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Immediate Dentin sealing versus delayed dentin sealing for indirect E-max ceramic restorations

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Abstract:
***Background**: The aim of the current study is to evaluate the effect of different types of dentin sealing on the bond strength of E_max ceramic restoration.*
***Materials and Methods**: Twenty specimens were fabricated, then bond strength was measured after two sealing techniques.*
***Results**: Results showed a significant difference in bond strength between different techniques. Immediate dentin sealing showed a significantly higher values than delayed dentin sealing.*
***Conclusion:** Within the limitation of this in vitro study, it may be concluded that dentin sealing has a great influence on the bond strength, with immediate dentin sealing being superior to delayed dentin sealing.*
***Key Word**: Lithium disilicate; bond strength; Emax; ; dentin sealing.*

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I. Introduction

Adhesion to restorations is achieved by using bonding agents and is essential in modern restorative materials from mechanical, biological and aesthetic perspectives [1]. Resin adhesives and resin cements are found in self-cure, light-cure and dual cure formulations. The degree of polymerization plays a vital role in determining the ultimate biological, physical and mechanical properties of the material. It is significant to establish a strong bond between restoration and dentin. The clinical success of composite and ceramic indirect restorations is attributed to the reliable bond between adhesive cementing systems (resin cements/bonding agents) and mineralized dental tissues [2,3]. However, as light intensity reaching the resin cement is strongly attenuated by either distance from the light source or from the absorbing characteristics through the indirect restorative material, [4] dual-cured resin materials have been developed [5,6].

II. Material And Methods

In the existing in-vitro study, twenty specimens were constructed from freshly extracted molars, bond strength was evaluated after two techniques of den

Study Design: In-vitro study Study
Location: Study done in Department of Fixed prosthodontics, Ain-shams University, Egypt.
Study Duration: November 2017 to December 2021 .
Sample size: 20 specimens.
Sample size calculation: A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that the effects of different tested variables and their interaction are not significant. By adopting an alpha level of (0.05) a beta of (0.8) i.e. power=80% and an effect size (f) of (0.77) calculated based on the results of a previous study, the predicted sample size (n) was found to be (20) samples. Sample size calculation was performed using G*Power1 version 3.1.9.7.

Procedure methodology
A:Teeth preparation:
The occlusal surfaces were ground flat to expose the dentin surface (figure 1, 2) using a low speed diamond saw3 (figure 3) under water cooling. Then polishing at 600-1000 grit was followed to smoothen the exposed dentin surfaces and to remove contaminations produced by smear layer.

Figure (1): Low speed diamond saw

Figure (2): Exposing occlusal dentin

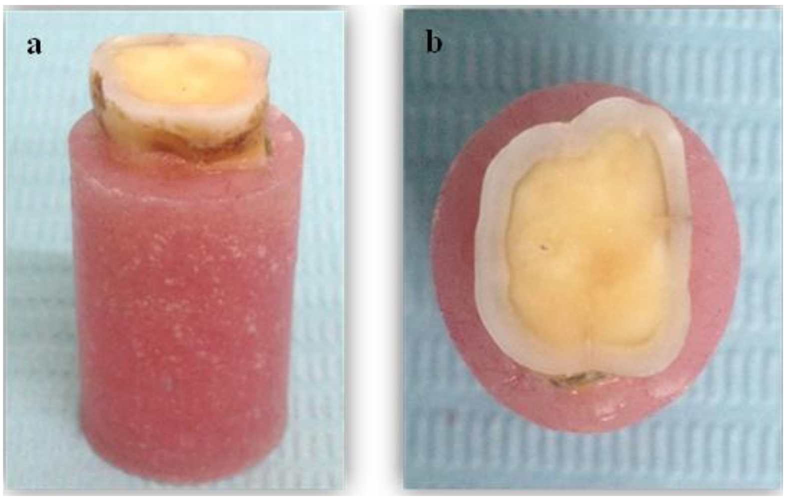

Figure (3): a) exposed dentin, b) occlusal view

B:Dentin sealing:
1. Delayed dentin sealing:
In DDS groups, teeth were covered by a layer of temporary filling material directly after cutting and immersed in saline solution for 48 hours (Figure 4).

Figure (4): Temporization of DDS group

After the temporization period, the temporary filling was removed with an excavator and dentin was cleaned using (50µm aluminum-oxide powder) airborne-particle abrasion4, then it was ready for surface treatment for ceramic disc cementation.

2. Immediate dentin sealing:

In IDS group, teeth were dried thoroughly for 5 secs. Followed by application of adhesive5 using micro-brush6 (figure 5), the single bond universal adhesive was applied over all the dentinal surfaces according to the manufacturer's instructions. A single coat of the adhesive was applied and rubbed for 20 seconds then blown with a gentle air blow for 5 seconds, followed by light curing for 20 seconds using LED curing light7 at a light intensity of 1200 mw/cm2, then isolated with petroleum gel to avoid any bonding with the subsequently applied provisional restoration. After the temporization period (Figure 6), the temporary filling was removed and dentin was cleaned by different modalities of surface refreshment and then the dentin will be ready for ceramic discs Cementation.

Figure (5): Sealing dentin with adhesive

C:Fabrication of ceramic discs:
IPS emax CAD blocks were rounded into a 6 mm diameter cylinders using a milling machine (figure 6, 7).

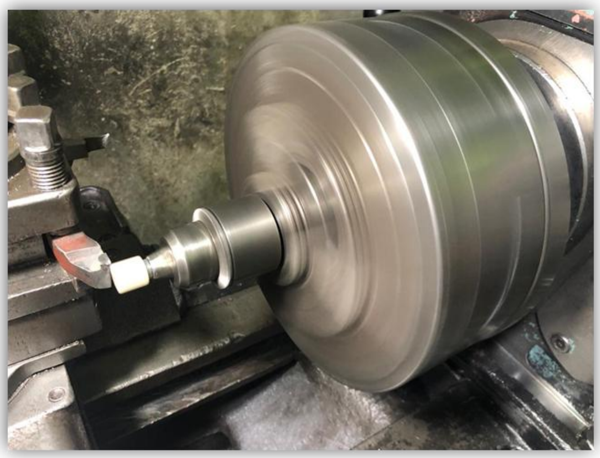

Figure (6): Milling machine forming ceramic cylinder

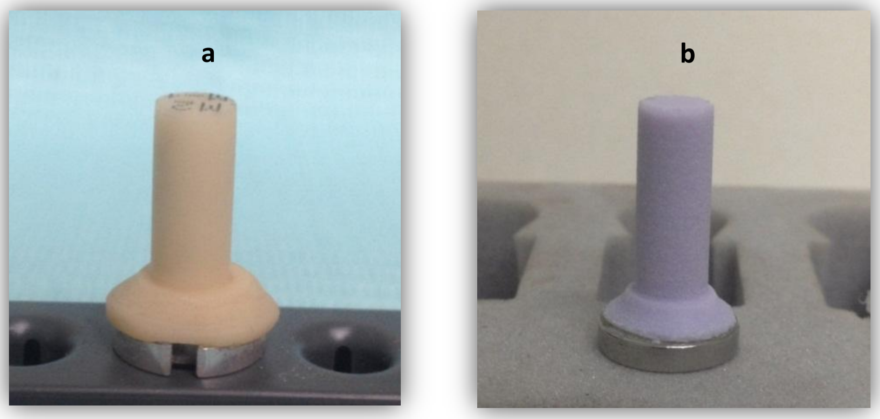

Figure (7): 6mm Ceramic cylinders: a) Vita enamic, b) e-max cylinders

20 ceramic discs were machined from their respective cylinders by using a low speed precision diamond saw10. emax CAD was cut into uniform standard thickness of 3mm (figure 8).

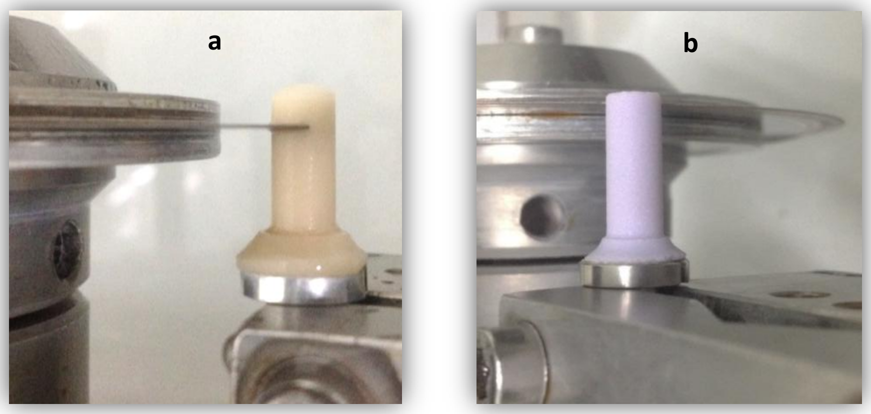

Figure (8): Low speed diamond saw cutting 3mm ceramic discs: a) vita enamic, b) emax

These discs were cut under integrated coolant delivery system that flooded the samples from both sides of the blade while tracking the blade movement. The blade of thickness (0.4mm) travelled linearly providing constant feed rate cutting of 15.7 mm/min blade was of 2500 rpm in 50 rpm increments.
All samples were prepared by the same operator following manufacturers' recommendations for the purpose of standardization. A caliper was used to verify the thickness (figure 9).

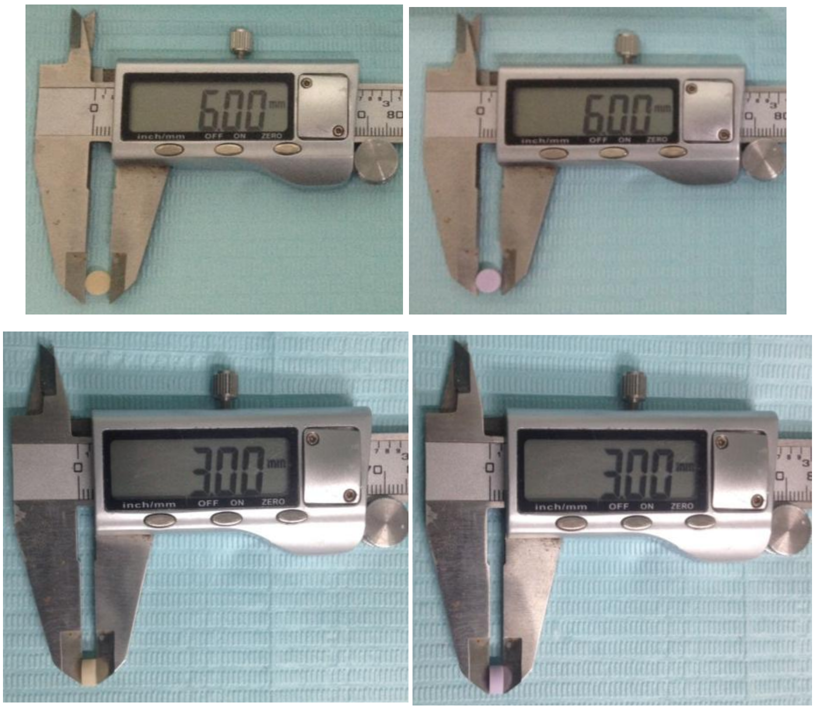

Figure (9): Caliper confirming the discs measurements

After fabrication of e.max CAD discs, crystallization was performed, the material was heat treated following the manufacturer's instructions in a ceramic furnace11 (figure 10, 11, 12). The crystallization process was executed where:
The stand by temperature: 403 °C

Figure (10): Crystallization cycle of e.max in programat p 310.

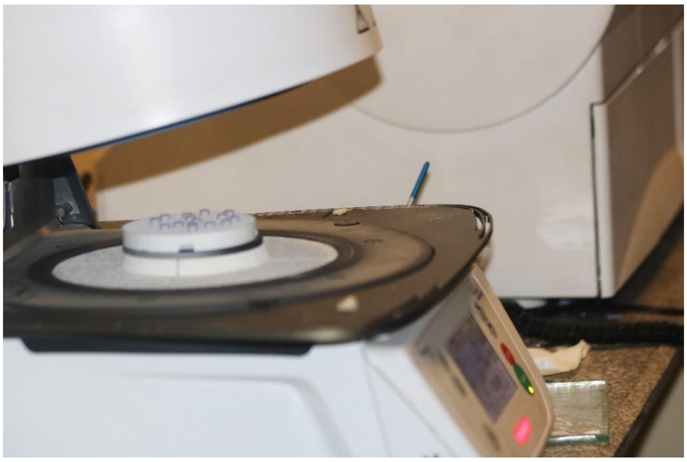

Figure (11): emax discs inside the furnace

Figure (12): Crystallized emax discs

First stage firing temperature: 770 °C heating rate of 60°C/min.
Holding time: 10 minutes.
Second stage firing temperature (850 °C), heating rate of 30 °C /min
Holding time: 10 minutes.
Long term cooling: 700 °C, cooling rate of 0° C/min.
D:Checking and finishing of ceramic discs:
Finishing of emax discs was performed using diamond polishing system12 (Figure 13) followed by glazing using glaze paste13 (Figure 14).

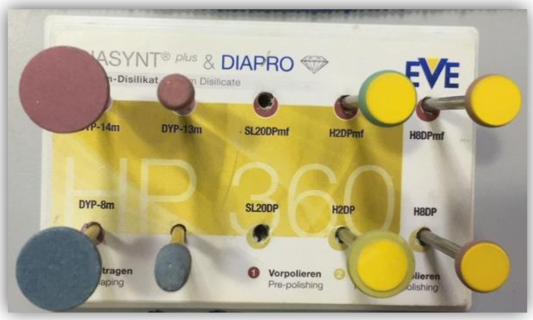

Figure (13): e-max finishing and polishing kit

Figure (14): e-max glaze

E:Ceramic discs surface treatment:
Etching of emax ceramic discs was done using 9% hydrofluoric acid gel15 for 20 seconds. The discs were then rinsed thoroughly for 60 seconds and dried with oil free air. The surfaces were then silanized 16 and left to react for 60 seconds (Figure 15).

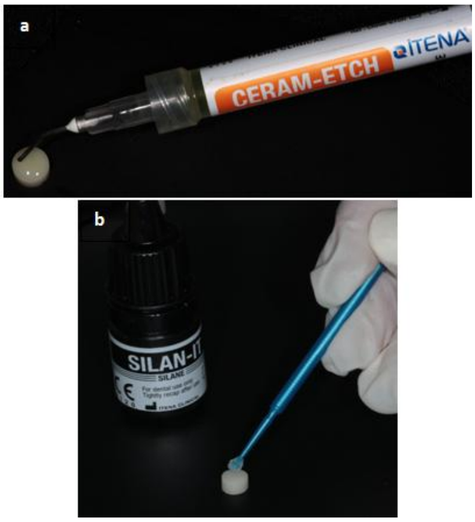

Figure (15): a. Ceramic etching, b. ceramic silanization

For Vita Enamic discs, etching was done using 9% hydrofluoric acid gel for 60 seconds, then rinsed thoroughly for 60 seconds and dried with oil free air. The surfaces were silanized and left to react for 60 seconds.

F:Bonding procedure:
The adhesive17 was applied, with gentle agitation for 15 seconds using a fully saturated applicator, then air thinned for 5 seconds, then adhesive was light cured for 10 seconds using LED curing unit18 at a light intensity of 1000 mW/cm2 (Figure 16). Air-blocking barrier (glycerin Gel) was applied to polymerize the oxygen-inhibition layer with 10 seconds of additional light curing.

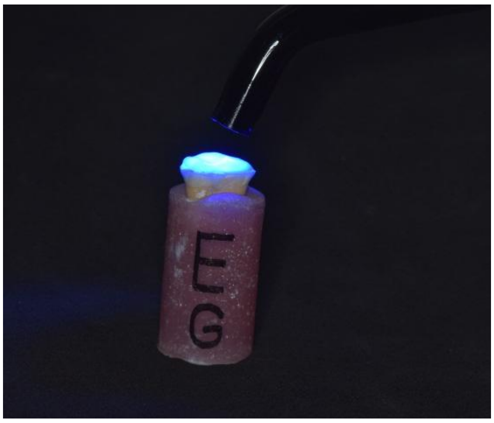

Figure (16): Pre curing of the adhesive layer

G:Ceramic discs cementation:
Ceramic discs were cemented to the treated dentin surface according to each group using selfetch adhesive dual cure resin cement19.
A special loading device was designed to apply a constant load of 1Kg to the ceramic discs. This load was used to create a uniform resin luting layer of approximately 100 µm, so as to simulate the film thickness employed for all-ceramic indirect restorations. Initial light curing was performed for 10 seconds. Excess cement was removed using a dental probe. The luting agent was polymerized from each direction (mesial, distal, buccal, lingual, and occlusal) with LED curing unit20 for 40 seconds.

H:Tensile bond strength testing:
Custom-made stainless-steel mold was prefabricated to aid in the tensile bond strength test. It consisted of two parts, a circular part (6 mm diameter and 3 mm depth) to contain the ceramic disc inside it, and a handle which was perforated at its end to aid in the attachment to the upper fixture of the universal testing machine21 (figure 17). After cementation of the ceramic disc to the dentin surface, each specimen was cemented to the custom made mold using cyanoacrylate adhesive (figure 18).

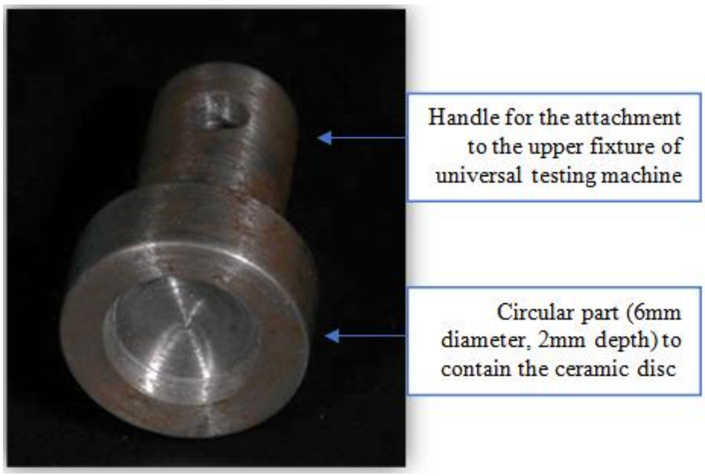

Figure (17): Custom made stainless steel mold

Statistical analysis

Numerical data were explored for normality by checking the data distribution using KolmogorovSmirnov and Shapiro-Wilk tests. Data showed parametric distribution so; they were represented by mean and standard deviation (SD) values. Three-way ANOVA was used to study the effect of different tested variables and their interaction on color change and surface roughness. Comparison of main and simple effects were done utilizing multiple t-tests with bonferroni correction. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with IBM3 SPSS4 Statistics Version 26 for Windows.

III. Result

- **Effect of different dentin sealing protocols on Tensile bond strength:**

Mean and standard deviation (SD) values of tensile bond strength (MPa) for different sealing protocols were presented in table (8) and figure (18).

There was a significant difference between different dentin sealing protocols ($p<0.001$). Samples with IDS-(without glycerin) treatment (25.13±0.46) had the highest tensile bond strength mean value followed by IDS-(with glycerin) (23.07±0.52) while DDS (22.02±0.47) had the lowest mean value. Pairwise comparisons showed different dentin sealing protocols to be significantly different from each other ($p<0.001$).

Table (8): Mean ± standard deviation (SD) of tensile bond strength (MPa) for different sealing protocols for Emax

Material	Sealing protocol (mean±SD)		p-value
	Immediate dentin sealing	Delayed dentin sealing	
Emax	25.13 ± 0.46^{A}	22.02 ± 0.47^{C}	**<0.001***

- Means with different superscript letters in the same horizontal raw are statistically significantly different*; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

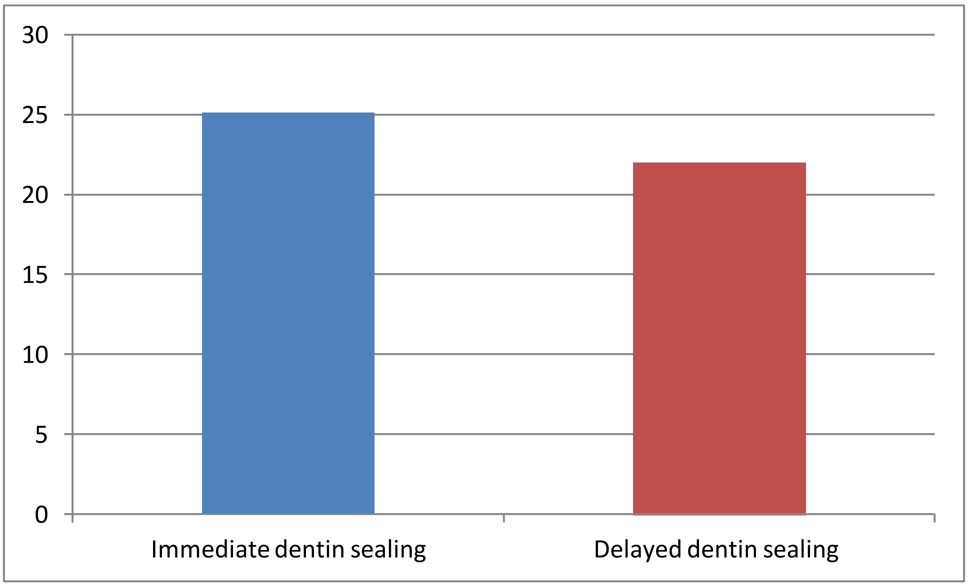

Figure (18): Bar chart showing average tensile bond strength (MPa) for different sealing protocols for Emax

IV. Discussion

This study was performed on natural human extracted teeth. To minimize the possible variations, selection of teeth of average sizes and almost similar shapes allowing a maximum deviation of 10% from the determined mean was performed before testing. The occlusal half of extracted molars was removed using a model trimmer to expose the mid-coronal dentin for bonding. [7]

The protocols of immediate and delayed dentin sealing used in this in-vitro study was according to a previous study by Murata et al. in 2018, who used scotchbond universal adhesive for sealing the dentinal tubules for its consistent bond strength to dentin and high bonding to all indirect restoration materials, followed by a self-etch (adhesive) resin cement for cementation of ceramic restoration materials.[8] Lithium disilicate glass ceramic IPS e.max CAD is one of the most popular restorative materials in almost all the indications of fixed prosthodontics due to its esthetic nature, favorable mechanical properties, and ease of use, together with the possibility of manufacturing low thickness restorations adhesively bonded to the dental substrate. [9] IPS E.max

CAD blocks were rounded into a 6 mm diameter cylinders using a milling machine to ensure bonding is limited to dentin only. Ceramic discs were machined from their respective cylinders into 3 mm thickness, as 2 mm is the minimal thickness for indirect restoration and an extra 1 mm was added to be inserted and cemented inside a mold that was customized for tensile bond strength testing(10).

Self-etch (Adhesive) resin cement was used in this study because it requires a separate step of adhesive application unlike the self-adhesive, which allows testing the different sealing protocols. However, total etch resin cement although having a separate bonding step, it does not serve the purpose of the study testing bonding to dentin. In this in-vitro study tensile bond strength test was selected to test the bond strength of ceramic material to dentin, since debonding is one of the major failures in prosthetic dentistry. Measurement of bond strength is a method for evaluating adhesive restorations. The laboratory environment represents an ideal set of conditions in comparison with the oral environment of the patient. Previous studies have examined adhesion using the mean values of bond strength as a representative parameter. Assessments using mean values represent a quantitative evaluation of the adhesion. (11)

V. Conclusion

Within the limitations of this in vitro study the following conclusion could be drawn:
For E-max tested ceramic materials, bonding to prepared dentin using immediate dentin sealing protocol resulted in a significantly higher tensile strength values than bonding with delayed dentin sealing protocol.

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