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RESEARCH ARTICLE

Laboratory Evaluation of IPS-lithium Disilicate Orthodontic Brackets (*In vitro* Study)

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ABSTRACT

The purpose of the study is to evaluate the microhardness and light transmission through new Emax brackets with two ceramic brackets commercially available in the markets. The brackets were divided into three groups: (1) E max brackets (IPS E-max press, Ivoclar, Germany), (2) Gemini clear brackets (Unitek, 3M, USA), and (3) discovery pearl ceramic brackets (Dentaurum, Germany). The Vickers hardness test was used to evaluate the hardness of the wings in addition the light transmission of three brackets types were tested through using an orthodontic light cure device and light meter. The hardness test of discovery pearl ceramic brackets and Gemini clear brackets gave significantly higher than E.max one while later gave significantly more light transmission through it when compared with another two brackets. In conclusion, the noticeable tested brackets make E max material one of choice for modern esthetic brackets in future although the hardness is less comparing the other tested brackets due to the purity of material compering with other test brackets which are reinforced of their material, the new material requiring improving of mechanical performances.

Keywords: Ceramic brackets; IPS E-max press; Orthodontic bracket wings; Translucency; Vickers hardness test

INTRODUCTION

As in contemporary dentistry, the advancement in orthodontics extremely important; silicate glass ceramics have recently been introduced as machinable materials to meet the increased strength, durability, and wear resistance (Galantea et al., 2019). Ceramic bracket was introduced in the 1980s as an alternative to metal brackets that were more esthetically pleasing, the ceramic brackets currently available are almost composed of aluminum oxides and show high strength, chemical stability, and biocompatibility (Kukiattrakoon and Samruajbenjakul, 2010).

Variety of lithium disilicate (Li2Si2O5) materials translucency and durability are generally presents as crowns and veneers. The morphology of this material consists of microstructure formed by interlocking needle-like crystals embedded in a matrix of glass. Due to this morphology, cracks are forced to spread around each individual crystal lithium disilicate) (Figueiredo-Pina et al., 2016), this form of microstructure will increase strength and toughness in contrast to other widely used glass-ceramics: They have twice the strength of the first generation of leucite-reinforced ceramics (Denry and Holloway, 2010); many problems again facing in this material like wings fracture and discoloration, as a representative glass-ceramic material, lithium disilicate material IPS e.max system (Ivoclar Vivadent AG, Schaan, Liechtenstein) reveals greater resistance to fracture toughness and flexural strength (Motro et al., 2012) and allows dental technicians to customize dental restorations with heat-pressing or machining technology in terms of shape and esthetics. To date, however, the application of lithium disilicate has not been reported in the orthodontic field.

MATERIALS AND METHODS

Making New E-max Brackets

Bracket duplication

3M ceramic bracket was used as a sample for duplication (3M Company, Gemini clear Brackets). The elastomeric impression material heavy and light body, Harvard PremiumSil, UK, were used to take an impression and for duplicating the bracket.

The bracket was removed, and the negative impression of the bracket was used as a mold to complete the procedure of duplication of bracket with E max.

Positive impression of E max brackets was made from pattern acrylic resin, GC U.S.A, and as a final step before the converting of acrylic resin brackets into E max bracket, Figure 1.

Laboratory work

The lab working started with sprueing procedure for pressing lithium disilicate ingots, the acrylic bracket model objects are sprued on the investment ring base laterally by attaching the base of the bracket to the wax to avoid damaging the wing and slot of the bracket, Figure 2.

After that, investing was carried out with IPS PressVEST Speed 200 g IPS Silicone Ring with the matching ring gauge is used for investment, the ring is flushed with the investment ring base. Investment material mixed with ratio (32 ml:22 ml) and slowly poured into the investment ring until it was full. The preheating and pressing cold IPS Alox Plunger and a cold IPS e.max Press ingot provided in the shade (high translucency A1) the press furnace (e.g., Programat EP 5010) switched on in time so that the self-test and preheating phase are completed. The divesting and finishing step with allow speed and light pressure the pressed Emax brackets are cut to the minimum, Then cleaned with the steam cleaner (Ivoclar Vivadent/Emax revolution instruction), finally Glaze firing was made, Figure 3.

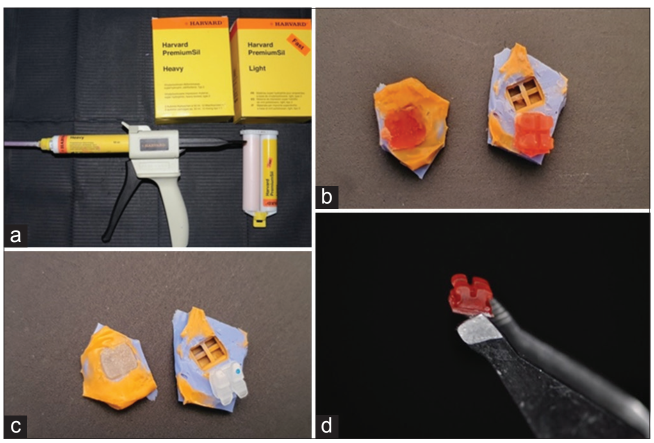

Figure 1: (a) The elastomeric impression material heavy and light body, Harvard PremiumSil, UK, (b) negative impression of 3M bracket, (c) positive impression of 3M ceramic bracket by acrylic, (d) side view of acrylic bracket

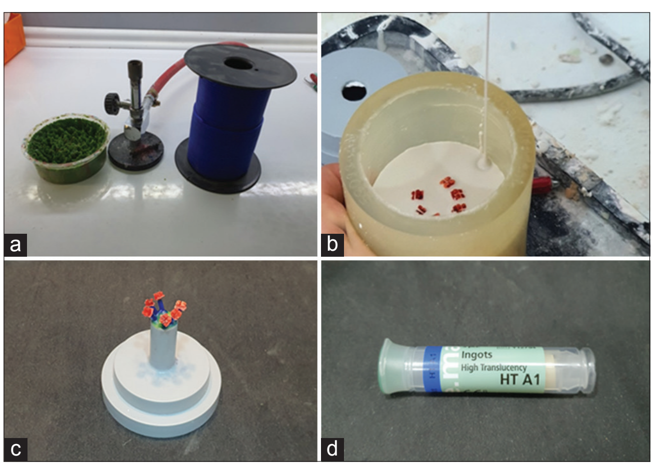

Figure 2: (a) Wax wire and gas torch, (b) acrylic bracket attached to the ring base by sprue wax wire, C the ring base with brackets are put in investing, (c) the ring base and attached acrylic brackets are imbedded in investment material, (d) height translucency H1 A1 ingot

Mold Preparation for Microhardness Test

A plastic tube was cut into cylindrical part each of them (diameter 2.54 cm and the height 1 cm); all brackets were embedded in epoxy resin, vertex, Netherlands, into the mold. In the way that the side of the bracket wings are appeared on the surface of the mold, these brackets were grounded and polished with grinding and polishing machine, until 4000 grit-size and subsequently polished according to the instructions given for ceramic materials, to clearly measure dimensions of the indentation (Struers A/S, DK), Figure 4.

Laboratory Tests

Microhardness test

Three types (15 brackets/each) were prepared from each bracket type. Hardness test performed by a microhardness tester (Digital Microhardness tester, time group Inc., China, each bracket was tested 3 times and the measurement was recorded each time to obtain the mean value, the test made with a Vickers hardness test a highly polished, pointed square-based pyramidal diamond

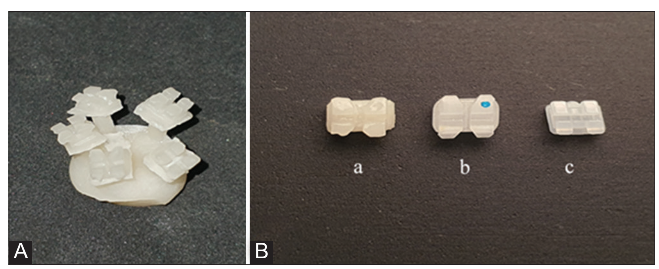

Figure 3: (A) Emax bracket after divesting, (Ba) Emax bracket after glazing, (Bb) 3M/Gemini clear ceramic bracket, (Bc) Dentaurum/ discovery peal ceramic bracket

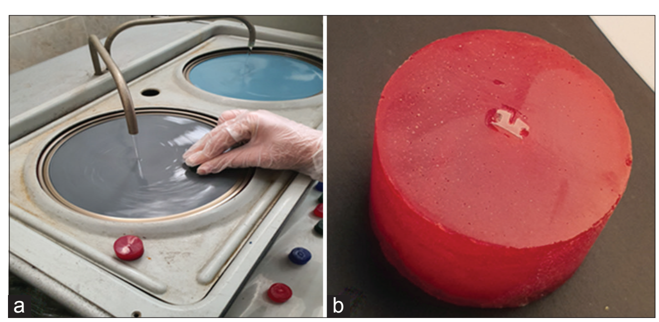

Figure 4: (a) A metallographic grinding/polishing machine, (b) the acrylic mold and the bracket after polishing

is used as the indenter, using 200 g load and 15 s contact time, Figure 5.

Light transmission

The light-curing unit LEDEX wl-090 (Dentmate, Korean) was used at emitting 1400 mW/cm^2 and wavelength 390 ~ 480 nm, peak: 405 and 460 nm with sensor to measure the light intensity. For standardization criteria, the light cure was measured by putting the light cure away from testing area equal to the thickness of the tested brackets and its 450 mW\cm^2 (holding of light cure through test tube holder from the base as shown in Figure 6 for distance fixation). The exposure mode used 20 s and re-calibrate was used to measure the intensity each time. The bracket (n:15 per brand) placed in the sensor in the way that the labial surface of brackets looking toward the light cure tip so that the direction of light through the bracket will be in the way that the light transmits throughout the surface of the bracket same as during fixation of brackets in the oral cavity. The measurement will be repeated 6 times for each bracket. The data of light transmission test with brackets were excluded from the standard light transmission ability of the light cure device (without bracket) which is 450 mW\cm^2 to measure how much light was scatter or absorbed through the tested brackets (Ali et al., 2011, Eliades et al., 1995).

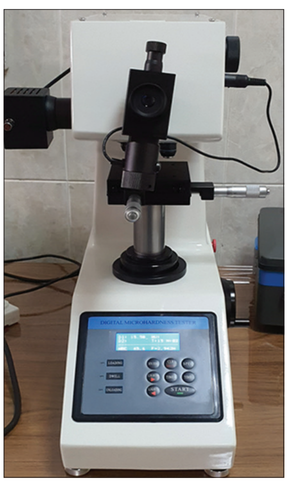

Figure 5: Digital microhardness tester (Time Group Inc., China).

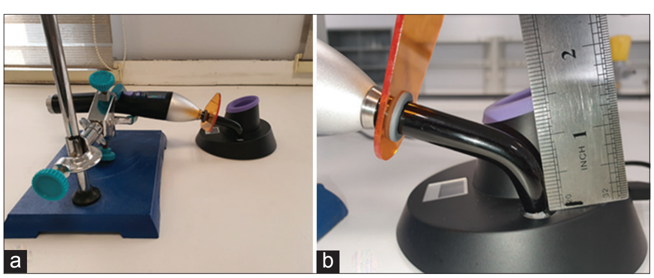

Figure 6: (a) The light is held by lab support stand and burette clamp, (b) the distance from the tip of light cure to the bracket surface is fixed on 1 mm

RESULTS

Microhardness

Statistically significant differences were not found in VH between two commercially available ceramic brackets (Gemini clear ceramic brackets and discovery pearl ceramic). The lowest hardness test was showed in E max brackets, Table 1.

Light Transmission

The highest light absorbed or scattered recorded by Gemini clear brackets then discovery and the lowest light lost shown in E max one, Table 2.

DISCUSSION

The introduction of the first generation of ceramic brackets raised concerns about the clinical performance of these materials, especially after some problems related to plastic brackets like decreased ability to transfer torque to the tooth, because of permanent deformation associated with their low elastic modulus (Eliades and Bourauel, 2005).

Ceramic brackets are fulfilling the orthodontist's need for excellent performance, as well as the patient's demand for superior esthetics. Ceramic materials, like any new material, may need modifications to the technique. (Jena et al., 2007). Again, multiple complications during the use of ceramic brackets in clinical practice were appeared. The main problems include bracket fracture, especially of the wings, increased friction comparing with metal brackets (Guerrero et al., 2010), attrition of teeth which occur against the bracket due to the material type in addition to color stability. (Guignone et al., 2015).

Table 1: Vickers hardness measurements (means and standard deviations)*

Brackets name	Mean (SD)*	Duncan**
E max	476.1600 (2.9)	A
Gemini clear	1744.7600 (1.6)	B
Discovery pearl	1721.7200 (3.7)	B

*Standard deviation, **Different letters mean significantly different at $P \leq 0.05$

Table 2: The activation light results through tested brackets (means and standard deviations)

Brackets	Means/(450 mW\cm^2)**	% D.L***
E max	391.3 (16.81)^c	13%
Gemini clear	322.82 (25.81)^a	28.25%
Discovery pearl	358.67 (17.63)^b	20.23%

*Same superscripts imply mean values with no statistically significant differences, **Light intensity emitting from of light cure without brackets (standardization criteria), ***Percentage representing the decrease in density of light transmission (scattered or absorbed). Type of statistical system: SPSS version 17

The majority of researches concentrated on to the wings (Johnson et al., 2005) and the hardness testing was always carried out on it because this structure is considered as the most sensitive in addition the hardness values are straightly related to the wear resistance of the orthodontic brackets and finally affected on durability of these brackets especially for new intruding materials. The microhardness results showed the Gemini clear and discovery pearl the highest hardness value comparing with E max one, although the IPS E max materials improved mechanically comparing with other ceramic material (Holand et al., 2009, Ritter, 2010). This result may be the purity of materials of E-max brackets comparing with ceramic reinforced brackets. In addition, the composition of materials like the discovery pearl is composed of highly pure polycrystalline aluminum oxide manufactured by ceramic injection molding (CIM) technique (manufacturer information) which makes all atoms are densely packed into random arrays which are much more harder to drive a crack through (Griggs, 2007, Denry and Holloway, 2010, Kelly and Benetti, 2011, Saint-Jean, 2013).

The microhardness results of new created brackets were low in comparing to other tested brackets but it is clinically acceptable as new material. This result may be due to IPS e.max press which has elongated crystals of approximately mean grain length and diameter approximately 3–6 μm in length and 0.6–0.8 μm diameters (Holand and Beall, 2012). The ingots are produced using bulk casting which is a continuous manufacturing process based on glass technology (casting/pressing procedure). This new technology uses optimized processing parameters, which prevent the defect in the bulk of the ingot from the formation (Holand and Beall, 2012, Datla et al., 2015). According to the manufacturer, IPS e.max press has a flexural strength of 400 MPa and a fracture toughness of 3.0 MPa. The low hardness results comparing with polycrystalline brackets will be explained by two ways, the 1st one related to the thickness of materials, especially the wings comparing to the normal thickness of crown or restorative materials (Omor et al., 2013). The 2nd cause may be related to new molding injection technology that increases the physical properties of material (Chien et al., 2004)

The clarity of the orthodontic brackets is one of the important factors affecting the shear bond strength in the future and time of curing. The E max brackets gave the lowest light lost comparing with the other two tested brackets. The main cause of the variety of material of E max that commercially available in the marketing today, starting from a high translucent material to the lowest one due to the demand of esthetic. The variety of translucency of E max material gave her the best option for patients according to their teeth color according to the manufacturer information.

The difference in thickness of the materials not only for E max but also other esthetic materials play a major role in the amount of light passing through (Al-Juaila et al., 2018, Czigola et al., 2019).

From another hand, the thickness of the material also may be an effect on shear bond strength through how much the light passes through and degree of curing of adhesive. Moghaddas et al., 2017 showed that the thickness of lithium disilicate ceramic <1 mm no effect of shear bond strength. The interface between the glassy and crystalline phases of the material is responsible for the properties of light scattering noted in the material. Hence, increasing the percentage of materials crystallinity will improve mechanical properties by compromise the translucency and color of the material (Luo and Zhang, 2010).

CONCLUSION

1. The discovery pearl and Gemini clear ceramic brackets gave higher hardness value comparing with new E max brackets
2. No statistically difference between discovery pearl and Gemini clear ceramic brackets
3. The tested brackets attenuated the light-curing intensity between 13% and 28%. The E max gave the lowest percentage of losing of light
4. E max brackets are the future of more esthetic brackets because of more color options with expectation high shear bonding strength with improving of mechanical properties of material.

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