Comparative Evaluation of Flexural Strength of 2 Nanoceramic Composite Resin CAD/CAM Blocks (Lava Ultimate and Vita Enamic) and a Lithium Disilicate Glass Ceramic (IPS e.max CAD)

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Abstract: Recently, new generations of nanoceramic composite resin CAD/CAM blocks, have been introduced to dentistry, which are claimed to have higher flexural strength, fracture, fatigue and wear resistance, and beside natural looking appearances can be polished easily. Therefore, the aim of this study was to compare flexural strength of 2 nanoceramic composite resin CAD/CAM blocks (Lava Ultimate and Vita Enamic) and a lithium disilicate glass ceramic (IPS e.max CAD) material.

In this experimental study, resin nanoceramic blocks, Lava Ultimate (3M, ESPE, USA), Vita Enamic (VITA Zahnfabrik, Bad Säckingen, Germany) and a lithium disilicate glass ceramic, IPS e.max CAD (Ivoclar Vivadent, Schaan, Liechtenstein) prepared for flexural strength test on the basis of ISO 6872:2008. For 3 point bending test, 30 rectangular specimens (10 for each group) with the dimensions of ~14mm×4 mm×1.2 mm were prepared and loaded on a 10 mm span with crosshead speed of 1 mm/min by a universal testing machine (Zwick/Roell). Differences between the means of the 3 groups were analyzed with one way ANOVA followed by multiple comparison Tukey HSD test. Also the normality of the tested groups evaluated with kolmogorov Smirnov test.

The mean flexural strength and standard deviation was 139.9±21.2MPa for Lava Ultimate, 273.8±56.03MPa for IPS e.max CAD and 127.7±11.9 MPa for Vita Enamic. Significant differences were found between the groups (P<0.001). The Tukey HSD test showed that flexural strength of IPS e.max CAD is significantly higher than two other ceramics (p<0.05). IPS e.max CAD exhibited higher values in flexural strength between the 3 groups. The others respectively were Lava Ultimate and Vita Enamic. The flexural modulus of Lava Ultimate and Enamic was greatly improved to levels not seen before in dental resin composites. However, their consideration and clinical use in patients with high muscular and masticatory forces especially patients with bruxism and clenching, better to be similar to that of conventional dental CAD/CAM resin composites and be limited to inlay, onlay and veneer restorations.

Keywords: Ceramics, CAD/CAM, Flexural strength, composite resins

INTRODUCTION

For decades, full coverage restorations have been used as the most common fixed prosthetic treatment to restore the function and appearance of the destroyed natural teeth [1]. Metal ceramic crowns have been considered the gold standard for full coverage restorations, due to their high strength, excellent fit and marginal integrity and long term survival rate [2, 3]. However, biologic complications such as periodontitis [2, 4], chipping and ceramic debonding [5] and lack of natural appearances are considered to be the problems of these restorations [6]. Therefore, the interest and demand from patient and clinician for biocompatible metal free restorations, has encouraged researcher to seek alternatives [1, 7]. To fulfill these requirements, all-ceramic restorations with the advantages of soft tissue biocompatibility [8], color stability, improved wear resistance and excellent light transmitting properties [9] have been developed.

In 1965, McLean [10] introduced an alumina reinforced core ceramic, which was used for anterior
teeth restorations. Meanwhile, CAD/CAM technology (computer aided design/computed aided) was introduced to dentistry in the 1980s [11, 12]. In principle, this technology have been developed for fully sintered ceramic blocks (hard machining), it has now been expanded to partially sintered ceramics (soft machining), that are later fully heat treated to ensure adequate sintering [13]. As a result, new generations of ceramic and composite materials for bi-layered and monolithic applications were developed. However, chipping of the bi-layered all-ceramic restorations [2,14] and bulk fracture of monolithic all-ceramic restorations, still demonstrate the most commonly reported laboratory and clinical complications [15-17]. All ceramic crowns have been used widely as a superstructure of dental implants in recent years [18,19]. There are two types of inherent flaws that compromise the ability of all-ceramic restorations to withstand occlusal forces: fabrication defects (internal voids, porosities, or microstructural features that arise during processing) and surface cracks (defects on the surface as a result of machining and grinding process) [20, 21]. Lithium disilicate glass ceramic (IPS e.max CAD) which investigated in this study is a CAD/CAM generated restoration [7]. Reparability of conventional ceramics in oral environments is often problematic. In comparison, composites can be repaired simply but they have poor mechanical characteristics and biocompatibility [22]. Therefore some authors are following more optimal restorations on the basis of modulus elasticity of composites similar to dentin and esthetic of feldspatic ceramics similar to enamel [23].

Recently, new generations of nanoceramic composite resin CAD/CAM blocks, Lava Ultimate (3M, ESPE, USA) nano ceramic particles embedded in a highly cured resin matrix and Vita Enamic (VITA Zahnfabrik, Bad Säckingen, Germany) polymer-infiltrated ceramic, have been introduced to dentistry, which are claimed to have higher flexural strength, fracture, fatigue and wear resistance, and beside natural looking appearances can be polished easily [24-26]. Therefore, the aim of this study was to compare flexural strength of 2 nanoceramic composite resin CAD/CAM blocks (Lava Ultimate and Vita Enamic) and a lithium disilicate glass ceramic (IPS e.max CAD) material. The null hypothesis was that there is no significant difference between the flexural of strength of the three groups.

METHODS AND MATERIALS
In this experimental study, three CAD/CAM ceramic Materials were compared. Resin nanoceramic blocks, Lava Ultimate (3M, ESPE, USA) and Vita Enamic (VITA Zahnfabrik, Bad Säckingen, Germany) and a lithium disilicate glass ceramic (IPS e.max CAD, Ivoclar Vivadent, Schann, Liechtenstein) as a control group were prepared for the flexural strength test according to the ISO 6872: 2008 [27] [Fig 1].

For 3 point bending test, 30 rectangular specimens (10 for each group) with the dimensions of ~14mmx4 mmx1.2 mm were prepared using a cutting machine (Struers Minitom, Willich, Germany) at a rate of 250 rpm under water irrigation as instructed by the manufacturers [24]. Lava Ultimate and Vita Enamic just were polished with abrasive discs SiC paper 500, 1200 and 2400 # (LaboPol-1, Struers, Willich, Germany), while IPS e.max CAD specimens were fully crystallized at 850ºC for 10 minutes in a ceramic furnace (VITA Vacumat 6000, Zahnfabrik, Germany). Then the specimens were loaded by a universal testing machine (Zwick/Roell, Z050, Germany) with crosshead speed of 1 mm/min on a 10 mm span. The loading apparatus was 4 mm in diameter [Fig 2].
Fig-2: Universal testing machine for flexural strength test

Differences between the means of the 3 groups were analyzed with one way ANOVA followed by multiple comparison Tukey HSD test. Also the normality of the tested groups evaluated with kolmogorov Smirnov test.

RESULTS

For all the specimens, the flexural strength values were calculated with the mean values, standard deviation, maximum, and minimum displayed in Table 1.

The kolmogorov Smirnov test showed the normality of the distribution (P>0.05). The mean flexural strength value was 139.9±21.2MPa for Lava Ultimate, 273.8±56.03MPa for IPS e.max CAD and 127.7±11.9 MPa for Vita Enamic. Significant differences were found between the groups (P<0.001) by one way ANOVA [Tab 1].

The Tukey HSD test showed that flexural strength of IPS e.max CAD is significantly higher than the two other ceramics (P<0.05) [Tab 2].

### Table 1: Descriptive statistics of flexural strength (MPa) for all ceramic groups

<table>
<thead>
<tr>
<th>Ceramic block</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean ± SD</th>
<th>ANOVA analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lava Ultimate</td>
<td>112.65</td>
<td>175.47</td>
<td>139.9±21.2</td>
<td>F=52.751 p-value&lt;0.001</td>
</tr>
<tr>
<td>IPS e.max CAD</td>
<td>158.27</td>
<td>352.96</td>
<td>273.8±56.03</td>
<td></td>
</tr>
<tr>
<td>Vita Enamic</td>
<td>106.73</td>
<td>148.96</td>
<td>127.7±11.9</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2: Tukey HSD test for multiple comparison between the 3 groups.

<table>
<thead>
<tr>
<th>Comparisons</th>
<th>Differences Mean</th>
<th>Std. Error</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lava Ultimate vs IPS e.max CAD</td>
<td>133.844</td>
<td>15.778</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IPS e.max CAD vs Vita Enamic</td>
<td>146.066</td>
<td>15.778</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Lava Ultimate vs Vita Enamic</td>
<td>12.222</td>
<td>15.778</td>
<td>0.722</td>
</tr>
</tbody>
</table>

DISCUSSION

Based on the results of the present study, the null hypothesis was refuted. A statistically significant difference in flexural strength (P< 0.001) was observed between the 2 nanoceramic composite resin CAD/CAM blocks, Lava Ultimate and Vita Enamic, and a lithium disilicate glass ceramic (IPS e.max CAD) material.

Although there are limitations with all these methods, the ISO standard test to determine the strength of polymer based restorative materials remains the three-point bend test. Accordingly, the utilization of this method to test these new materials allows for easy comparative analysis with other previously published results employing the same standard test methods.

Lava Ultimate was introduced into the dental market in 2012 and contains a blend of individually bonded nano-particles and nano-particles agglomerated in clusters, all embedded in a highly cross-linked polymer matrix. It contains a total nanoceramic filler content of approximately 80 % by weight [24]. Vita Enamic launched onto the market in 2013 and has been called a “hybrid ceramic” or a polymer-infiltrated-ceramic network (PICN) [26].

The flexural strength of resin nanoceramic CAD/CAM blocks in our study was similar to the value reported by other researchers [28-31]. Although, our results showed that the mean value of just Vita Enamic met the claims of the manufacturer [26]. He and Swain [32, 33] described the mechanical properties of these materials and found that they were very similar to natural dentin and enamel. Different results were found in the current study compared to other studies for flexural strength. Albero A et al. [34] evaluated the
characterization of a novel cad-cam polymer-infiltrated-ceramic-network. The results showed IPS e.max presented mechanical properties significantly better than other materials. Although, Vita Enamic had higher flexural strength than Lava Ultimate, but it was not significant. In accordance with the current study, Thornton I et al. [31] stated that in comparison to conventional resin composites, the presence of ceramic nano-particles in Lava Ultimate and Enamic did not greatly improve flexural strength of these materials. Their results showed that the flexural strength of Enamic was statistically significantly lower than that of Lava Ultimate, while the flexural modulus of Enamic was statistically significantly higher. Also, Kopffmann C et al. [30] evaluated the comparison of filler morphology, mechanical strength and milling characteristics of 4 different CAD/CAM blocks for Sirona inLab MC XL milling system and showed that Coltene (Coltene AG) had the highest flexural strength, and Vita Enamic the Lowest one.

When looking at the spectrum of resin composite-ceramic, it becomes clear that the new nanoceramic resin composite materials do not behave similarly to the tested control, a lithium disilicate ceramic, IPS e.max CAD, and actually behave as resin composites.

This in vitro study had some limitations such as difficult simulation of the oral environment. Further in vitro and in vivo investigations are necessary to evaluate surface roughness, marginal integrity, reparationability and milling accuracy of these new materials.

CONCLUSION
IPS e.max CAD exhibited higher values in flexural strength between the 3 groups. The others respectively were Lava Ultimate and Vita Enamic. Clinically it is demonstrated that IPS e.max CAD can tolerate higher values of mechanical loads until fracture. The flexural strength of Lava Ultimate and Enamic was greatly improved to levels not seen before in dental resin composites. This characteristic similar to the tooth makes them an option to be considered as crown materials. However, their consideration and clinical use in patients with high muscular and masticatory forces especially patients with bruxism and clenching, better to be similar to that of conventional dental CAD/CAM resin composites and be limited to Inlay, Onlay and Veneer restorations.

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