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Marginal Fit of Pressed Versus Repressed Zirconia-Reinforced Lithium-Disilicate Occlusal Veneer

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Aim: The purpose of this in-vitro study was to evaluate the effect of repeated heat pressing of zirconia- reinforced -lithium disilicate on the marginal adaptation of occlusal veneers.
Materials and Methods: forty resin dies, duplicated from mandibular left first molar typodont tooth that was prepared to receive occlusal veneer, were equally divided into two groups (n=20) as follow; Group 1 (pressed specimens) included resin dies received occlusal veneers fabricated from freshly pressed Vita Ambria ingots, while Group 2 (re-pressed specimens) included resin dies received occlusal veneers fabricated from repressed buttons, which were remnants from the initial pressing. Cementation of the occlusal veneers was done using dual cure resin cement. Marginal fit was assessed using a stereomicroscope after thermocycling. Statistical analysis was done by using an independent sample T-test for comparing the two groups.
Results: The highest average values marginal gap were recorded in Group 2 while the lowest average values were observed in Group 1, however the difference between groups was statistically non-significant, as determined by the independent sample T-test ($p > 0.05$).
Conclusion: It was concluded that repeated pressing of leftover material has no statistically significant effect on the marginal adaptation of zirconia-reinforced lithium disilicate occlusal veneers.

Keywords: Zirconia-reinforced lithium disilicate, marginal adaptation, repressing.

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Introduction

Ceramic dental restorations have become more and more popular in recent years because of their superior aesthetics and metal-free construction. Profound advancements in all-ceramic materials have opened amazing possibilities for the creation of lifelike restorations with dependable, long-lasting outcomes.[1] According to their microstructure, dental ceramics can be classified into three main categories; polycrystalline, glass and hybrid ceramics.[2-4] Zirconia-reinforced lithium disilicate (ZLS) material blends the optical characteristics of lithium disilicate with the improved mechanical potency of zirconia. This innovative material comprises a glass-ceramic matrix of lithium metasilicate (Li_2SiO_3) reinforced with 8–12% zirconium dioxide (ZrO_2) grains; they might act as a crystal phase to slow the spread of cracks.[5,6] post-crystallization, the microstructure exhibits fine-grained characteristics (Li_2OZrO_2-SiO_2).[7]

Vita Ambria, pressable pellets of zirconia-reinforced lithium silicate (ZLS) are utilized for a wide range of applications including laminate veneers, inlays, onlays, partial and full veneer crowns, and three-unit restoration up to the second premolar.[8]

According to techniques of ceramics fabrication, they were classified as heat-pressed, slip-casting, CAD/CAM, and traditional powder/liquid methods. The intrinsic microstructure and fabrication method of any system determine its mechanical and optical characteristics.[9] Both pressing and milling techniques generate substantial leftover material, with pressing providing the benefit of possibly recycling items that are otherwise disposed. Sintering and slip casting methods generally exhibit higher porosity and inferior marginal fit compared to heat pressing.[10] Heat pressing promotes superior crystalline distribution within the glass matrix, reduced porosity, and enhanced marginal accuracy relative to other methods.[11,12]

Regarding pressable ceramic technique, High-temperature melted ingots are subsequently squeezed into a lost-wax mould.[13] Following pressing, the sprues and buttons are usually disposed; However, certain dental laboratories could choose to repress these buttons to reduce waste. Repressing leftover material not only reduces treatment costs for patients but also contributes to environmental conservation. Consequently, to ascertain whether recurring heat pressing treatment of the glass-ceramic material is feasible. A prior work assessed the impact of numerous heat presses on the microstructure, hardness, and strength of a pressable ceramic based on leucite.[14] It was determined that multiple pressing may have a positive impact on the assessed mechanical properties of dental ceramics. EL-Etreby et.al[15] examined the impact of re-pressing and thermomechanical ageing on the fracture strength of lithium disilicate crowns. They found that interconnected microstructure of lithium disilicate crystals became denser after repressing and this may have contributed to significantly increase fracture strength of re-pressed crowns.

Additionally, Emam ZN [16] examined how re-pressing affected the micro shear strength and surface topography of two press ceramics, the Celtra press and the IPS e.max press. The outcomes demonstrated that while re-pressing glass-ceramics enhanced the surface topography, the bond strength was weakened. It was found that the investigated glass-ceramic materials may both be recycled without appreciably altering the surface roughness.

Regarding the physical characteristics, El- Etreby AS[1] examined how re-pressing affected the IPS e.max Press's color, translucency, surface roughness, and microstructure. The results showed that repressing had no impact on the optical and mechanical properties as well.

Additional pressing has been reported not to adversely affect the flexural strength of pressable ceramics. [10,17,18,19] However, information regarding the effect of repeated heat pressing on marginal adaptation after thermocycling is lacking. Therefore, this study aims to investigate the impact of repeated heat pressing on the marginal adaptation of zirconia-reinforced lithium disilicate glass ceramic occlusal veneers after thermocycling. The null hypothesis was that there would be no effect of repressing ZLS on the marginal adaptation of occlusal veneers.

Material and method

Study design:

This study was conducted as an experimental laboratory study.

Study setting:

This study was carried out at Fixed Prosthodontics Department, Faculty of Dentistry, Tanta University.

Ethical considerations:

The research ethics committee's criteria were closely followed in the planning and execution of this study at the Faculty of Dentistry, Tanta University.

The total sample size was estimated based on pilot study using IBM SPSS. The minimum estimated sample size was 20 samples per group to have 95% power at the significance level of 0.05.

Sample size = $(Z^{2*}(P)^*(1-P))/C^2$

(Where z= z value (1.96 for 95% confidence level), p=percentage picking a choice, expressed as a decimal, c= confidence interval, expressed as a decimal).

A prototype mandibular left first molar from Nissin Dental Model (Product INC., Kyoto, Japan)) was vertically mounted in auto-polymerized acrylic resin (Acrostone, Ramses Co), positioned 3mm apical to the CEJ under the guidance of a surveyor to ensure precise parallelism.

Standardized tooth preparation replicating a worn occlusal table was achieved using a linear precision saw (Isomet 5000) to remove the coronal tooth structure 4mm occlusal to the CEJ. Indexing notches on the mesial and distal finish lines were created by a round-ended diamond high-speed rotary bur. The prepared tooth was duplicated using addition silicon (Dupliflex Addition Silicone, Protechno, Spain) mold and cast with epoxy resin (Kemapoxy150, CMB Chemicals, Egypt) to yield 40 resin dies. These resin dies were evenly split into two groups: Group 1 (pressed specimens) included 20 resin dies received occlusal veneers from freshly pressed Vita Ambria (Vita Zahnfabrik, Bad Säckingen, Germany) ingots, while Group 2 (re-pressed specimens) included 20 resin dies received occlusal veneers from repressed buttons, which were remnants from the initial pressing.

Duplicated resin dies were scanned using a 3D intraoral scanner (Runyes, Ningbo, China) to obtain precise three-dimensional images. Subsequent design of wax patterns was carried out using Exocad software (Exocad, GmbH, Darmstadt, Germany), adhering to standard measurements: 1mm at the fossa and 1.5mm at the cusp tip, with 0.03mm cement gap and spacer application of 90%, this was around half millimeters away from the finish line. After that wax patterns (Norton, China) were 3D printed, sprued, and invested. The investment material was allowed to set for a half hour, followed by wax removal using a wax burnout furnace (Ney, US Dental), as per the manufacturer's recommendations. Veneers in Group 1 were pressed using a heat press furnace (EP3000, Ivoclar Vivadent) with new Vita Ambria ingots. Post-pressing, the investment ring was promptly removed, and rough divesting was done by employing airborne particle abrasion of 110µm alumina particles (Cobra, Renfert) under 4 bar pressure, followed by 2 bar pressure for soft divesting. The pressed veneers underwent a 10-minute immersion in 1% hydrofluoric acid (Invex liquid, Ivoclar Vivadent) to eliminate the investment's reaction layer, followed by another cycle of soft divesting. Veneers were then separated from sprues and buttons using a disc, the sprues were discarded while buttons were retained for further use. Buttons were refined and shaped to resemble new Vita Ambria ingots using diamond discs and stones. For Group 2, the previous steps were repeated using trimmed leftover buttons to fabricate repressed occlusal veneers.

Surface treatment of the intaglio surface of occlusal veneers was done with 9.5% hydrofluoric acid gel for 20 seconds, followed by a 60-second rinse with running water and air drying for a half minute. A ceramic primer (BISCO Dental Products, Illinois, U.S.A.) was then applied to the inner surface of all restorations by a micro brush and left to dry for one minute. Each epoxy resin die underwent air abrasion with 50µm particle size for 10 seconds, then 15 seconds of etching using 37% phosphoric acid etching gel, 20 seconds of rinsing, and 5 seconds of air drying. A micro brush was used to apply a bonding agent (All Bond Universal Adhesive, BISCO Dental Products, Illinois, U.S.A.) to the die. Excess solvent was then allowed to air dry for three seconds before being light-cured for twenty seconds.[15]

The resin die was coated with Bisco-Duo-Link Universal™ dual-cure resin cement, and each occlusal veneer was bonded to its corresponding die. Light curing was performed for 2 seconds; after using a sharp explorer to remove extra cement, glycerin gel was applied around the edge to remove the layer that inhibited oxygen flow. A specially designed loading device of 3 kg was applied to each specimen. Final curing of the resin cement was executed for twenty seconds / surface in each direction.

All specimens underwent 5000 thermocycles, between 5 and 55°C, with a duration of 30 seconds and a dwell time of 10 seconds, simulating six months clinically.[15] Vertical marginal gaps were measured with a stereomicroscope (SZ11, Olympus, Japan), three points per surface (buccal, lingual, mesial, and distal), resulting in 12 measurements per occlusal veneer at 40X magnification. The data collected was processed and statistically analyzed (Figure 1).

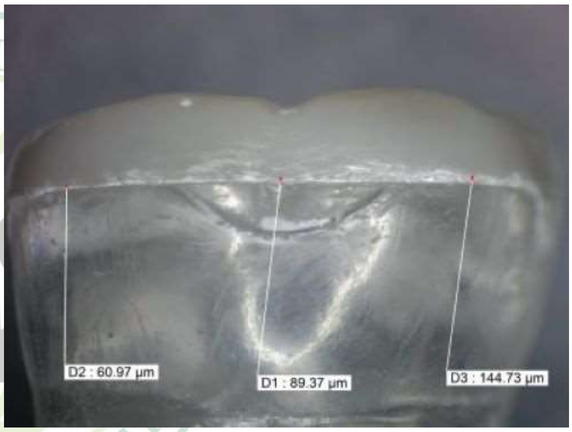

Figure 1: stereomicroscope image with measuring sites

Results

Comparing of data was done by using numerical variables by statistically describing them using mean and standard deviation. An independent sample T-test was employed, with two-sided p-values ≤ 0.05 deemed statistical significance. Statistical analyses were conducted using IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 25 for Microsoft Windows.

Regarding the marginal gap distance, it was shown that the highest average ± SD values were recorded for **Group 2** (101.11 ± 11.3 µm), but the lowest average ± SD values were observed in **Group 1** (94.88 ± 12.47µm). However, the results of independent sample T-test showed that the differences between groups were not statistically significant ($p > 0.05$) (Table. 1) (Figure. 2).

Table 1: Intergroup comparison, mean and standard deviation values of marginal gap (Mm)

Groups		Mean	SD	95% Confidence Interval for mean		P value
				Low	High	
Buccal	Press	98.59	12.59	85.39	111.80	0.868 NS
	Re press	99.50	3.33	96.00	102.99	
Lingual	Press	100.78	8.89	91.45	110.12	0.957 NS
	Re press	101.11	11.34	89.21	113.01	
Mesial	Press	97.23	6.12	90.81	103.64	0.710 NS
	Re press	99.16	10.75	87.88	110.44	
Distal	Press	94.88	12.47	81.79	107.95	0.464 NS
	Re press	98.94	3.86	94.87	102.99	

SD = standard deviation P = Probability NS = non-significant (p>0.05)

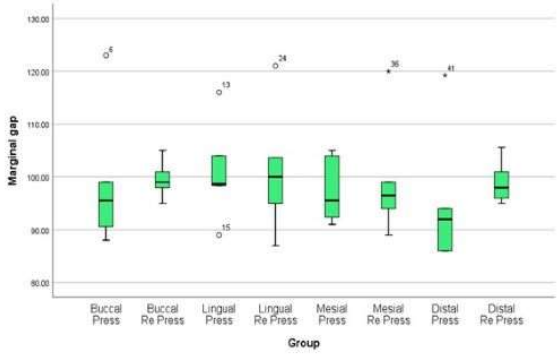

Figure 2: Box plot showing marginal gap values (Mm).

Discussion

Restoration margins are crucial for clinical success, influencing both mechanical and aesthetic qualities. Achieving a high marginal fit not only reduces the chance of endodontic problems, periodontal disease, and carious lesions but also minimizes microleakage, plaque deposition, and cement degradation.[4,20]

In the present study, tooth preparation was conducted using a linear precision saw for the purpose of standardization and mitigate potential errors often encountered with manual preparation of many abutments. The design of the preparation and thickness of the restoration were done based on previous studies.[21] Indexing notches were created on the mesial and distal finish line with high-speed round- ended diamond rotary bur to facilitate seating of the restorations and prevent their rotation.

Instead of manually constructing the wax pattern and applying arbitrary spacer thickness to the die, a 3D printing machine was employed to ensure uniformity in spacer setting parameters. This approach also eliminates dimensional errors that may arise from thermal tensions released during the wax heating and cooling phases.[22,23] Heat pressing, rather than the sintering technique, was employed for glass ceramics due to its popularity, ease of use, lower porosity, and superior marginal adaptation.[4,24]

Zirconia-reinforced lithium disilicate material used in the current study because of the improved mechanical potency of zirconia, Additionally, the microstructure shows fine-grained features after crystallisation.[5,7]

All specimens were cemented to replicate real intraoral conditions. To ensure an even cement layer, a cementing device with a 3 kg load was utilized. Excess cement was removed to prevent misleading measurements of marginal gap. Assessment of the marginal fit was conducted with a stereomicroscope which was chosen for its simplicity and practicality.[25]

Evaluating changes in the properties of dental materials over time is the main benefit of including an ageing component in any study for the properties of those materials. The thermocycling test was used in this study to evaluate the ageing process. This test involves regularly exposing the material to hot and cold cycles, simulating thermal stresses seen in the oral environment.[26]

The null hypothesis of this present study stating that repeated repressing of leftover material wouldn`t affect the marginal adaptation of ZLS occlusal veneers after thermocycling was accepted.

The current study`s largest mean ± SD values were observed in the repressed specimens however, the difference between groups was not statistically significant and all gap values observed in this study were within the clinically acceptable range (≤ 120 µm) as indicated by McLean and von Fraunhofer[27-29] and is still regarded as the marginal gap's clinically acceptable limit. This may be occurred due to strong interlocking crystals of repressed ZLS which withstand thermocycling without change in the marginal gap.[15]

The current study's findings are in a line with a previous study which show the effect of repeated heat-pressing on marginal and internal fit of e-max press after thermomechanical fatigue and concluded that there was no significant effect on both of them.[12] These findings also can be explained and supported by El-Etreby AS.[1] who evaluated the effect of repressing and glazing on color reproduction, translucency and surface roughness of lithium disilicate glass-ceramics. He revealed that there was complete absence of surface pores in both of pressed and repressed groups. This conclusion was supported by SEM images.

On the other hand, the current study's findings conflict with those of a prior investigation that evaluated the impact of repeated heat repressing on the marginal accuracy of IPS Empress II. In the previous study, groups were divided based on the percentage of repressed material used and found that the vertical marginal gap increased with higher percentages of repressed material, but up to 50% with fresh ingots did not affect all-ceramic restorations' clinical efficacy and dependability in terms of marginal adaptation.[30]

In addition, another previous study investigated the impact of various concentrations of IPS e.max repression on the marginal gap. There was a discernible statistically significant difference between the groups when the percentage of repressed material exceeded 50% and this come in contrast with the present study.[31] However, the fact that the materials varied in terms of crystal % and size makes it difficult to compare the findings of this study with those of other investigations. However, one of the limitations of the current study was that using resin die instead of natural tooth. Another limitation was that measurement methods could be done by using other methods such as scanning electron microscope or cone beam for more accurate measurement. Also, further investigations were recommended by using different ceramic materials with different percentages of repressed material.

Conclusion

Within the constraints of the current investigation, it was determined that:

Repeated pressing of leftover material has no statistically significant effect on the marginal adaptation of zirconia-reinforced lithium disilicate occlusal veneers.

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Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Declarations:

Ethics approval and consent to participate: The study was approved by the research ethics committee of faculty of dentistry, Tanta University. (Approval No. R-FP-3-24-3100). No consent available.

Competing interests: The authors declare that there is no conflict of interests regarding the publication of this paper

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