Original Article

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Bonding Ceramic to Dentin: Effect of Immediate Dentin Sealing

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ABSTRACT

Statement of problem: Limited information is available on the effect of immediate dentin sealing (IDS) on bond strength. For an indirect restoration, temporary cementation inevitably contaminated collapsed dentin collagen. **Purpose:** This in vitro study investigated the effect of immediate dentin sealing and different types of temporary cements on microtensile bond strength (μTBS) to pressed ceramic restorations. **Material and methods**: A total of sixty human maxillary premolars were selected with comparable dimensions as well as being free of caries, fracture lines and cracks. Group of teeth after cutting the occlusal surface perpendicular to the long axis of the tooth to expose the mid-coronal dentin surface were followed by temporary cement either resin based (RC) (Provitemp) or conventional temporary cement (CC)(NETC) for two weeks. A total of 60 Emax press lithium disilicate glass ceramic specimens were fabricated. The Intaglio surface of specimens was etched with Hydrofluoric acid (Bisco), cleaned and dried followed by silane application (Bisco) then divided into 6 groups. **Group 1**: cemented to freshly cut dentin without dentin sealing (C). **Group 2**: cemented to immediately sealed dentin (IDS). **Group 3**: cemented to immediately sealed dentin after resin based temporary cement application for two weeks (IDS-RC). **Group4**: cemented to immediately sealed dentin after conventional temporary cement application for two weeks (IDS-CC). **Group 5**: cemented to dentin (without sealing) after resin based temporary cement application for two weeks (C-RC). **Group 6**: cemented to dentin (without sealing) after conventional temporary cement application for two weeks (C-CC). Bonded specimens were stored in water bath at 37°C for 5 months followed by thermal cycling for 5000 thermal cycles**.** μTBS was recorded for each specimen. Statistical analyses were conducted with two- and one-way ANOVAs and Tukey's HSD test at (α=0.05). **Results**: Immediate dentin sealing significantly increased the bond strength (P<.05) (μTBS) for the following groups compared to control group C (6.37±3.26); IDS (13.76±7.72),IDS-RC (15.24±5.6);IDS-CC **(**13.99±6.98**.**)However Temporary cementation didn't increase (μTBS) for groups; C-RC (5.08±2.91); C-CC(4.45±1.92) **Conclusion:** Immediate dentin sealing has a significant impact on long-term bonding to lithium disilicate glass ceramic compared to freshly cut dentin but temporization had a little effect.
Clinical significance: Immediate dentin sealing improved adhesion and durability of lithium disilicate glass ceramics indirect restorations to human dentin.

Keywords: Immediate dentine sealing, Emax press, temporary cements, bonding, indirect restoration.

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INTRODUCTION:

Maintaining as much tooth structure as possible has never been easy.[1] Furthermore, maintaining a balance between mechanical, functional, biological, and esthetic factors depends critically on the preservation of the tooth structure. The demand for tooth-colored restorations has been heightened due to the increased interest in cosmetic dentistry.[3] However, direct composite restorations have a number of difficulties and drawbacks, such as fracture, sensitivity, discoloration, and deboning due to polymerization shrinkage.[4] Indirect restorations overcome these issues as they have further advantages in restoring large cavities, such as ease of restoring proximal contour, occlusal morphology, and obtaining good marginal adaptation. [5] It also has high fracture resistance, high wear resistance, less polymerization shrinkage, and consequently less microleakage.[6]

Bonding to dentin has been known as one of the major challenges in adhesive dentistry mainly because of the inherent characteristics of this substrate.[7,8]Bacterial and fluid penetration through the exposed dentinal tubules can result in colonization of microorganisms, post-operative sensitivity, and the potential for subsequent irritation of the pulp.[9]

To avoid these possible sequelae, whenever a substantial accessible area of dentin has been exposed during tooth preparation for indirect bonded restorations, local application of a dentin bonding agent (DBA) is recommended.[10]

Sealing the dentin with a bonding agent immediately after preparation reduces the permeability of the dentin both in the short and long term.[16] This technique has evolved into what is now known as immediately dentin sealing (IDS).[10]

The process of ceramic restoration cementation has multiple factors to be considered to achieve optimum results, from suitable treatment plan followed by temporary cementation, temporary removal, conditioning of substrates ending with cementation of restoration.[11] To ensure proper attachment of an indirect restoration, basically two aspects must be taken into consideration: conditioning the intaglio surface of ceramic restoration and conditioning of the tooth substrate followed by cementation. The most commonly used

conditioning method for the glass-ceramic is application of hydrofluoric acid and silane coupling application.[12]

A significant increase in bond strength has been suggested when the adhesive was polymerized before to application of the resin cement in indirect restorations. This adhesive pre-polymerizing step could prevent complete seating of the indirect restoration.[13] On the contrary, there is low-certainty evidence that IDS does not reduce post operative sensitivity(POS)in teeth restored with indirect restorations.[14]

Maintaining pulp protection as well as aesthetics and functionality requires temporary restorations and cementation, for which materials containing eugenol are generally used.[15]Zinc oxide-eugenol (ZOE) cements are commonly used for temporary cementation because of their sedative effect, ease of removal, low cost, and excellent sealing property.[16] However, Eugenol is a free radical that partially or completely inhibits the conversion of resin materials.[17]Therefore, it can compromise the sealing and retention of adhesive restorations.[18] This can lead to leakage along the bond interface, which may cause pulp problems, hypersensitivity and secondary caries the most common reason for restoration replacement.[19]

Several studies have shown that the contamination of resin adhesive with provisional cements reduces bond strength of resin cement for the final cementation.[20] The use of calcium hydroxide and zinc oxide eugenol-free cement has been shown to have little or no effect on bond strength of final restorations as compared to zinc oxide-eugenol and resin-based provisional cements.[21]

Therefore, the purpose of this study was to evaluate the impact of immediate dentine sealing on the bond strength to pressed ceramics and temporization as a factor that may influence bonding efficacy.

MATERIAL AND METHODS:

Ethics approval: The protocol was approved by the ethical committee of the Faculty of Dentistry, Mansoura University

A total of sixty human maxillary premolars extracted for periodontal reasons were collected from the Oral and Maxillofacial Surgery Department,

Clinic of Faculty of Dentistry, Mansoura University. Teeth were selected of comparable dimensions as well as being free of caries, fracture lines, cracks or endodontic treatment. Teeth were cleaned by ultrasonic cleaner and stored at 4º C in a saturated solution of thymol in distilled water.[22] A total of 60 Emax press lithium disilicate glass ceramic specimens were laboratory fabricated, Table (I). The materials used in this study are detailed in Table (I). A total of 6 groups (n=10) were prepared for micro tensile bond strength test (μTBS). Emax press ceramic specimens intaglio surfaces were etched using 9% hydrofluoric acid (Bisco, USA) for 20 s according to manufacturer instructions, rinsed with water spray for 60 seconds and then air dried for 20 seconds and followed by silane application (Bisco, USA) for 60 s to the etched surface then air thinned.[23,24]

Immediate Dentine Sealing: exposed dentin surfaces were immediately sealed using universal adhesive system (Bisco All Bond Universal) with the aid of a micro-brush. Universal bonding agent was applied onto the entire adhesive surface and scrubbed for a period of 20 seconds; air dried gently for 3 sec, dried with stronger air to dry dentin surface until a glossy, immobile film layer results. Light curing for 10 seconds was performed using LED curing light (Nano light cure; COXO DB) with power density of 1000 mW/cm2 according to the manufacturer instructions. Then, provisional cement was applied to interim acrylic resin blocks according to groups.

Each tooth was etched using 37% phosphoric acid (MetaBiomed, Korea) and then a universal bond (Bisco, USA) was applied, agitated for 20 seconds and cured for 10 seconds according to manufacturer instructions using LED light curing unit (nanocoxo, China) light intensity: 1000 mW/cm2. Self-Etch/Self Adhesive Resin Cement (SuperCem, Korea) was then loaded into the intaglio surface of each treated specimen. Each specimen was then cemented to its corresponding prepared tooth. A device was constructed to standardize load application; a 5 kg static stress for 5 minutes during cementation process.[25]

- Group C: freshly cut dentin after surface treatment was cemented to each corresponding emax specimen. (control group)
- Group IDS: teeth were cut, followed by immediate dentin sealing then cemented to each corresponding emax specimen.
- Group IDS-RC: teeth first were cut, followed by IDS, then temporarily

cemented by resin based temporary cement (Provitemp, ITENA Clinical, France) for two weeks, removal of temporary, then ultrasonic cleaning followed by teeth conditioning then finally cemented to each corresponding emax specimen.

- Group IDS-CC: teeth first were cut, followed by IDS, then temporarily cemented by conventional non eugenol temporary cement (NETC, Meta Biomed, Korea) for two weeks, removal of temporary, then ultrasonic cleaning followed by teeth conditioning then finally cemented to each corresponding emax specimen.
- Group C-RC: teeth were cut, then temporarily cemented by resin based temporary cement (Provitemp , ITENA Clinical, France) for two weeks, removal of temporary, then ultrasonic cleaning followed by teeth conditioning then finally cemented to each corresponding emax specimen.
- Group C-CC: teeth were cut, then temporarily cemented by conventional non eugenol temporary cement (NETC, Meta Biomed, Korea) for two weeks, removal of temporary, then ultrasonic cleaning followed by teeth conditioning then finally cemented to each corresponding emax specimen.

One hour after cementation, bonded specimens were stored in water bath at 37℃ for 5 months followed by thermal cycling for 5000 thermal cycles. A universal testing machine (Instron, MA, USA) was used for recording (μTBS) in (MPa) of each bonded specimen.

To assess the failure patterns, the debonded specimens were examined using Binocular optical microscope at magnification 30X. Debonded surfaces were assigned to cohesive failure (within the adhesive luting resin or within the restorative ceramics), adhesive at ceramic/cement interface or mixed adhesive/cohesive patterns.[26] Representative specimens for each failure pattern were examined using a scanning electron microscope (Jeoljsm 6510LV, Japan) with an acceleration voltage of 15 kV. SEM micrograph at X 2000 magnification.

Statistical Analysis:

Statistical software (SPSS version 27 SPSS, Inc, Chicago, Ill) was used for statistical analyses. Statistical analyses were performed by Post Hoc Tukey-HSD test at ($P \leq 0.05$).

Table1: Materials utilized in the study in detail.

Material	Product name	Main composition	Manufacturer	Lot number
Universal adhesive	**Bisco** All Bond-Uinversal Adhesive		**Bisco**,Schaumburg,IL60193 **USA**	2400000019
Conventional temporary cement	NTEC Non.Eugenol temporary cement	-Base(zinc oxide, mineral oil) -catalyst(Rosin, Nonanoic acid)	**Meta** Biomed Cp.LTD,Chungcheong buk-do, **Korea**	NET2211034
Resin based temporary cement	**Provitemp** Temporary cement	Flouride , chlorohexidine,Potassium nitrate, Methacrylate, Urethandymethacrylate,Polymerization activator	**ITENA** Clinical, Villepinte, **France**	4232-05QTP
Hydrofluoric acid	**Bisco** Porcelain Etchant	9.5% Bufferd hydrofluoric acid Gel	**Bisco**,Schaumburg,IL60193 **USA**	1300001105
Silane coupling agent	**Bisco** Porcelain primer	Pre-hydrolyzed no mix silane primer	**Bisco**,Schaumburg,IL60193 **USA**	2300000646
adhesive resin cement	**SuperCem** Self-Etch/Self Adhesive Resin Cement		**DENTKIST,Korea**	3023023
Acid Etchant	**Meta** Biomed acid etch	37% Phosphoric acid etching gel	**Meta** Biomed Cp.LTD,Chungcheong buk-do, **Korea**	MET2201071
Lithium disilicate Pressed Ceramic	IPS e.max press Ingots Impulse V1	SiO2 Additional components: Li2O,K2O,MgO,ZnO,Al2O3,P2O5 and other oxides	**Ivoclar** Vivadent AG, Liechtenstein Fl-9494 Schaan	T19802

RESULTS:

The values of μTBSare listed in Table**2**. IDS significantly ($P \leq 0.05$) increased μTBS in MPa of the following groups:IDS-RC (15.24±5.6), IDS-CC(13.99±6.98) and IDS (13.76±7.72),However temporary cementation did not increase μTBS for groups; C-RC (5.08±2.91), C-CC (4.45±1.92) compared to control group C (6.37±3.26).

Considering the failure pattern of debonded specimen (Figures 1,2), debondedspecimens showed mixed failure within the adhesive luting resin cement or the restorative emax specimen or adhesive failure pattern for all specimens in C group , C-RC group and IDS-CC group , while all specimens in group IDS and group IDS-RC showed mixed failure within the adhesive luting resin cement or the restorative emax specimens or adhesive failure pattern for all specimens except one specimen showed cohesive failure in ceramic.

Considering group C-CC, debonded specimens showed mixed failure within the adhesive luting resin cement or the restorative emax specimens or adhesive failure pattern for all specimens except one showed cohesive failure pattern in dentin.

Figure (1): Adhesive failure between resin cement and dentin

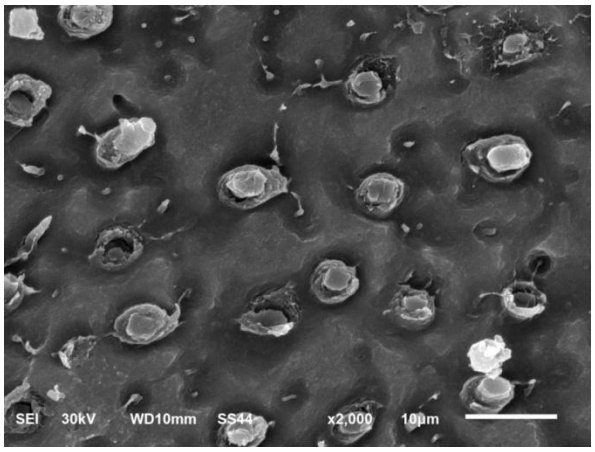
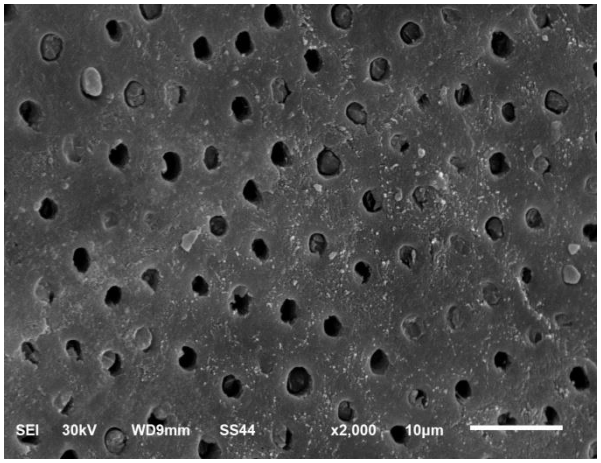


Figure 2:Cohesive failure in dentin



Groups	Mean ± SD	Group 1 (Control Group)	Group 2 (IDS)	Group 3 (IDS + Conventional Cement)	Group 4 (IDS + Resin Cement)	Group 5 (Conventional Cement Only)	Group 6 (Resin Cement Only)
Group 1 (Control Group)	6.37±3.26		0.052	0.042*	0.008*	0.972	0.995
Group 2 (IDS)	13.76±7.72	0.009*		1.000	0.991	0.052	0.014*
Group 3 (IDS + Conventional Cement)	13.99±6.98	0.007*	1.000		0.996	0.042*	0.011*
Group 4 (IDS + Resin Cement)	15.24±5.6	0.001*	0.991	0.996		0.008*	0.002*
Group 5 (Conventional Cement Only)	4.45±1.92	0.972	0.009*	0.007	0.001*		1.000
Group 6 (Resin Cement Only)	5.08±2.91	1.000	0.014*	0.011*	0.002*	0.995	

Table (2): Tukey Post-hoc test among the studied groups at P-Value < 0.05

DISCUSSION:

The null hypothesis of this study was that IDS and type of temporary cement could affect μTBS to pressed ceramic. The results of the present study approved the hypothesis partially. TheμTBS measurements were significantly affected with the use of IDS but temporary cementation did not show significant effect on μTBS.

The most important technical factor for long-term restoration success and enhanced prosthesis retention is bonding of fixed prosthodontics.The importance of micromechanical bonding to dentin has been acknowledged within the past ten years.[12]Current study indicates that adhesive monomers that penetrate the exposed collagen fibers during acid etching are primarily responsible for bonding to dentin. It is claimed that the IDS approach improves bond quality

and decreases gap formation, microleakage, pulpal irritation, and dentinal hypersensitivity.[16]

According to **Harden *et al***.[27] the IDS procedure improves the bond strength between freshly cut dentin and resin-based indirect restorations, irrespective of the adhesive technique employed. However, limited information exists regarding the effectiveness of the IDS technique when universal adhesive is used.[28]

Hence, this current study investigated the impact of IDS protocol of freshly cut dentin using universal adhesive on microtensile bond strength of lithium disilicate glass ceramic luted to dentin surfaces and whether different temporary cements have a positive effect or not.

The hypotheses of this research was approved as glass ceramic specimens bonded to IDS treated dentin showed higher significant difference compared to control samples ($P \leq 0.009$). Using the IDS technique with universal adhesive was proven to be an effective way to improve the ultimate bonding strength and reduce dentin permeability of ceramic restorations, according to another in-vitro investigation.[29]

The surface of dentin is subjected to oral conditions, where fatigue can affect the mechanical and physical properties of dentin-resin bond strength.[30] Therefore, all tested samples in this study were thermally cycled before subjected to microtensile bond strength test. Long-term water storage and thermal cycling are trustworthy methods for assessing the bond effectiveness, advocated by many studies.[31,32] Thermal cycling is one of the most popular techniques in laboratory research, and it is also extensively acknowledged in worldwide literature, among the systems that can replicate thermal stresses. In this study, Specimens were subjected to long term water storage in water bath at 37°C for 5 months followed by 5000 cycles of thermal cycling before microtensile bond strength measurement. The means of μTBS of IDS groups were higher compared to groups was not subjected to IDS.

Temporary cementation did not increase μTBS for groups; C-RC (5.08±2.91), C-CC (4.45±1.92) compared to control group C (6.37±3.26).Their decreased values might be due to absence of IDS, superficial hybrid layer formation, mechanical properties of cement, improper removal of smear layer.[33]

Despite the numerous advantages mentioned for IDS in several published studies, this technique is time-consuming and requires more materials and steps. This method has a high technical sensitivity. If the adhesive layer is too thick, the strength of ceramic restorations

will decrease due to less space and a large difference in the elastic coefficient of the adhesive layer and restorations, especially ceramic restorations.[33]On the other hand, if a very thin adhesive layer (less than 40 microns) was formed, all the thickness of the adhesive turned into an air-inhibited layer and the adhesive did not polymerize, and this method practically lost its clinical effectiveness.[34]

To eliminate the interference with the impression materials, it is recommended to use digital impression methods, and if impression materials are used, the oxygen-inhibiting layer of the IDS surface should be thoroughly cleaned and removed to prevent incomplete polymerization of the impression materials.[35]

Few clinical studies have investigated the effectiveness of this technique. Gresnigt *et al.*[36] reported that IDS increased the survival rate of restorations if more than 50% of dentin was exposed. However, Van den Breemer *et al.*[37] showed IDS was not superior in the survival rate and success of restorations.

The fact that bonded specimens were only subjected to the hydrolytic effect of water and thermal stresses from thermal cycling may be one of the study's limitations in vitro. Nevertheless, bonded specimens were not exposed to the mechanical pressures brought on by masticatory forces that arise in clinical situations. The fact that bound specimens were only kept in water could be another drawback.

CONCLUSION:

Within the limitations and based on the outcome of present study, the μTBS test supported by analysis of failure mode of adhesive/dentin interface, the following conclusions could be drawn:

1. Immediate dentin sealing seems to improve the bond strength of emax lithium disilicate to dentin.
2. Different types of temporary cements had no adverse effect on the bond strength of emax lithium disilicate to dentin.

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