MARGINAL FIT OF ESTHETIC CROWNS: EFFECT OF DIFFERENT FABRICATION TECHNIQUES AND FINISH LINE DESIGNS

Shereen El Sayed *

ABSTRACT

Objectives: The aim of this in-vitro study was to examine the effect of different finish lines and ceramic materials with different fabrication techniques on the vertical margin gap distance of all-ceramic crowns.

Materials and Methods: Two stainless steel models were machined to simulate full coverage all-ceramic crown preparations for a mandibular molar. The first model was prepared with 1mm chamfer finish line, 10mm diameter at the marginal circumference, 5mm axial height and 10˚ total convergence angle. The second model was prepared with 1mm shoulder finish line with rounded axio-gingival internal line angle, 10mm diameter at the marginal circumference, 5mm axial height and 10˚ total convergence angle. A total of thirty all-ceramic crowns were constructed over the two stainless steel models (n= 15). For each finish line, all-ceramic crowns were divided into three groups (n=5) according to the ceramic material and fabrication technique used: Group I: The ceramic crowns were constructed from resin nanoceramic Lava Ultimate material using CAD/CAM technique. Group II: The ceramic crowns were constructed from IPS e-max CAD ceramic material using CAD/CAM technique. Group III: The ceramic crowns were constructed from IPS e-max Press ceramic material using heat pressing technique. Vertical margin gap distance of the all-ceramic crowns was assessed on the stainless steel models without cementation using an image analysis system in combination with a stereomicroscope. The data were collected, tabulated and statistically analyzed.

Results: IPS e.max CAD showed the highest mean vertical margin gap distance (μm) followed by IPS e.max Press, Lava Ultimate showed the least vertical margin gap distance for both chamfer and shoulder finish lines with a significant difference between each others. Shoulder finish line design exhibited lower vertical margin gap distance than chamfer finish line design for all groups with a significant difference in group II and group III while group I showed no significant difference.

Conclusions: Regarding all-ceramic materials and techniques used in the present study, all systems exhibited clinically acceptable vertical margin gap distance. As regard to the all-ceramic materials, resin nanoceramic Lava Ultimate material showed the least vertical margin gap distance in both shoulder and chamfer finish line designs. Concerning the fabrication techniques, the results of this study shows that excellent marginal adaptation can be achieved using CAD/CAM fabrication technique specially when there is no need for subsequent sintering process. Lithium disilicate e-max Press exhibited better marginal fit than e-max CAD. Rounded shoulder finish line designs proved to be reliable design in relation to the marginal accuracy within different all-ceramic materials and techniques.

KEYWORDS: Resin Nano Ceramic Lava Ultimate, IPS e-max Press, IPS e-max CAD, CAD/CAM Technique, Heat Pressing Technique, All-ceramic Crowns, Marginal fit, Shoulder finish line, Chamfer finish line.

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INTRODUCTION

The growing patients’ demand for highly esthetic and natural appearing restorations has led to the production of new all-ceramic materials, whose mechanical properties have been dramatically improved to provide suitable longevity and limitation of the technical problems within dental restorations (1).

Marginal fit is one of the most important criteria for the long term success of ceramic restorations. The marginal gap must be minimized, otherwise a significant space between the tooth and restoration will expose the luting material to the oral environment, resulting in a more aggressive rate of cement dissolution caused by oral fluids and chemo-mechanical forces (2). The consequent microleakage may result in inflammation of the periodontal tissues, secondary caries and subsequent failure of the prosthesis (3,4).

Advancements in dental ceramic materials and processing technologies have led to the introduction of different techniques to produce dental restorations with improved marginal fit such as CAD/CAM systems and heat pressing techniques (5,6). The use of prefabricated blocks and standardized scanning and milling procedures in CAD/CAM systems minimize the influence of the dental laboratory technician in the production process and result in better quality restorations (5,7). Nowadays, CAD/CAM requires simple clicks in order to design and fabricate accurate restorations (8,9).

IPS e.max Press demonstrates a technical improvement in the production process of a lithium disilicate pressed glass ceramic using lost wax technique. Ingots of lithium disilicate are subjected to heat pressing which uses a pneumatic press within a special oven to press ceramic material into the mold. Press-on ceramics allow accurate reproduction of the wax pattern and controlled processing resulting in accurate restoration (10).

In addition, a machinable block form of lithium disilicate (IPS e.max CAD) is available, but only partial crystallization is achieved within the block. The partially crystallized blocks must be subjected to heat crystallization process after milling to reach their full strength (11).

Resin nanoceramic is a new CAD/CAM product utilizing an innovative nano ceramic technology. This material is unique in durability and function. The material is neither a composite resin nor a ceramic material, hence it is a mixture of both. This material is easily machined chair side or in dental lab, polishes quickly to an esthetic finish. The manufacturer claims that the excellent millability of resin nanoceramic restorations provides better marginal quality than glass ceramics (12).

Thus we have different processing techniques with several choices of the restorative materials and it is important to assess the adaptation of CAD/CAM and heat-pressed restorations to increase the knowledge on the advantages and limitations of each processing technique.

Marginal fit is used in the evaluation of the fixed restorations and is defined as a parameter that measures the proximity between the margin of the restoration and the finish line on the prepared tooth (10). Clinical factors such as tooth preparation geometry, type of finish line and type of cement or laboratory factors related to the ceramic manufacturing technique and material are variables that influence the marginal fit of all-ceramic crowns (13-16).

Heavy chamfer and rounded shoulder finish lines have been advocated for the all-ceramic crowns (17). Therefore, care must be taken while designing and creating appropriate finishing line depending on the restorative material being used and its manufacturing process, the desired esthetic
outcome, occlusal considerations and the condition of the underlying tooth structure \(^{(18)}\).

Thus, the purpose of this in-vitro study was to assess the effect of different finish lines and ceramic materials with different fabrication techniques on the vertical margin gap distance of all-ceramic crowns. Null hypothesis to be tested was: Marginal fit of three all-ceramic crowns is not influenced by ceramic materials, techniques and finish lines.

**MATERIALS AND METHODS**

Two stainless steel models were machined to simulate full coverage all-ceramic crown preparations for a mandibular molar. The first model was prepared with 1mm chamfer finish line, 10mm diameter at the marginal circumference, 5mm axial height and 10° total convergence angle. The second model was prepared with 1mm shoulder finish line with rounded axio-gingival internal line angle, 10mm diameter at the marginal circumference, 5mm axial height and 10° total convergence angle.

To standardize measurement points during vertical marginal gap distance, a vertical line parallel to the long axis of the stainless steel model was drawn on the base of the model and a notch was placed at the occluso axial line angle for exact repositioning of the all ceramic crowns in consecutive measurements (Fig. 1).

A total of thirty all-ceramic crowns were constructed over the two stainless steel models (n=15). For each finish line, all-ceramic crowns were divided into three groups (n=5) according to the ceramic material and fabrication technique used:

- **Group I:** The ceramic crowns were constructed from resin nanoceramic Lava Ultimate material (“LU”, 3M ESPE, Germany) using CAD/CAM technique.
- **Group II:** The ceramic crowns were constructed from IPS e-max CAD ceramic material (IPS e.max Press, Ivoclar Vivadent AG Schaan Liechtenstein) using heat pressing technique.
- **Group III:** The ceramic crowns were constructed from IPS e-max Press ceramic material (IPS e.max Press, Ivoclar Vivadent AG Schaan Liechtenstein) using heat pressing technique.

Samples Classification is shown in table (1). Materials tested, chemical composition and manufacturer are presented in table (2).

**Fig.1:** Dimensions of the first and second stainless steel model (A=5mm, B=10mm, C=1mm chamfer finish line, D=1mm rounded shoulder finish line, E= notch at the occluso-axial line angle)

### TABLE (1) Samples classification.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ceramic Material</th>
<th>Fabrication Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Resin nanoceramic Lava Ultimate CAD-CAM (CLC) (n=5)</td>
<td>CAD-CAM</td>
</tr>
<tr>
<td>II</td>
<td>IPS e-max CAD CAM-CAM (CEC) (n=5)</td>
<td>CAD-CAM</td>
</tr>
<tr>
<td>III</td>
<td>IPS e-max Press Heat Pressing (CEP) (n=5)</td>
<td>Heat Pressing</td>
</tr>
</tbody>
</table>

**MARGINAL FIT OF ESTHETIC CROWNS**

- **Group I**
- **Group II**
- **Group III**

<table>
<thead>
<tr>
<th>Ceramic Material</th>
<th>Fabrication Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPS e-max CAD CAM-CAM (CEC) (n=5)</td>
<td>CAD-CAM</td>
</tr>
<tr>
<td>IPS e-max Press Heat Pressing (CEP) (n=5)</td>
<td>Heat Pressing</td>
</tr>
<tr>
<td>IPS e-max Press Heat Pressing (CEP) (n=5)</td>
<td>Heat Pressing</td>
</tr>
</tbody>
</table>

- **Group I:** The ceramic crowns were constructed from resin nanoceramic Lava Ultimate material (“LU”, 3M ESPE, Germany) using CAD/CAM technique.

- **Group II:** The ceramic crowns were constructed from IPS e.max CAD ceramic material (IPS e.max CAD, Ivoclar Vivadent AG Schaan Liechtenstein) using CAD/CAM technique.

- **Group III:** The ceramic crowns were constructed from IPS e-max Press ceramic material (IPS e.max Press, Ivoclar Vivadent AG Schaan Liechtenstein) using heat pressing technique.
TABLE (2) The chemical composition and the manufacturers of the materials used in this study

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin Nano Ceramic Lava Ultimate blocks</td>
<td>Total nanoceramic material content is 80% by weight: - silica nanomers (20 nm), - zirconia nanomers (4-11nm), - zirconia-silica nanocluster particles (0.6-10 µm). Highly cross-linked methacrylate-based resin matrix SiClane coupling agent</td>
<td>3M ESPE, Germany</td>
</tr>
<tr>
<td>IPS e-max CAD blocks</td>
<td>- SiO₂, Li₂O, K₂O, MgO, Al₂O₃, P₂O₅ and other oxides</td>
<td>Ivoclar Vivadent</td>
</tr>
<tr>
<td>IPS e-max Press Ingots</td>
<td>SiO₂ 57 – 80% Li₂O 11 – 19% K₂O 0 – 13% P₂O₅ 0 – 11% ZrO₂ 0 – 8% ZnO 0 – 8% other oxides and ceramic pigments 0 – 10%</td>
<td>Ivoclar Vivadent</td>
</tr>
</tbody>
</table>

Impressions of the two stainless-steel models were taken using polyvinyl siloxane impression material (Imprint II, 3M ESPE, Germany). An extra hard type IV special stone material (special stone CAM base VITA dentonapicodent) was poured inside the impressions according to manufacturer instructions to obtain two stone models ready for scanning. The two stone models were scanned each at a time in the inLab scanner (Cerec in Lab, Sirona Dental Company, Germany). The scanned 3D images of the two models were saved for subsequent designing step. The crown design for each stainless steel model was selected in the CAD/CAM software (InLab 3D version 2.90, Sirona Dental Company, Germany) where all parameters were set for the two finish line designs. The thickness of the all-ceramic crown was adjusted to be 1mm at the finish line, 1.5mm at the axial surfaces, and 1.5mm at the occlusal surface with normal anatomical shape. The two designs were milled in the CAD/CAM milling machine (Sirona Cerec inLab MC XL milling machine) after choosing the type of the block.

Ten Lava Ultimate all-ceramic crowns (group I: CLC, SLC) and Ten IPS e-max CAD all-ceramic crowns (group II: CEC, SEC) were milled.

After milling, the Lava Ultimate all-ceramic crowns were finished and polished according to manufacturer instructions with no firing required. The IPS e-max CAD all-ceramic crowns were fully crystallized in a furnace (Programat P500, Ivoclar, Vivadent, Schaan Liechtenstein) for 30 minutes at 850°C according to manufacturer instructions. (Fig.2, 3)

As for group III (CEP, SEP): one of the previously constructed all-ceramic Lava Ultimate crowns was scanned in order to standardize the shape and dimensions of all the groups.

The two previously constructed stone models were scanned using 3D optical scanner (S600, Zirkonzahn, Gais, Italy). The milled Lava Ultimate crown was seated on the stone model and scanned on the same scanner. The CAD/CAM software (Modellier, Zirkonzahn, Gais, Italy) was adjusted to allow the design of a new restoration to be exactly the same shape of the scanned restoration through an icon called “Adapt in Situ”. Ten wax patterns were milled (five wax patterns for each finish line design).

Ten IPS e-max pressable all-ceramic crowns were fabricated using heat-pressing technique (IPS e-max press, Ivoclar, Vivadent) by the aid of the previously constructed milled wax patterns (Fig. 4).

The previously constructed milled wax patterns were sprued on the IPS e-max investment ring base (IPS e-max investment ring system; Ivoclar Vivadent). Investing was carried out using the IPS silicon ring. Following setting of the investment (IPS Press Vest Investment material; Ivoclar Vivadent), the ring was transferred to a preheated burn out...
oven (Vulcan 3-130; Dentsply, USA). Ceramic ingots (IPS e-max Press Ingots; Ivoclar Vivadent) were placed inside the ring and transferred to the pressing oven (P500; Ivoclar Vivadent) to complete the pressing cycle. The crowns were devested using airborne particle abrasion (50µm Al₂O₃ at 1 bar, 30 PSI). Finishing was done using fine diamond disc and grinding instruments according to manufacturer’s instructions.

A specially constructed metal frame was developed to hold the crown over the stainless steel model precisely, enabling the application of a constant load parallel to the long axis of the model and to maintain the force applied so rebounding of the crown was prevented during vertical marginal gap distance measurement procedure. The frame was designed to accommodate a set containing the stainless steel model and the all-ceramic crown during each measurement, fixed in the frame by means of a screw positioned in the upper part of the device (13).

Vertical margin gap distance of the all-ceramic crowns was assessed on the stainless steel models without cementation (13), using an image analysis system. This method uses image analysis software (Image J-1b, USA) in combination with a stereomicroscope (Olympus, SZ-PT: Japan) (16).

For all measurements, the crowns were placed on the stainless steel models and secured in place on the metal frame. Four points were marked with an indelible marking pen in the middle of the buccal, lingual, mesial and distal surfaces. Two added marks for each surface were marked 2 mm mesial and distal to the middle points to obtain a total of twelve measuring points for each crown.

For each crown, the area of interest was captured by CCD digital camera (DP-10 Olympus, Japan) mounted on the stereomicroscope (Fig. 5). The vertical margin gap distance between the cervical margin of the crowns and the finish line on the stainless steel models was assessed at the previously
marked points. These readings were calculated using the image analysis software.

**Statistical analysis:**

Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 22 for Windows.

Data were presented as mean and standard deviation (SD) values. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Vertical Margin Gap Distance showed normal distribution. One Way-ANOVA was used to study the effect of different ceramic restoration on mean vertical margin gap distance. Independent t-test was used to study the effect of different finish lines on mean Vertical margin gap distance. The significance level was set at $P \leq 0.05$.

**RESULTS**

Mean and standard deviation (SD) for the Vertical margin gap distance ($\mu$m) for different ceramic restorations and finish lines were presented in Table (3) and figures (6, 7).

**Effect of different all-ceramic materials and techniques:**

- CEC: IPS e.max CAD (74.79±22.63$\mu$m) showed the highest mean vertical margin gap distance ($\mu$m) followed by CEP: IPS e.max Press (59.53±10.42$\mu$m) followed by CLC: Lava Ultimate (31±5.56 $\mu$m) for chamfer finish line with a significant difference between each other at $p \leq 0.001$.

- SEC: IPS e.max CAD (59.06±11.67 $\mu$m) showed the highest mean vertical margin gap distance ($\mu$m) followed by SEP: IPS e.max Press (47.89±11.30 $\mu$m) followed by SLC: Lava Ultimate (28.2±7.34 $\mu$m) for shoulder finish line with a significant difference between each other at $p \leq 0.001$.

**Effect of different finish lines**

- Group I: Insignificant difference on mean Vertical margin gap distance ($\mu$m) resulted between chamfer (31±5.56$\mu$m) and shoulder (28.2±7.34$\mu$m) at $p=0.182$ for Lava™ Ultimate.

### TABLE (3) Mean and standard deviation (SD) of vertical margin gap distance ($\mu$m) for different ceramic restoration and finish line.

<table>
<thead>
<tr>
<th>Ceramic Restoration</th>
<th>Lava Ultimate</th>
<th>IPS e.max CAD</th>
<th>IPS e.max Press</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td><strong>Vertical margin gap distance (μm)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chamfer</td>
<td>31.00$^c$</td>
<td>5.56</td>
<td>74.79$^a$</td>
<td>22.63</td>
</tr>
<tr>
<td>Shoulder</td>
<td>28.20$^c$</td>
<td>7.34</td>
<td>59.06$^a$</td>
<td>11.67</td>
</tr>
<tr>
<td>P-value</td>
<td>0.182 NS</td>
<td>0.015$^*$</td>
<td>0.002$^*$</td>
<td></td>
</tr>
</tbody>
</table>

Means with the same letter within each row are not significantly different at $p=0.05$. $^*$= Significant
Group II: Chamfer finish line (74.79±22.63 μm) showed higher mean vertical margin gap distance (μm) compared to shoulder finish line (59.06±11.67 μm) at p=0.015 for IPS e.max CAD.

Group III: Chamfer finish line (59.53±10.42 μm) showed higher mean vertical margin gap distance (μm) compared to shoulder finish line (47.89±11.3 μm) at p=0.002 for IPS e.max Press.

DISCUSSION

Strength and precision of marginal fit are considered the main requirements for clinical success of all ceramic restorations. The margin of a restoration is considered a critical area which needs careful tooth preparation, appropriate finishing lines depending on the chosen restorative material to obtain durable restoration. The marginal region of the restoration is often the thinnest portion and therefore more vulnerable to failure according to the material used and the forces being exerted on the margin.

Types of finish lines, ceramic materials and manufacturing techniques are the variables that have been investigated for all ceramic crowns in this study.

Two types of standardized stainless steel dies were used for construction of all ceramic crowns to ensure standardized prepared abutments and more uniform measurement along the preparation compared to natural tooth. The non-uniform natural teeth preparation might have incorporated other variables during margin measurements.

The results of this study showed rejection of the null hypothesis. The three different ceramic crowns showed significant differences among each other for both chamfer and shoulder finish lines. Although both IPS e.max Press and IPS e.max CAD are constructed from the same material, they differ in manufacturing technique. The pressable lithium disilicate is manufactured by a process called bulk casting production to create the ingots. This process is based on melting, cooling, simultaneous nucleation of two different crystals and growth of the crystals that is constantly optimized to prevent defects.

The machinable block form of lithium disilicate is manufactured according to a similar process but only partial crystallization is achieved. Thus the blocks can be milled in a crystalline intermediate phase. Then the restorations reach the fully crystalline phase with high strength after the milling procedure and firing cycle.

IPS e.max Press crowns showed better vertical margin gap distance than IPS e.max CAD.
This may be due to the difference in the fabrication methods between IPS e.max Press and IPS e.max CAD crowns. The pressable ceramics crowns were fabricated using the lost wax technique and heat pressed technique in a computer controlled press oven. There was no subsequent sintering stage which could subject the crown to distortion and shrinkage. These results were consistent with those found by Abo Shelib et al who concluded that the manufacturing process influences the marginal fit of ceramic restorations. They stated that in pressable ceramic technique, the molten ingots are pressed under controlled environment producing accurate reproduction of fine details especially at the margins.

Neves et al further support these findings. They found statistical significant difference in marginal fit when IPS e.max crowns were produced with heat pressed technique or with CAD/CAM systems. They stated that errors in preparation design especially involving the margin is easier to deal with when lost wax technique is used. Moreover, poor preparations result in higher marginal gap in CAD/CAM systems.

On the other hand IPS e.max CAD crowns were produced after milling and subsequent firing cycle. The milling process and size of the milling burs may have affected the marginal adaptation of the final crowns. Moreover, the sintering stage itself might consequently have a negative effect on marginal accuracy as it is associated with a certain amount of shrinkage.

On the contrary, the conclusions drawn from the systematic review done by Danraj and Sathyamurthy stated that the marginal discrepancy of all ceramic crowns constructed by CAD/CAM technique are similar to other conventional techniques including heat pressing technique.

In this study the wax patterns that were used to obtain the pressable e-max ceramic crowns were constructed using CAD/CAM to ensure standardization of the same shape and dimensions of the other groups. In addition, manual wax ups might have been associated with non-uniform layers which might have led to distortion in the pressing process.

Although the wax patterns were constructed using CAD/CAM technique for the purpose of standardization, the margination that had been done directly before investing might have added a positive effect on the marginal fit of the IPS e-max press crowns.

Besides, in the heat pressing technique, the full contour wax pattern was invested and the ingot was pressed into the resultant investment mold. The proper matching between the thermal expansion of the investment material and the ceramic material seems to be more accurate than the amount of shrinkage resulting from the sintering cycles after milling in case of CAD/CAM technique. Contradicting to this explanation, Martinez-Rus et al claimed that the crystallization process after milling does not cause any major shrinkage. As for the heat pressing technique, the number of handling procedures such as waxing, investing and finishing still has the potential to introduce marginal discrepancies in the final crown.

It is of value to mention that the CAD/CAM system used for fabrication of wax patterns was different than the CAD/CAM system used for milling of e-max CAD crowns. Thus differences in scanning quality and reproduction of the product details during milling process might have been a factor that favored one CAD/CAM system over another. The wax patterns were milled using a 5-axis milling unit (ZirkonZahn CAD/CAM 5 Tec machine) while the IPS e-max CAD crowns were milled using a 4-axis unit (Sirona CerecimLab MC XL milling machine) which may contribute to the overall quality of the margin of the restoration. The study which was done by Hamza et al confirmed the previous assumption. Their results proved that the different CAD/CAM systems did affect the marginal fit of CAD/CAM ceramic restorations,
regardless of the ceramic type. They suggested that differences in the scanning process and number of axes of the milling machines affected the marginal fit of the restoration.

The revolutionary nano ceramic technology with the new resin nano ceramic Lava Ultimate CAD/CAM product was unique in the marginal fit for both chamfer and shoulder finish lines. This block is highly heat cured through a controlled proprietary manufactured process that eliminates the need for a firing step after milling (12). Results of this study showed that Lava Ultimate crowns had the least vertical margin gap distance with significant difference between them and IPS e.max CAD and IPS e.max Press crowns. This may be due to the low brittleness of Lava Ultimate material resulting in excellent machinability and ease of final adjustment and finishing without the need for subsequent firing in a porcelain furnace.

All ceramic crowns showed better vertical margin gap distance on shoulder finish line than chamfer finish line. There was a statistically significant difference between shoulder and chamfer finish lines in the IPS e.max CAD and the IPS e.max Press crowns. However Lava Ultimate crowns showed no significant difference between both designs. This was consistent with Subasi et al (16) who concluded that IPS e.max Press presented better margin fit in shoulder preparations than chamfer preparations. Several studies (22,24,25) found that rounded shoulder finish line design has better marginal fit than chamfer finish line design within different all-ceramic restorations. This may be attributed to the fact that in shoulder margin design the minimum thickness of the margin is one millimeter with a flat base in its configuration. However the minimal thickness of the chamfer design may be less than one millimeter in the most outer thinnest part. This might have led to greater marginal discrepancies during milling.

On top of that, it was proven that production of milled restorations with chamfer finish line design is somehow complicated due to the presence of concave and convex areas with this kind of finish line (22).

The vertical margin gap distance measurements were done without cementation as the cement layer may cover the evaluation points and led to interference with the measurement procedure at the crown margins (26,27). Furthermore, the purpose of this study was to investigate the primary precision of marginal fit of all-ceramic materials and techniques without the introduction of any other parameter.

There are some limitations within this study. Although the use of stainless steel abutments ensures the standardization, the use of natural anatomical prepared teeth might have changed the results of the marginal discrepancy. Another limitation is that the crowns were not subjected to an artificial aging process. Aboushelib et al (10) confirmed that the thermal cycling had a significant effect on the marginal fit. In addition, the vertical marginal gap distance was not further evaluated after cementation of the crowns which might have aided in simulation of the clinical conditions. Cementation might have led to a minimal increase in the marginal gap as proved by some previous studies (13,19)

Summarizing the previous discussion, dental ceramics introduced in the last years provide different promising esthetic and mechanical properties. The choice of one specific type and technique of ceramic over another one should be based on proper assessment of the advantages, disadvantages and limitations of the materials with adequate level of scientific evidence (1). A special attention should be given to the postmilling procedures in CAD/CAM restorations. The fact that resin nanoceramic Lava Ultimate crowns were not subjected to any heat treatment after retrieval from the milling machine unlike lithium disilicate groups may contribute to the best marginal fit. It is worth noting that regarding the CAD/CAM restorations, a lot of factors may affect the overall quality of the margin such as the system used for image capturing, the software used for designing, the size of the drill,
the precision of the milling unit and the calibration of the machine (20,29).

Further research will be needed to examine the marginal accuracy of all-ceramic systems in clinically simulating environment after final cementation procedures. The effect of scanning and milling processes on the marginal fit of CAD/CAM restorations with the influence of thermocycling and cyclic loading must be evaluated.

CONCLUSIONS

Within the limitations of this study, the following conclusions may be drawn:

1. Regarding all-ceramic materials and techniques used in the present study, all systems have clinically acceptable vertical margin gap distance.

2. As regard to the all-ceramic materials, resin nanoceramic Lava Ultimate material showed the least vertical margin gap distance in both shoulder and chamfer finish line designs.

3. Concerning the fabrication techniques, the results of this study shows that excellent marginal adaptation can be achieved using CAD/CAM fabrication technique specially when there is no need for subsequent sintering process.

4. Lithium disilicate e-max Press exhibited better marginal fit than e-max CAD.

5. Rounded shoulder finish line designs proved to be reliable design in relation to the marginal accuracy within different all-ceramic materials and techniques.

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