in distilled water. Lithium disilicate discs were cemented following dentin conditioning with a three-step etch and rinse adhesive. In Group B (IDS), the three-step adhesive was applied to dentin. The dentin surfaces were conditioned only in the final cementation for Group C (DDS). The intaglio surfaces of test groups were contaminated with try-in paste. All specimens were thermally cycled 3000 times at 5–55 °C and were subjected to shear tests. An additional three specimens for each group were contaminated with try-in paste and subjected to the same surface cleaning as the test specimens were examined with SEM/EDS. The adhesive surfaces were also examined with SEM/EDS for try-in paste remnants. Group C showed a significant decrease in bond strength values compared to Group B and Group A (5.84 ±1.4 MPa, 11.45 ±2.4 MPa, and 10.29 ±2.5 MPa, respectively). No statistically significant difference was detected between Group B and Group A ($p \geq 0.05$). The SEM-EDS analyses revealed obstructions of the dentinal tubules in the try-in-paste-contaminated specimens. Immediate dentin sealing application enhanced the bonding strength of lithium disilicate to the try-in-paste-contaminated dentin. Try-in paste contamination over dentin negatively influenced the bonding process.

**Keywords:** bond strength; delayed dentin sealing; immediate dentin sealing; try-in paste; lithium disilicate

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## 1. Introduction

Minimally invasive restorations have become popular among patients demanding high esthetics. The preparation of the teeth for all-ceramic restorations is usually restricted to enamel [1]. However, dentin exposure is common. The retention of minimally invasive restorations highly depends on the adhesive properties of luting cement rather than the geometric configuration of the preparation [2]. Thus, optimal adhesion between the tooth and restoration is crucial.

Two different techniques have been described in the literature regarding the timing of the dentin-bonding agent (DBA) application [3]. The conventional procedure consists of the application of a DBA just before the final cementation of the restoration after the etching of the dentin with phosphoric acid; hence, this is called delayed dentin sealing (DDS). The other technique involves the immediate application of DBA upon exposure of the dentin during the preparation session before provisional restoration application and impression-taking, which is called immediate dentin sealing (IDS) [4]. With this

technique, an improvement in bond strength to the dentin can be achieved by preventing the contamination of dentin surfaces and the collapse of the unpolymerized hybrid layer using a total-etch adhesive [1,5–11]. To achieve optimal adhesion between the restoration and dentin surface, the infiltration of DBA into the dentinal tubules and the formation of resin tags (hybridization) are mandatory, independent of the preferred bonding technique [10,12]. The clinical performance of a restoration–tooth complex is strongly dependent on the adhesive procedure [13–15].

Try-in pastes are glycerin-based hydrophilic substances that can be used for determining a colour match to the final polymerized cement. Using try-in pastes before the final cementation of all ceramic restorations may prevent further colour mismatches [16]. Manufacturers recommend cleaning the dentin and intaglio surface of the restoration with an oil-free air–water spray or running tap water [8]. However, the application of try-in pastes on dentin may contaminate the surface by infiltrating into the dentinal tubules due to its hydrophilic nature.

This study aimed to evaluate try-in paste contamination on the shear bond strength (SBS) of lithium disilicate glass–ceramics to the dentin surfaces treated with immediate and delayed dentin sealing techniques. The null hypothesis to be tested was that there would be no difference in terms of SBS between lithium disilicate glass–ceramics and try-in-paste-contaminated dentin treated with IDS or DDS.

## 2. Materials and Methods

A total of 33 human maxillary and mandibular molars with no cracks, restorations, or other defects were collected. The project has been evaluated and approved by the Ethical Committee for Non-invasive Research of the Faculty of Medicine of Cukurova University with the number 50243401/2021-10. The extracted teeth were disinfected in 0.5% chloramine for 24 h and stored in a distilled water at room temperature. The teeth were then embedded in an acrylic resin material (Technovit; Kulzer, Wehrheim, Germany). The occlusal half of each tooth was removed with a diamond saw to expose the mid-coronal dentin, and then polished flat with a 600-grit silicon carbide abrasive paper (Hermes; ExaktApparatbau, Norderstad, Germany) under wet conditions (Exakt 400 CS, ExaktApparatbau, Norderstad, Germany). The surfaces were inspected with a stereomicroscope (Mantis FX, Vision Engineering, Surrey, UK) under a magnification of ×20 to disclose enamel remnants.

A stainless-steel mould with a diameter of 5 mm and a 3 mm depth was manufactured. Autopolymerizing acrylic resin disc patterns (Pattern Resin LS, GC America In, Alsip, IL, USA) were prepared using the steel mould. After inspection for surface irregularities, the disc patterns were spread (Wax wire, BEGO, Bremen, Germany), invested with a phosphate-bonded investment (IPS PressVEST Speed, IvoclarVivadent, Schaan, Liechtenstein), and pressed from lithium disilicate pressable ingots (IPS e.max Press; IvoclarVivadent, Schaan, Liechtenstein) according to the manufacturer's instructions. Sprues were cut using a diamond saw and ceramic discs were inspected for surface porosities. A total of 30 lithium disilicate discs with a diameter of 5 mm and a depth of 3 mm were prepared. Before the cementation procedure, the numbers were drawn to randomize the specimens and determine the corresponding test group. In total, 30 of the specimens were divided into 3 groups (n = 10 per group). An additional 3 prepared specimens from each group were reserved for scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) examinations without surface conditioning with DBA to evaluate the try-in paste contamination of the dentin surfaces. The flow chart of the study is presented in Figure 1.

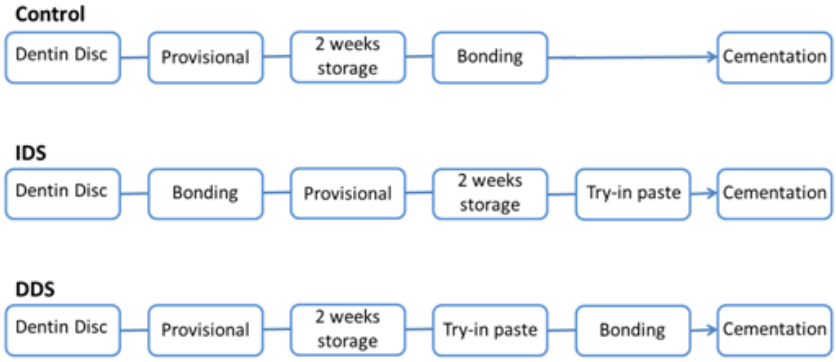



**Figure 1.** The flow chart of the study.

The adherent surfaces of the ceramic discs were sandblasted with 50 micron $Al_2O_3$ (Korox, Bego, Bremen, Germany), ultrasonically cleaned (Biosonic JR, Whaledent Int, Melville, NY, USA) with distilled water, and dried, and silane was applied (MonobondPlus; IvoclarVivadent, Schaan, Liechtenstein). Resin-based discs from provisional restoration material (Protemp Garant; 3M ESPE, Seefeld, Germany) were fabricated using the same steel mould and then used for preparing acrylic patterns.

Group A: The routine clinical application procedures of lithium disilicate (IPS e.max Press; IvoclarVivadent, Schaan, Liechtenstein) restorative material from preparation to cementation were simulated. Group B: The adhesive was immediately applied to dentin. Group C: The dentin surfaces were conditioned only in the final cementation for DDS.

For the Group A samples, the immediate dentin coating procedure and try-in paste contamination were not applied. Before coating, 600-grit silicon carbide paper was applied to the dentin surface to remove any possible roughness on the surface. The exposed dentin was polished with SiC sandpapers (#600) for 30 s to standardize the smear layer [17]. The tooth surface was covered with eugenol-free interim cement material (Kerr, Tempbond NE, KaVo Kerr, Brea, CA, USA). The samples were kept in distilled water for a week. At the end of the waiting period, the interim cement material was cleaned with pumice powder and water [18]. The inner surfaces of the porcelain discs were roughened with hydrofluoric acid for 20 s (BISCO, Inc. 1100 W. Irving Park Rd. Schaumburg, IL, USA), washed with compressed air and water for 60 s, and dried. The inner surface of the porcelain discs was silanized (Monobond Plus, IvoclarVivadent, Schaan, Liechtenstein), left for 60 s, and dried. The tooth surface was cleaned of cement residues with pumice, and then etched with 37% phosphoric acid (IvoclarVivadent, Schaan, Liechtenstein) for 15 s and washed. A bonding agent (Syntac Primer, IvoclarVivadent, FL-9494 Schaan, Liechtenstein) was applied to the surface-treated dentin samples with a brush, kept for 15 s, and air-dried. The bonding agent (Syntac Adhesive, IvoclarVivadent, Schaan, Liechtenstein) was then applied using a brush and air-dried after 10 s. A bonding agent (HeliobondIvoclarVivadent, Schaan, Liechtenstein) was applied to the tooth surface. A light polymerized resin cement (Variolink Veneer, IvoclarVivadent AG) was applied to the porcelain specimens placed on the teeth. To ensure the initial fixation, polymerization was carried out using an LED (light-emitting diode) light device (Bluephase, IvoclarVivadent) in low mode (450 mW/cm$^2$) for 3 s at an angle of 90° to contact the porcelain. Then, excess cement was cleaned with dental sond, and glycerine gel was applied. Samples were polymerized in high mode (650 mW/cm$^2$) mesial, distal buccal, and lingual for 20 s with a light device. After the polymerization process was completed, the cement residues were removed and the periphery of the porcelain discs was polished with a rubber disc (3M Espe, Sof LexTM Finishing Disc, Saint Paul, MI, USA).

For Group-B samples, 600-grit silicon carbide paper was applied to the dentin surface before coating to remove any possible roughness on the surface. The exposed dentin was polished with SiC sandpapers (#600) for 30 s to standardize the smear layer. Phosphoric acid (37%) was applied to the surface to cover the dentine and left for 15 s. After cleaning the acid with air–water spray, a bonding agent (Syntac Primer, IvoclarVivadent, Schaan,

Liechtenstein) was applied with a brush, kept for 15 s, and air-dried. Syntac Adhesive was then applied using a brush and air-dried after 10 s. Heliobond was applied to the tooth surface, thinned with compressed air, and irradiated for 3 s. Glycerin gel was applied to the surface and irradiated for 20 s more. The tooth surface was covered with temporary cement material. The samples were kept in distilled water for 1 week. The temporary cement material was cleaned with pumice and water at low speed with the help of a brush. The inner surface of the porcelain discs was roughened with hydrofluoric acid for 20 s, washed with compressed air and water for 60 s, and dried. After etching, the porcelain surfaces were contaminated with try-in paste and were brought into contact with the tooth surface. After four minutes, the ceramic sample was removed from the tooth surface. To clean the residues, phosphoric acid was applied to the ceramic surface for 1 min and then air–water spray was applied for 1 min. The tooth surface was also washed with air–water spray and dried. The inner surface of the porcelain discs was silanized with Monobond Plus, kept for 60 s, and dried. Variolink Veneer was applied on the porcelain samples, as indicated in group A.

The samples in group C were not immediately coated with dentin, but the try-in paste was contaminated. After the dentin surface was sand-blasted, the tooth surface was covered with temporary cement material (Kerr, Tempbond NE). The samples were kept in distilled water for a week. Then, the temporary cement material was cleaned with pumice and water. The inner surface of the porcelain discs was roughened with hydrofluoric acid (BISCO, Inc. 1100 W. Irving Park Rd. Schaumburg, USA) for 20 s, washed with compressed air and water for 60 s, and dried. After acid application, the porcelain surfaces were contaminated with trial paste to simulate clinical practice and were brought into contact with the cleaned tooth surface. After waiting for four minutes, the ceramic sample was removed from the tooth surface. In order to clean the residues, phosphoric acid was applied to the tooth surface and ceramic surface for 1 min, followed by air–water spray for 1 min. The inner surface of the dried porcelain discs was silanized with Monobond Plus, kept for 60 s, and dried. Syntac Primer was applied to the dentin samples with a brush, kept for 15 s, and air-dried. Syntac Adhesive was then applied with the help of a brush and air dried after waiting for 10 s. Heliobond was applied to the tooth surface, and it was thinned with compressed air and kept in a closed container. Variolink Veneer was applied on the porcelain samples, as indicated in group A.

All specimens were thermally cycled in a water bath (ST 402; Nüve, İzmir, Turkey) 3000 times between 5 °C and 55 °C, with a dwell time of 20 s in each bath and a transfer time of 10 s between baths, following the adhesive cementation of the lithium disilicate discs. After thermal cycling, all specimens were subjected to a shear test until debonding with a crosshead speed of 1 mm-s according to the ISO/TS 11405:2003 standards [19] with a universal testing machine (M500-25KN; Testometric, Lancashire, UK) (Figure 2) [18]. Immediately after the test procedure, the failure type was evaluated with a light microscope (IndentaMet; Buehler, Lake Bluff, IL, USA). Failure types were categorized as follows: Type 1: Adhesive failure (separation of resin cement from dentin tissue or ceramic). Type 2: Cohesive failure (separation of dentin tissue or resin cement from within itself). Type 3: Mixed failure (adhesive and cohesive failure together).

Three specimens reserved for SEM and EDS examination were contaminated with try-in paste in the same manner and were subjected to the same surface cleaning procedure as the SBS specimens. Surface area micrographs and elemental analyses were executed with an approximate accuracy of <1–2% on 6 selected intertubular and intratubular areas on each dentin specimen with a scanning electron microscope (Quanta; FEI, Eindhoven, The Netherlands) assembled with EDS (JXA; JEOL, Nieuw-Vennep, The Netherlands).

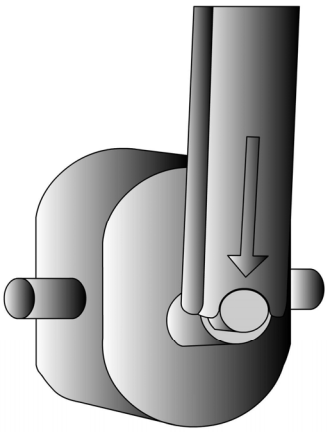


**Figure 2.** Schematic view of shear bond strength test.

The data obtained in the study were statistically analyzed using IBM SPSS Statistics vn. 20.0 software. The conformity of numerical variables to normal distribution was assessed with the Shapiro–Wilk test. The homogeneous distribution of the data was shown with the Levene test. Since the data were homogeneously distributed, the one-way ANOVA test was applied. The Dunn–Bonferroni test was applied as a post hoc test for pairwise comparisons between each independent group. A value of $p < 0.05$ was accepted as the level of statistical significance. Weibull analysis was also conducted, and the Weibull modulus was calculated for each group using SPSS 20.0.

## 3. Results

The mean SBS values of the lithium disilicate discs on dentin surfaces are presented in Table 1. Statistically significant differences were observed among the groups (df = 2; F = 7.79; $p = 0.004$). Group B had the highest SBS, while Group C had the lowest. Group C (5.84 ± 1.4 MPa) had a significant difference in SBS values compared to group B (11.45 ± 2.4 MPa) ($p = 0.008$) and group A (10.29 ± 2.5 MPa) ($p = 0.012$). There was no significant difference between groups A and B ($p = 0.823$). Groups A and C mainly showed an adhesive type of failure, while Group B mainly showed a mixed type of failure (Table 2). The representative SEM micrographs of the specimen surfaces after SBS tests are presented in Figure 3a–c. The pull-out of the dentin cuffs was observed for Group A (Figure 3a) and Group B (Figure 3c) specimens around the dentin tubules. The shear bond strength values of the study were evaluated with Weibull analysis (Figure 4). Group A had the highest Weibull modulus (m1 = 4.53), followed by Group B (m2 = 2.82) and Group C (m3 = 1.65). Unlike the Weibull modulus, the $R^2$ value for Group C (0.96) was higher than that of Group A (0.91) and Group B (0.86).

**Table 1.** Mean shear bond strength (MPa) and Weibull parameters (n = 10).

| | **Mean ± SD (MPa)** | **Weibull Modulus** | **$R^2$ for Weibull Modulus** |
|---|---|---|---|
| Group A | $10.29 \pm 2.5^{A}$ | 4.53 | 0.913 |
| Group B | $11.45 \pm 2.4^{A}$ | 2.82 | 0.862 |
| Group C | $5.84 \pm 1.4^{B}$ | 1.65 | 0.955 |
| *p* | 0.004 | - | - |

Different superscripted uppercase letters indicate significant different means within each column ($p < 0.05$).

**Table 2.** Distribution of failure types.

| | Adhesive | Cohesive | Mixed |
|---|---|---|---|
| Group A | 2 | 4 | 4 |
| Group B | 7 | 1 | 2 |
| Group C | 2 | 2 | 6 |

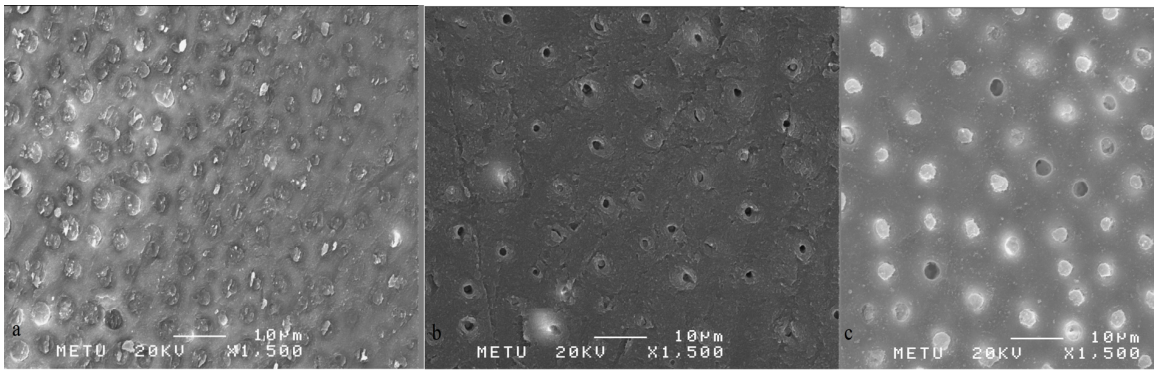



**Figure 3.** SEM images of Groups A, B and C used in the study at ×1500 magnification.

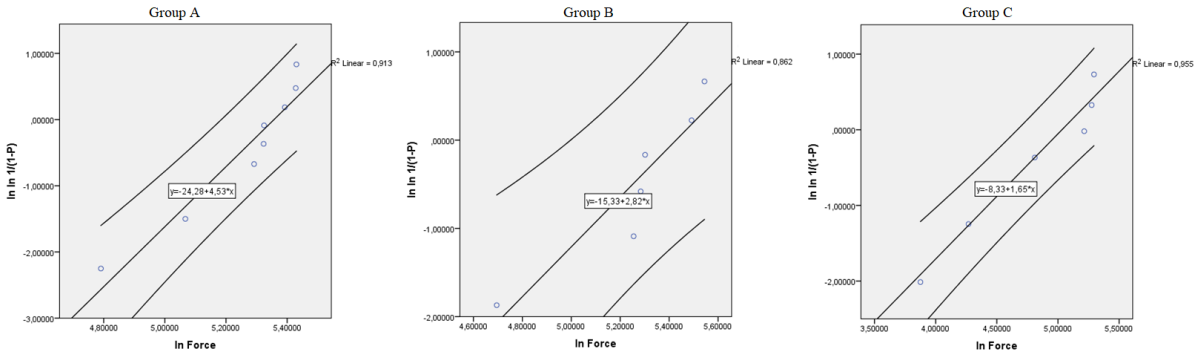



**Figure 4.** Weibull distribution of Group A, B, and C.

SEM-EDS analyses revealed the obstruction of the dentinal tubules with try-in paste contamination for all three specimens. Contaminations are shown with arrows in Figure 5. As seen in the representative EDS spectra from intratubular (Figure 6A) and intertubular (Figure 6B) dentin areas of a specimen, a significant carbon and zinc presence was evident from the EDS analyses, besides the natural compositional elements of the dentinal tooth structure. The weight percentages of the elements detected are presented in Table 3.

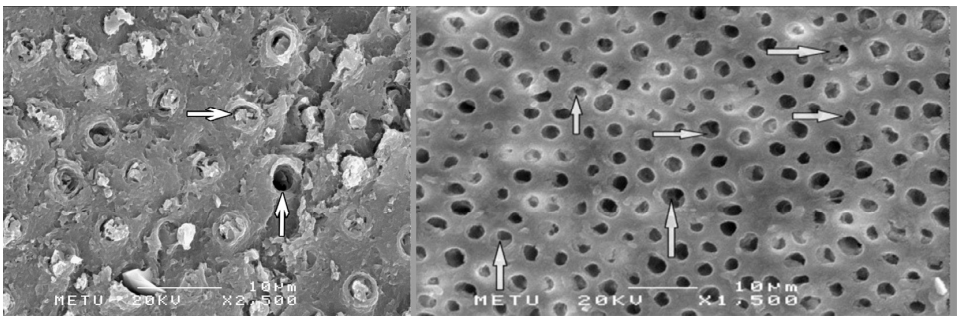



**Figure 5.** Representative scanning electron micrograph of dentin surface after try-in paste contamination and cleaning procedure. Contaminations are shown with arrows.

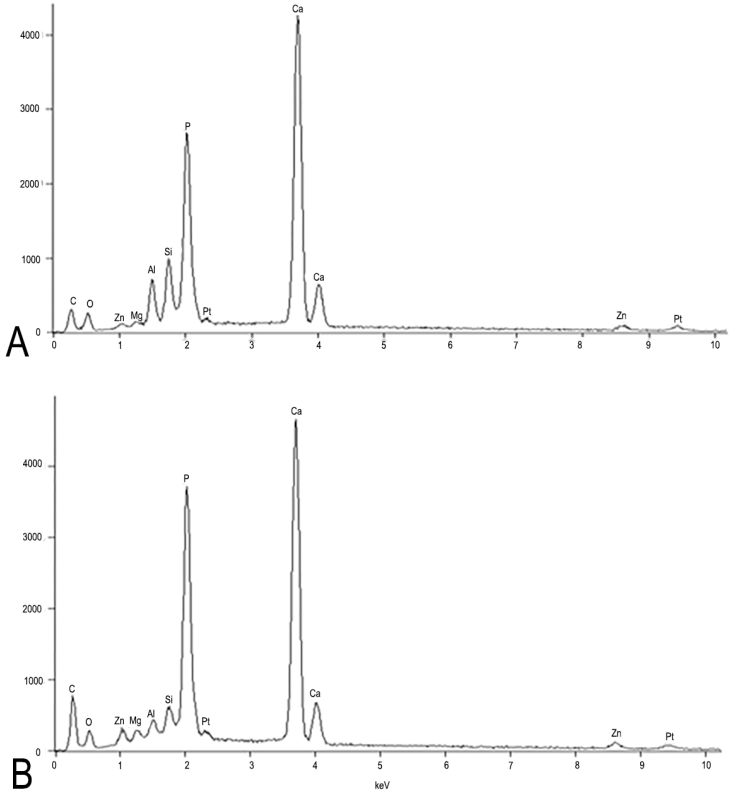



**Figure 6.** Energy dispersive X-ray spectroscopy analyses of intratubular (**A**) and intertubular (**B**) dentin.

**Table 3.** Weight percentages of elements from EDS analyses.

| | | Mg | Al | Si | *p* | Ca | Zn |
|---|---|---|---|---|---|---|---|
| Weight Conc (%) | Intratubular | 0.47 | 4.58 | 5.74 | 26.80 | 57.67 | 4.74 |
| | Intertubular | 1.64 | 1.94 | 2.16 | 33.17 | 55.89 | 5.21 |
| Atom Conc (%) | Intratubular | 0.69 | 6.12 | 7.38 | 31.24 | 51.95 | 2.62 |
| | Intertubular | 2.45 | 2.60 | 2.78 | 38.78 | 50.50 | 2.89 |

## 4. Discussion

The present study was designed to evaluate the effect of try-in-paste contamination on the SBS of dentin treated with IDS versus DDS to lithium disilicate pressable glass–ceramics. The null hypothesis was that there was no difference in terms of SBS between lithium disilicate ceramics and try-in-paste-contaminated dentin treated with IDS or DDS. The results fail to support the null hypothesis with a significant difference being demonstrated between the mean SBS of IDS and DDS.

Macro- or micro-test methods could be used for testing bond strength. Micro-tensile test setups have increased in popularity and were preferred by some researchers for offering a more uniform stress distribution at the bonded surface. Despite some advantages, preparing micro-tensile test specimens is a very technique-sensitive process. An interfacial crack can easily be created, which initiates crack propagation and results in an early failure at a lower strength [10]. Alternatively, the preparation of test specimens for macro-SBS testing is easy and fast, and no further specimen preparation is required after the bonding procedure. However, this testing has some disadvantages like uneven stress distribution across the interface. To overcome this problem, a crescent-shaped rod was used in the current study instead of a knife-edged rod. A crescent-shaped rod can dissipate the stress

better to a larger area, thus preventing stress concentrations [10]. Therefore, in the present study, the macro-SBS test was chosen as the testing method.

When the shear bond strength test results were examined, the highest bond strength value was found in the IDS-applied group (11.45 MPa) and the lowest value was found in the contamination group (5.84 MPa). However, the difference between the bond values of the IDS-applied Group B and the control group was not statistically significant. ($p > 0.05$). Similarly, in the study by Dalby et al., in which they examined the effect of the IDS procedure on the bond strength of press ceramics, the bond strength values of the IDS-applied groups were found to be between 6.94 and 10.03 MPa. No significant difference was found between the bond values of the IDS-applied groups and the control group [20]. These results are parallel to the current study. Choi compared the bond strengths of IPS Empress crowns in the IDS-applied and non-IDS-applied groups. The average bond strength values of the dentin-coated groups were found to be 4.11 and 11.18 MPa. The average bond strength of the uncoated group was found to be 3.14 MPa [21]. There are also studies reporting that the IDS procedure has no effect on bond strength. Feitosa et al. examined the effect of resin coating on bonding in indirect restorations. The average bond strength value of the uncoated group was found to be 9.5 MPa, while the values in the coated groups were found to be 9.2 MPa and 12.2 MPa, and no significant difference was found between the groups [22].

Cleaning the dentin surface before cementation is crucial. The temporary cementation of provisional restorations with eugenol-free cement could contaminate exposed dentin and may negatively affect the bond strength. Different methods have been described for cleaning the dentin surface. One study investigated the cleaning efficiency of different cleaning techniques on provisional cement-contaminated dentin [11]. The researchers could not find provisional remnants on the dentin surface with EDS analysis except for the groups cleaned with hand instruments and water rinse only. Another study investigated the influence of different cleaning methods on IDS and DDS. The highest bond strength values were found when fluoride-free pumice paste was chosen for the cleaning method [12]. In another study, it was pointed out that all cleaning methods decreased the thickness of the DBA, especially when they had a non-filler content. However, none of the cleaning procedures removed the entire thickness of the DBA [3]. The researchers also pointed out the importance of the application of an air barrier to prevent an oxygen-inhibited layer from removing the entire DBA and exposing the dentin [3]. The fluoride-free pumice cleaning method was employed in the current study with a low-speed hand instrument using a brush. The application of an air barrier before polymerization was performed for every specimen.

Metal oxides are commonly used as colourants in the dental industry. They are mixed in a composition of impression pastes, dental ceramics, and dental composites, among others. Try-in pastes are composed of glycerol and metal oxides like Al, Si, Ti, Fe, and Zn, which are used for creating different colours to match the colour of the resin cement [9]. Earlier a study on uncontaminated dentin with X-ray photoelectron spectroscopy and EDS presents the peaks of the major elements like Ca, P, C, N, and O [13]. In the current study, EDS from intra- and intertubular dentin disclosed metal oxide besides the natural composition of dentin, which is evidence of try-in paste remnants. Intertubular and intratubular EDS analysis results were obtained. In the analysis taken from the intratubular region, Ca and P found in dentin tissue were detected in high amounts. Also, C, O, Si, Al, Pt, Zn, and Mg were found in trace amounts. The weight percentages of the elements were 0.47% Mg, 4.58% Al, 5.74% Si, 26.8% P, 57.67% Ca, and 4.74% Zn. In the analysis taken from the intertubular region, Ca, P, C, O, Si, Pt, Zn, and Mg were detected in different amounts. The weight percentages were determined as 1.64% Mg, 1.94% Al, 2.16% Si, 33.17% P, 55.89% Ca, and 5.21% Zn. The presence of these metal oxides, which are used as colour pigments, was in accordance with the mechanical test results and pointed out the try-in paste contamination for group C causing lower bond strengths.

A strong bond can be achieved by creating a solid interphase or hybrid layer with the penetration of monomers into hard tissues. The importance of this penetration was pointed out because once this infiltrated monomer polymerized, a structural bond, as in the dentin–enamel junction, can be created [1]. SEM images from Groups A and B revealed peritubular pullout, which was evidence of strong adhesion. Usually, a strong correlation is found between the mean bond strength and the type of failure. The higher the bond strength, the higher the rate of cohesive failure [11]. Failure types are given in Table 2. When the failure types in this study were examined, adhesive-type failure was seen mostly in Group B, the IDS-applied group, and mixed-type failure was seen in Group C. In Dalby et al.'s study, the failure type mostly seen in IDS-applied groups was mixed-type [20]. In Islam et al.'s study, adhesive failure was seen mostly in the group without IDS [23]. However, it is stated that the failure type depends on the difference in the surface structure of the dentin, head speed, and the fact that the force is not distributed equally to every point for any reason [24]. It was also reported that the observed interface failure is related to the test method used. Figure 5 shows an SEM image of a sample from the IDS-applied group. Breaks at the dentin tubule mouths indicate cohesive breakage within the dentin tissue. Considering the bond strength data of this group, cohesive rupture in dentin is an indicator of good bonding to dentin. The smear layer in the dentin tubules was removed with the acid applied after preparation and the tubule mouths became open. The adhesive applied afterwards penetrated the tubules and created a strong bond. During rupture, there was some rupture from the tubule walls along with the resin. In the SEM image taken from a sample from the control group, the tubule mouths seen as blocked with resin cement show cohesive rupture from within the resin cement (Figure 3). When Figure 3c is examined, the tubule mouths are seen as blocked with resin cement. During rupture, cohesive rupture occurred from within the resin cement. In the clearly observed tubules, the test paste may have penetrated the tubules due to its hydrophilic properties and prevented the adhesive from entering the tubule. It is thought that this is the reason why the bond strength was significantly lower in the contamination group.

For the infiltration of a monomer into dentinal tubules, etching is crucial. A phosphoric acid concentration of 35% is enough to remove the smear layer and open the dentinal tubules. Different etching techniques, such as single-, two-step, or three-step procedures, have been described in the literature. Although there is a tendency to simplify bonding procedures for ease of use, more favourable and reliable adhesion in the long term can be achieved with three-step total-etch adhesives [16,18]. It has been strongly recommended to use the total-etch technique if IDS is to be planned [1]. Thus, the total etching protocol was followed in the current study according to the manufacturer's instructions. In clinical practice, in order to clean the residual cement more easily, we polymerize the resin cement for 3 s at 450 mW/cm in the first step. After the residual cement is cleaned, we complete the polymerization process from four directions. Since this study was planned to simulate the clinic, the same application was made to the study samples. However, this situation may cause our bond strength values to decrease.

The application of a Weibull analysis is strongly suggested for strength data of brittle materials. The Weibull modulus of Group A was higher than those of both Groups B and C. The higher Weibull modulus indicates less spread of the data and less variability among the measurements. However, a lower Weibull modulus for Group C indicated a wider distribution compared to the other groups. The $R^2$ value for Group C was higher than for Groups A and B. A higher $R^2$ represents a more precise fit of each data point on the equation line. Although Group C had a relatively lower Weibull modulus, each measurement fit on the line better. The sample size of each group in this study was ten; however, it has been recommended that a sample size of thirty should be used when Weibull analysis is conducted [25]. However, several studies were conducted on fewer than 30 specimens, and Weibull analysis was used [26,27]. Although a smaller sample size yielded enough data to analyze the Weibull modulus, it is a limitation of the current study.

SEM-EDS analyses showed that cleaning procedures were unable to remove the try-in pastes entirely (Figure 5). Remnants of try-in pastes in and around openings of dentinal tubules prevent the penetration of DBA and decrease the bond strength values. The importance of the application of DBA to freshly cut and etched dentin before any contamination has been pointed out [1]. IDS increased the penetration of DBA into dentinal tubules and guaranteed the formation of resin tags, thereby improving bond strength [28–30]. Group B showed statistically higher bond strength values than Group C in the current study [1,5]. The application of DBA immediately after dentin exposure prevented the obstruction of dentin tubules by try-in pastes.

In this in vitro study, shear bond strength values were obtained in sample groups where IDS and DDS applications were made. The obtained values indicate that dental clinicians can perform IDS applications safely. However, we can emphasize the need to carry out studies to compare the IDS and DDS methods in terms of microleakage.

## 5. Conclusions

Within the limitations of this in vitro study, it can be concluded that an immediate dentin sealing application enhanced the bonding strength of lithium disilicate glass–ceramics to the try-in-paste-contaminated dentin. Try-in-paste contamination over dentin negatively influenced the bonding process.

- Immediate dentin sealing is the process of applying a bonding agent on the dentin surface immediately after preparation.
- Full ceramic bond strength can be increased with immediate dentin sealing.
- Try-in-paste contamination decreases the bond strength of the ceramic on dentin surfaces.

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