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Impact of various Press able Lithium Silicate Ceramic Crown compositions on Fracture Resistance, Color Stability, and Marginal Adaptation

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ABSTRACT

Objectives :The aim of this in-Vitro study was to assess color stability, marginal gap and fracture resistance for different pressable glass ceramic materials Lithium disilicate, Zirconia reinforced lithium silicate and Zirconia reinforced Lithium disilicate

Asound,caries–freemaxillary first molar free cracks was obtained from the outpatient clinic of Maxillofacial and Oral surgery. Tooth was mounted in epoxyres in block then tooth preparation was achieved using adental survey or The prepared tooth was scanned ,then Fiber rein forced resin blank (trilor) was milled by CAD/CAM milling machine to produce thirty fiber reinforced resin abut mentdies then their corresponding ceramic crowns were fabricated with the same shadeA2 according tothemanufacturerinstructions.thirtyspecimens were divided into 3 groups (n=10) according to the type of pressable ceramic material used as follow: Group E:Lithium di silicate ceramic material (IPS e.max press),GroupC:ZirconiareinforcedLithiumsilicatece ramicmaterial(Celtrapress) and Group A Zirconia reinforced lithium di silicate ceramic material.(Vita -ambria)..The ceramic crowns were checked and cemented on their corresponding constructed dies. All specimens will be subjected to thermo cycling thenpost the cycling Marginal gap, color changes will be measured. All specimens willbe subjected to fracture resistance test.

Keywords: CAD/CAM, trilor , color stability test , margin adaptation test and fracture resistance test, Lithium disilicate glass ceramics, Zirconia reinforced lithium silicate glass ceramics, Zirconia reinforced lithium disilicate glass ceramics.

I-INTRODUCTION

Ceramic materials are crystalline inorganic, nonmetallic materials that consist of metallic and nonmetallic elements bonded together primarily by ionic and/or covalent bonds. which include complex mixture of metal oxides, borides, carbides and nitrides.[9]Lithium disilicate, is one of monolithic ceramic systems that have increased popularity for anterior and posterior single crowns and partial coverage restorations.[3] These ceramics reveal a translucency and aesthetic appearance more than those high strength polycrystalline alternatives. However, the mechanical properties limit their use in the molar area.[4,5] To overcome this problem ,A new ceramic material for dental restorations has been lately introduced with altered chemical composition to progress the mechanical properities of these ceramics. Zirconia-reinforced lithium silicate ceramics were developed. To overcome this problem, Anew ceramic material for dental restorations has been lately introduced with altered chemical composition to progress the mechanical properities of the seceramics. Zirconia- reinforced lithium silicate ceramics were developed. Zirconia acts as a crystalline phase that can reinforce the material by avoiding crack propagation. Zirconia-reinforced lithium silicate ceramics combined nearlythemechanicalfeaturesofpolycrystallineceram icswiththeesthetic properties of glass ceramics in a monolithic restoration. Recently , zirconia-reinforced lithium disilicate press ceramic system has developed for highly esthetic and durable results with efficient processing. It's used for fabrication of inlays, onlays, partial veneer crowns, full veneer crowns, three- units bridges up to the second premolars and laminate veneer.

II. MATERIALSAND METHODS

The following in vitro procedures were followed the rules provided by the Local Research Ethics Committee of the faculty of dentistry, Mansoura University with approval number A06021121Materials used in the present study were tabulated according to product name, material type, chemical composition, lot number, and manufacturer. (Table1).

Product name	Material type	Batch(Lot) number	Composition	Manufacturer
TrilorFiber disc (CAD\CAM)	Fiber reinforced resin blank	Number Lot:1919	Fiber-Reinforced Composite (FRC) composites The woven fiber structure reproduces that of the fabric, in a multi-directional configuration, to offer the best performances.	Bioloren metal free dental solution Made in Italy
IPS e.max press	Lithium di silicate ceramic material	Z02JF3	SiO2 (71.9), Al2O3 (5.4), Li2O (13), K2O (2), Na2O (1.4), P2O5 (2.6), B2O3 (0.007), ZrO2 (1.7), CeO2 (1.2), V2O5 (0.15), Tb203 (0.35), Er2O3 (0.4), HfO2 (0.03)	Ivoclar Vivadent AG FL-9494 SCHaaN/Liechtenstein
Celtra press	Zirconia reinforced Lithium silicate	16004121	iO2: 59.3%, Al2O3: 3%, Li2O: 14.5%, K2O: 1.2%, Na2O: 0.2%, P2O5: 4.9%, B2O3: 2%, MgO: 0.01%, ZrO2: 9.3%, SrO: 0,0003%, CeO2: 0.83%, V2O5: 0.61%, Tb203: 3.3%, Er2O3: 0.73%, HfO2: 0.21%	Hanau-Wolfgang Dentsply sirona GERMANY
Vita Ambria	Zirconia reinforced Lithium Di silicate ceramic	91170	SiO2 (58–66), ZrO2 (8–12), Li2O (12–16), Pigments (<10), various (>10)	Vita Zahnfabrik, Bad Sachingen, Germany

A single sound, caries –free upper first maxillary molar free from cracks was attained from the outpatient clinic of Maxillofacial and Oral surgery. Tooth was mounted in epoxy resin block, then tooth preparation was performed using a dental surveyor .The prepared tooth was scanned by optical scanner. Fiber reinforced resin blank was milled by a CAD/CAM milling machine to produce thirty fiber reinforced resin abutment dies then their corresponding ceramic crowns were fabricated with the same shade A2 according to the manufacturer instructions. Thirty specimens were divided into 3 groups (n=10) according to the type of pressable ceramic material used as follow: Group E: lithium disilicate ceramic material (IPS e.max Press), Group C: zirconia reinforced lithium silicate ceramic material (Celtra press) and Group A: zirconia reinforced lithium disilicate ceramic material(Vita-ambria). The ceramic crowns were checked on their corresponding constructed dies. An adhesive resin luting cement was used to bond the restorations to the their corresponding abutment dies

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as stated by manufacterur's instructions. All samples were kept in distilled water for one day after cementation Baseline color and marginal gap measures were recorded . Then, Artificial aging process by thermocycling for 5000 cycles (5-55º C) was performed.to mimic 6 months inside oral cavity, Afterward, color stability and marginal gap were measured. All specimens were fractured under static compressive load using universal testing machine. Then, recording of fracture load (N) of each specimen was done. Two-way ANOVA, one-way ANOVA, and post hoc Tukey tests were used for statistical analysis of the data (α=.05).

III. RESULTS

Table (1): comparison of delta e between studied groups

	Emax	Celtra	Vita Ambria	Test of significance	Within group significance
Delta e Mean ±SD	2.12±0.11	2.61±0.23	3.15±0.26	F=58.68 P=0.001*	P1=0.001* P2=0.001* P3=0.001*

F: One Way ANOVA test , *statistically significant , p1: difference between e max & Celtra group, p2: difference between e max & Vita Ambria, p3: difference between vita Ambria & Celtra group.

IV. DISCUSSION

Pressable Ceramic restorations which were selected in this study , were lithium disilicate pressable glass ceramic (IPs e.max press), zirconia reinforced lithium silicate glass ceramics (.celtra press) and zirconia-reinforced lithium disilicate pressable glass ceramics(vita ambria) which have become increasingly popular in Prosthetic dentistry .

Zirconia component could act as a crystal phase reinforcing the material and avoiding crack spreading.[1] Zirconia Reinforced Lithium Silicate Ceramic (Celtra Press) is the new generation of high strength glass ceramics. The introduction of zirconia in each microstructure was said by its manufacture to enhance its strength to give exceptional flexural strength more than 500 MPa. It contains a homogeneous crystalline structure made of lithium silicate crystals, and reinforced with tetragonal zirconia fillers (about 10% by weight). Celtra Press has higher fracture toughness than IPs e.max.[2] Celtra Press has superior flexural strength of about 500 MPa (after power firing). [3]

It has high percentage of glass matrix which offers translucency, natural appearance and shades that match the color of natural teeth combined with high mechanical properties due to the addition of 10% zirconia (ZrO_2) which is incorporated totally in the glass phase, it is an etchable ceramics material. Moreover, the manufacturer has introduced a new investment material used for Celtra press with minimal reaction layer formation, leading to an excellent fit and shortening the time required for finishing, as the surface etching step is eliminated.

Crystals in the Celtra Press pellet are smaller in size leading to better compressibility and flowability (lower viscosity) during the pressing process than IPs e.max press. Thin sections of restorations can be pressed with less number of sprues. In combination with the newly introduced investment, only a minimal reaction layer is formed. Celtra Press has a lower pressing temperature (50–60°C) than conventional lithium disilicate glass ceramics. The lower pressing temperature greatly reduces the hardness of the reaction layer, resulting in simplicity of its removal, Simpler and faster polishing due to small crystal size.[1]

The null hypothesis was rejected, since the three pressable glass ceramic evaluated tested affected the physical properties of the color change and fracture resistance. esthetic factors play a significant role in the realm of dental restoration, underscoring the critical nature of color permanence in dental substances. The interaction of various food items and drinks with dental restorations can result in undesirable staining effects. Consequently, these influences have the potential to compromise the aesthetic integrity of the restorations. The extent of discoloration is predominantly dictated by the material's composition, environmental conditions, and duration of contact.[22]

Instrumental color measurement offers the advantage of objectivity and quantifiability. In the present investigation, the CIE lab formula was chosen to assess color variations. The degree of color change was expressed through ΔE, which represents the numerical separation between the L*a*b* coordinates of two hues. Previous studies have indicated a threshold for detectable color changes. Changes with $\Delta E < 1$ were imperceptible to the naked eye; those falling within the range of $1.0 < \Delta E < 3.3$ were visible only to trained individuals and deemed clinically acceptable, whereas values exceeding 3.3 were considered easily noticeable and clinically unacceptable.[23, 24]

In clinical scenarios involving various dental materials, the assessment of color discrepancies holds significant importance. The color permanence of resin matrix ceramics plays a crucial role, especially when observed clinically over a period. The escalating need for aesthetic treatments necessitates clinicians to exercise caution in the choice of restorative materials, as this factor significantly influences the efficacy of long-term treatments.[25]

In the current investigation, the highest average ΔE value is observed in Vita Ambria, followed by Celtra, and the lowest in E-max (3.15±0.26, 2.61±0.23, and 2.12±0.11, respectively). The Post Hoc Tukey test was employed for conducting pairwise comparisons among the groups under examination, revealing statistically significant distinctions between each pair ($p \leq 0.001$*). The color change detected in IPs e.max was more stable compared to Vita Ambria and Celtra.

Within the context of this research, the color alteration in Vita Ambria was deemed clinically acceptable (ΔE = 3.15), with Celtra Press following suit (ΔE = 2.61), and the least change observed in IPS e.max (ΔE = 2.12). IPs e.max exhibited the smallest color transformation among the trio of materials, indicating its superior stability, heightened translucency, toughness, and overall durability.

Therefore, IPs e.max stands out as one of the most extensively utilized ceramic substances, showcasing notably superior performance in terms of both optical properties and flexural strength.[26]

Therefore, in the present study, ΔE values lower than 3.15 were considered as clinically acceptable even in cases where there was statistically significant difference. [27, 28]

Bekheit et al. (2021) [29] indicated that IPs e.max press and Celtra press restorations exhibit color matching with adjacent natural teeth and high patient satisfaction, suggesting their suitability for use in aesthetic regions. Furthermore, Fasbinde et al. (2010) observed that lithium disilicate crowns achieved the highest acceptance score, Alpha score, after a 2-year follow-up, as per the United States public health service standards.

Rinke et al. (2015) posited in their research that the exceptional esthetic characteristics and color permanence of zirconia-reinforced lithium silicate could be attributed to the remarkably uniform microstructure of lithium disilicate and lithium metasilicate crystals, ranging from 0.5 µm to 0.7 µm.

Alp G et al. (2018) associated the enhanced aesthetic features of zirconia-reinforced

lithium silicate with its finely structured, uniform rod-like crystalline arrangement, ensuring long-term color stability.

The presence of 10% zirconia particles in zirconia-reinforced lithium silicate (Celtra press) may lead to increased ceramic opacity and reduced translucency, potentially affecting color stability and hindering complete polymerization of light-cure resin cement, thereby increasing susceptibility to discoloration.

Mohamed et al. (2021) investigated the impact of glass ceramic materials and resin cement curing methods on the color stability of sectional porcelain laminate veneers following artificial aging. IPs e.max press exhibited significantly lower color stability (ΔE 2.6) compared to Celtra press (ΔE 3.05). IPs e.max press glass ceramic demonstrated superior color stability over Celtra press, offering patients a suitable material for aesthetically enhancing anterior teeth while preserving natural appearance and tooth structure with optimal esthetics. The highest mean Fracture resistance is detected for vita Ambria followed by celtra and the least for E-max (2896, 2673 & 2094 newton) .Celtra press is another innovative advancement in glass ceramic materials containing 10% zirconia providing high mean flexural strength in addition to its high glass Content.[20]. Some manufactures claimed that the strength of ceramic material can be increased by subjecting the material to a thermal tempering cycle at 9% below pressing temperature.

Vita Ambria has excellent mechanical properties, including high fracture resistance. A study by Anusavice [35] , the high fracture toughness and resistance of zirconia-based ceramics like Vita Ambria, making them suitable for demanding clinical situations. Another study by Zhang et al. [36] evaluated the fracture resistance of different ceramic materials and found that zirconia-based ceramics exhibited superior fracture toughness compared to lithium disilicate-based ceramics like IPs e.max Press. Celtra Press is a glass ceramic material known for its strength and esthetics.

- Research comparing the fracture resistance of Celtra Press with other dental materials is limited, but it is often considered to have favorable mechanical properties, including fracture resistance, due to its composition and processing technique.

- While specific studies directly comparing Celtra Press with Vita Ambria and E-max Press may be scarce, Celtra Press is generally regarded as a reliable material for dental restorations, especially in situations where both strength and esthetics are important.

E-max Press is valued for its esthetics and moderate strength. While Celtra Press offers good fracture resistance, it may exhibit lower fracture toughness compared to zirconia-based ceramics like Vita Ambria.

A study by Fasbinder [30] compared the fracture resistance of E-max Press and zirconia-based ceramics, indicating that while E-max Press demonstrated favorable fracture resistance, zirconia-based ceramics showed superior mechanical properties overall. For buccal, distal, mesial, palatal surface ; statistically significant increase in marginal gap is detected for each of the studied groups ($p<0.001$ each) . For overall average marginal gap; statistically significant increase is detected for each of the studied groups ($p<0.001$ each) .

In the present study the marginal and internal gap of Vita Ambria was higher than that of IPS e.max press and Celtra press in contrast to Gerth [37] and El Hamid et al., [38]

Marginal fit has an impact on a dental restoration's long-term clinical performance in addition to its mechanical, cosmetic, and biological characteristics. Due to rapid degradation of dental cement and plaque buildup, large marginal gaps result in restorative failure. This is followed by marginal leaks and secondary caries. [39] It has been shown that the marginal fit of dental restorations plays a critical role in the development of secondary caries and periodontal disorders, both of which ultimately result in restoration failure. [40, 41]

In summary, while specific studies directly comparing Vita Ambria, Celtra Press, and IPs e-max Press may be limited, zirconia-based ceramics like Vita Ambria generally offer superior fracture resistance compared to lithium disilicate-based ceramics like E-max Press. Celtra Press falls between these two materials in terms of fracture resistance, often providing a balance between strength and esthetics in clinical practice.

The Vita Ambria contained 10% zirconia fillers in its lithium disilicate glass-ceramic matrix. Therefore, Vita

Ambria showed more fracture resistance than IPs e.max press.

V. CONCLUSIONS

Within the limitations of this in-Vitro study, it was concluded that; color stabilitywas affected by the chemical composition of glass ceramic material (Glass ceramics containing lithium disilicates provided better color stability than those containing zirconia).

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