Surface Treatment Strategies for Enhancing Bonding of CAD/CAM Ceramics to Dentin

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INTRODUCTION

Loss of retention is a complication of indirect glass-ceramic restorations. Clinical success of such restorations depends on the strength of their bond to the dental substrate. Bond strength depends on the dental substrate, resin cement and conditioning of intaglio surface of the indirect restoration. Ceramic restorations conventionally require conditioning with hydrofluoric acid (HF) followed by silanization and adhesive bonding. A novel single-step ceramic primer (MEP) is available as an alternative to the multistep HF treatment.

OBJECTIVES

The ideal bonding protocol of zirconia-reinforced lithium silicate ceramics (ZLS) to dentin is undetermined. This study evaluated the influence of surface treatments and cement type on bonding of CAD/CAM zirconia reinforced lithium silicate (ZLS) to dentin and interpreted the results with the aid of failure analysis and surface topography.

METHODS & MATERIAL

- 120 freshly extracted molars were collected under an approved protocol Kuwait University's Health Science Centre Ethics Committee. Dentin surfaces were exposed and standardized.
- Celtra Duo and Vita Suprinity® PC CAD/CAM blocks were sectioned to produce 60 slices each. VS slices were crystallized, and bonding surfaces regularized.
- Slices were randomly assigned to three groups according to surface treatment: no treatment (C); 5% hydrofluoric acid and silane (HF+S); Monobond Etch&Prime (MEP).
- The groups were further divided into four subgroups based on the cement used: etch-and-rinse cements Calibra Ceram (CC) and Duo-Link Universal (DL), and self-adhesive cements Multilink Speed (MS) and G-CEM LinkAce (LA). Bonded samples were stored in water and later sectioned into microspecimens (24 groups; n=5). Then the bonded samples were sectioned into microspecimens 24 hours after water storage at 37°C (Figure 1).

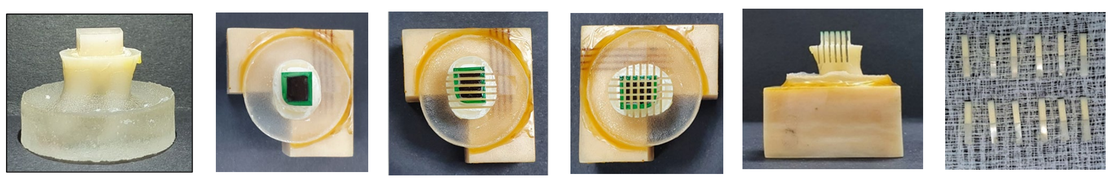

Figure 1: Sample preparation

- The microtensile bond strength (μTBS) was measured with a universal testing machine (ElectroPuls 3000, Instron).
- Fractured microspecimens were checked to determine the failure mode using an optical microscope.
- 15 additional ceramic slices were assigned to three groups (n=5) and received different treatments (no treatment (only grinding and polishing); HF; MEP). 3D topographic images and surface roughness analysis were performed ((Leica DCM8, Leica Microsystems).
- Scanning electron microscopy (SEM) images evaluated changes in surface topography (JSM IT200, JEOL).

STATISTICAL ANALYSIS

Data were analyzed using three-way ANOVA and Tukey's tests for μTBS, and Kruskal-Wallis and Mann Whitney U tests for surface roughness (α=5%). Tukey's post-hoc test compared means between cement groups. Chi-square test examined the relationship between cement category, surface treatment, and mode of failure. Kruskal-Wallis compared roughness parameters within the tested groups and Mann-Whitney U tests the effects of surface treatments for both ceramic materials.

RESULTS

- Bond strength was significantly influenced by the type of cement and the interaction between surface treatment and the type of cement ($p < 0.05$), Table 1.

Table 1:Three-way Analysis of Variance of between-factor effects on mean μTBS

Source of variation	df	Sum of Squares	Mean square	F	p	η_p^2
Corrected Model	15	1388.245	92.550	7.467	0.000	0.636
Ceramic material	1	4.834	4.834	0.390	0.535	0.006
Surface treatment	1	0.618	0.618	0.050	0.824	0.001
Cement type	3	1153.487	384.496	31.023	0.000	0.593
Ceramic*Surface treatment	1	3.639	3.639	0.294	0.590	0.005
Ceramic*Cement	3	50.744	16.915	1.365	0.262	0.060
Surface treatment*Cement	3	171.001	57.000	4.599	0.006	0.177
Ceramic*Surface treatment*Cement	3	3.923	1.308	0.106	0.957	0.005
Error	64	793.197	12.394			

- Control groups debonded during sectioning, whereas HF and MEP promoted similar bond strengths within same cement groups.
- Etch-and rinse cements demonstrated significantly higher mean μTBS than self-adhesive cements (Figure 2).

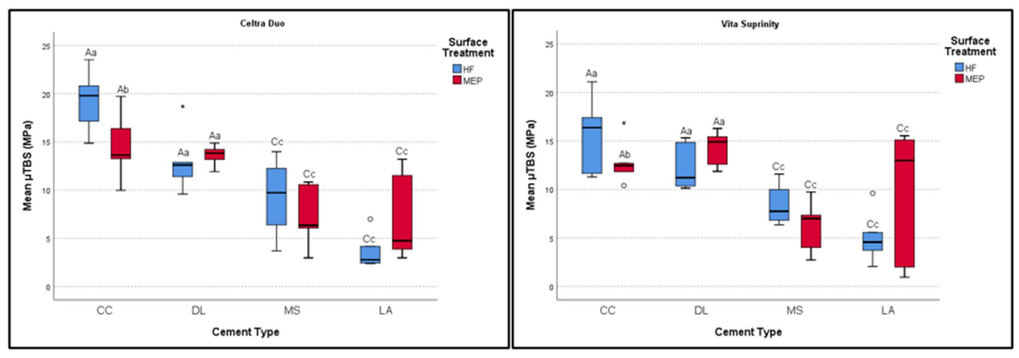

Figure 2: Mean μTBS (MPa) for cement groups with different surface treatments (5% HF and MEP). Tukey's post hoc test: same capital letters among cement groups signify no statistical difference; 2-way ANOVA: same small letters signify no statistical difference between surface treatment within cement groups. CC: Calibra Ceram; DL: Duo-Link; MS: Multilink Speed; LA: LinkAce.

- The most prevalent modes of failure of etch-and-rinse cements were mixed failure followed by cohesive failure in cement, whereas self-adhesive cements failed predominantly at the adhesive interface with dentin (Figure 3).

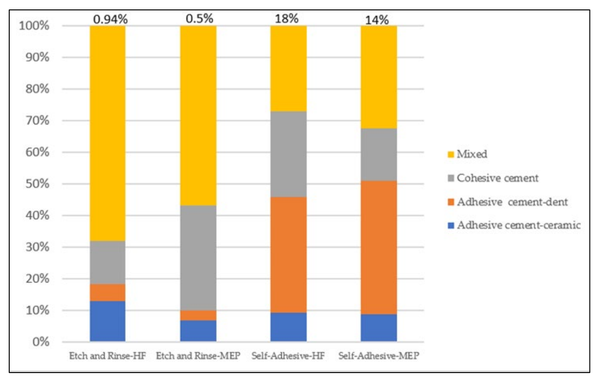

Figure 3: Failure modes distribution (%). Percentages on top of each bar correspond to the pretest failures

- Surface topography evaluation showed that both treated groups were significantly different than control group. HF promoted the highest roughness parameters and most prominent surface changes

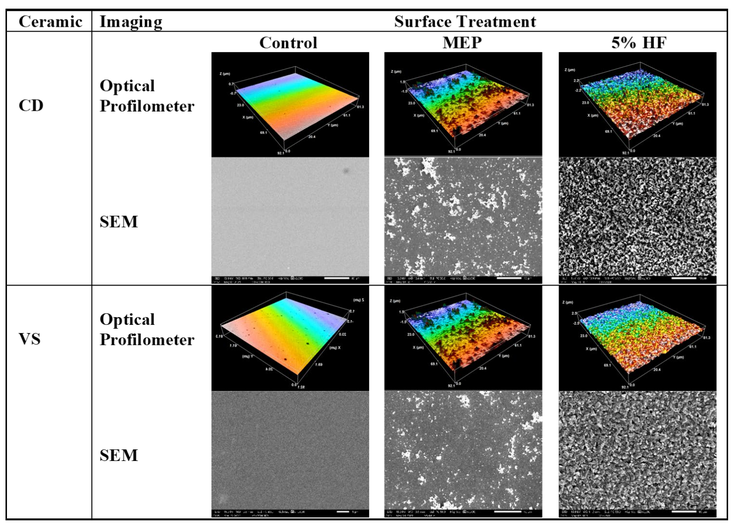

Figure 4: Profilometric and SEM images of CD and VS surfaces under different surface treatment protocols. Optical profilometer magnification 50x, SEM magnification 2000x. CD: Celtra Duo; VS: Vita Suprinity; MEP: Monobond Etch″ HF: Hydrofluoric acid.

CONCLUSIONS

- Effective surface roughening is indispensable for successful bonding of indirect glass-ceramic restorations, and MEP simplifies the bonding procedure and may be used as a viable alternative to HF etching and silanization.
- Etch-and-rinse cements remain to be the gold standard for cementation of such restorations.
- Surface treatment with MEP generated less roughness and micromorphological changes in ZLS ceramic surfaces compared to 5% HF.

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