



INFLUENCE OF CERVICAL MARGINAL ELEVATION WITH COMPOSITE RESIN AND BIODENTINE ON VERTICAL MARGINAL GAP OF CAD/CAM ENDOCROWN RESTORATIONS : AN IN VITRO STUDY

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ABSTRACT

Objective: This study evaluated the effect of cervical marginal elevation with composite resin and Biodentine on vertical marginal gap of CAD/CAM Endocrown restorations. **Materials and Methods:** Thirty two molars were used in this study divided into two equal main groups, Group I: 16 endodontically treated molars with MOD cavity were elevated distally with flowable composite, and Group II: 16 endodontically treated molars with MOD cavity were elevated distally with biodentine. Subsequently, endocrowns were fabricated to restore the prepared teeth. Each main group was subdivided into 2 equal subgroups according to the material into (Vita Enamic and IPS e-max CAD endocrowns) (n=8). Restorations were cemented using dual cured resin cement, then all samples were subjected to thermocycling for 5000 cycles (TC). The vertical marginal gap was measured before and after thermocycling using a digital microscope. **Results:** The results showed that there was not significant increase in the vertical marginal gap after thermocycling in all groups except composite with Vita Enamic group showing better marginal adaption than other groups and there was no significant difference in the marginal gap between the control side (mesial side) and distal side. **Conclusions:** Marginal elevation with flowable composite resin was more favorable with Vita Enamic endocrown. There was no significant difference of endocrown margins on sound dentin or on elevated margins.

KEYWORDS: CAD /CAM Endocrown, Thermocycling, Marginal elevation, Marginal gap.

INTRODUCTION

It is well known that when cervical defects or caries are extended into deep subgingival areas, tooth preparation, impression registration, and proper moisture control are very difficult procedures⁽¹⁻⁴⁾. Furthermore, marginal accuracy of indirect restorations is difficult to control, adhesive cementation of these restorations and excess cement in the gingival sulci are hardly detectable, causing

biological problems and violation of biological width^(3,4). The biological width can be maintained in two ways, either surgically by crown lengthening or orthodontically by tooth extrusion. The use of direct resin composite for cervical marginal elevation is a less invasive alternative to surgical crown lengthening and orthodontic extrusion^(5,6). New bioactive materials with good mechanical and adhesive properties and good marginal sealing like Biodentine were developed^(7,8).

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Because of dental ceramics intrinsic brittleness puts them at risk of chipping or fracture, modern computer-aided design/computer-aided manufacture (CAD/CAM) polymer-based materials have been developed in dentistry. Vita Enamic, a hybrid dental ceramic with a dual-network structure, is a monolithic form of polymer-based restorative material used in dentistry. It is a hybrid dental ceramic with a dual-network structure, where the dominant porous sintered feldspathic ceramic network is reinforced by a methacrylate polymeric network. Hybrid dental ceramic has been reported to offer high flexural strength values, good cosmetic properties, adequate stiffness and an elastic modulus approximately equivalent to that of dentin, as well as the capacity to develop high strength after adhesive bonding, allowing for minimally invasive restorations to be fabricated^(9,10).

Endocrown is a one-piece restoration that is secured to the pulp chamber's internal section as well as the cavity edges of endodontically treated posterior teeth. It is more conservative than typical post and core systems and relies on micromechanical retention and adhesive resin cementation^(11,12).

The flow of fluids, bacteria, chemicals or ions, and even air between a restorative material and a prepared cavity wall of a tooth is known as micro-leakage. Cervical margin elevation may aid light curing of direct resin materials as well as the marginal integrity of indirect restorations that are placed on top of it. Cemented restorations with marginal opening and micro-leakage may result in disintegration of the luting agent, caries, hypersensitivity, and periodontal inflammation⁽¹³⁻¹⁵⁾.

Thermocycling is an *in vitro* method that involves exposing the restoration and tooth to temperature fluctuations that are similar to those found in the oral cavity. Temperature changes, in combination with tension from occlusal pressures, can cause the resin to expand and contract at the margins, affecting the marginal gap. Thermocycling replicates the introduction of hot and cold extremes

into the oral cavity, which can change the coefficient of thermal expansion and contraction between the tooth and the restorative material⁽¹⁶⁾.

The purpose of this research was to see how cervical margin elevation using resin composite and biodentine affected the vertical marginal gap of vita enamic endocrowns before and after thermocycling. Null hypothesis of this study was that cervical marginal elevation with composite resin or biodentine will not affect the vertical marginal gap of Vita Enamic endocrowns before and after thermocycling.

MATERIALS AND METHODS

Grouping:

Thirty two molars were used in this study divided into two equal main groups, Group I: 16 endodontically treated molars with MOD cavity were elevated distally with flowable composite, and Group II: 16 endodontically treated molars with MOD cavity were elevated distally with biodentine. Subsequently, endocrowns were fabricated to restore the prepared teeth. Each main group was subdivided into 2 equal subgroups according to the material into (Vita Enamic and IPS e-max CAD endocrowns) (n=8). (Figure 1)

Preparation of samples:

Thirty two freshly extracted molar teeth were debrided of residual plaque and examined to ensure that they were free of defects and stored in distilled water at room temperature after disinfection until further processing. Access cavity was performed in all teeth, canals will be cleaned mechanically using one rotary system and chemically using non-hypo chloride solution, then finally obturated using Adseal sealer and gutta percha. Each tooth was mounted in the center of a roughened specimen carrier and embedded in auto-polymerizing resin, while the tooth was held 2mm away from the cemento-enamel junction using parallometer. (Paraflex, BEGO-Germany).

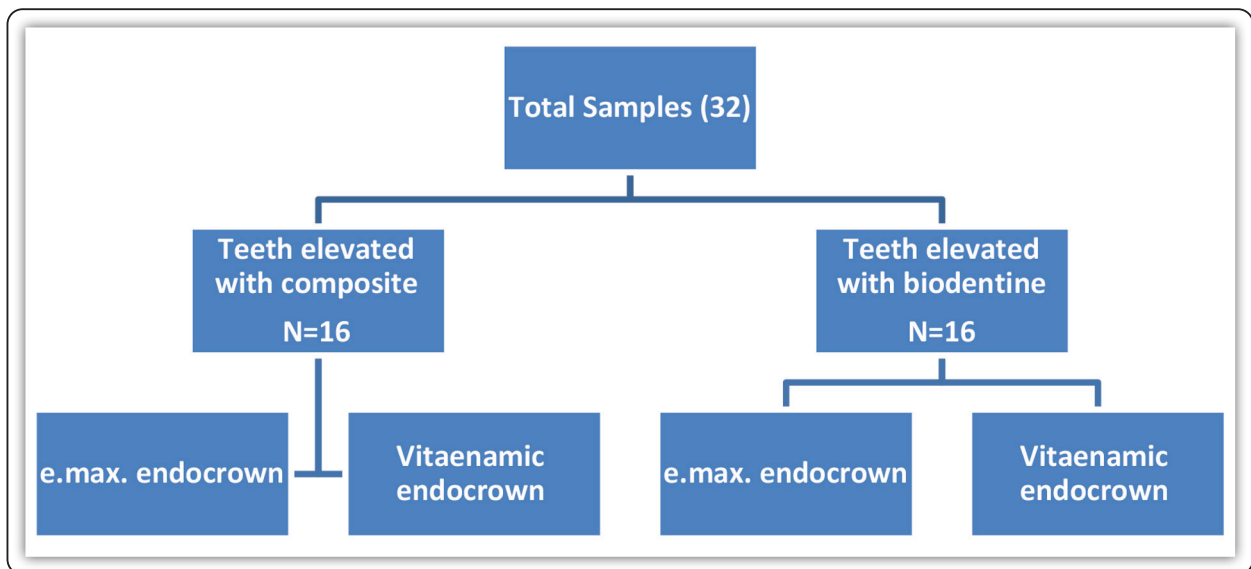


FIG (1) Samples grouping

Endocrown preparation:

For standardization of endocrown preparation a computer numerical control (CNC) was used for tooth preparation (High z-t 1000-Germany). A CNC machine is a motorized maneuverable tool and often a motorized maneuverable platform, which are controlled by computer, according to specific input instructions. Instructions are delivered to a CNC machine in the form of a sequential program of machine control instructions such as G-code, then executed. Preparation parameter were 2 mm reduction occlusally, 4 mm in width buccolingually at the isthmus area with a divergence angle of ten degrees, depth of coronal cavity is 3 mm and 2mm in depth at the bottom of proximal box. The cervical margin was prepared to be located 1mm above cemento-enamel junction mesially and 1mm below cemento-enamel junction distally. For standardization of predetermined thickness of pulp chamber in all samples, modeling wax of 2 mm thickness was put in pulp space, then the putty body impression material (Zhermack elit HD, Italy) was placed above it until occlusal surface and create hollow in distal side to inject flowable composite

resin after removing of wax. The distal margin is elevated in one group 16 samples with composite resin and another group with Biodentine about 2mm and circumferential matrix is used to eliminate any overhang and 2mm space is marked on the inner side of the matrix to avoid overfilling the box. (Figure 2)

Fabrication of the restorations:

All restorations were fabricated by 5 axis CAD/CAD system (Imes-Icore Germa). The prepared teeth were sprayed with Telescan (DFS-Diamon GmbH-Germany) to facilitate optical impression. The optical impressions were taken with the CAD/CAM scanner (Shenzhen UP3D Tech Co.,Ltd). The restorations were designed according to the manufacturer directions and Exocad software recommendations (Exocad Dental CAD 2.4 plovdiv version 2020). (Figure 3)

Cementation procedures:

Ultrasonic cleaning of restoration: All restorations were cleaned in an ultrasonic cleaning device (Silfradent, S.SOFIA, FORL, ITALY) in a 70% ethyl alcohol bath for 10 minutes to ensure a clean surface for the cementation.

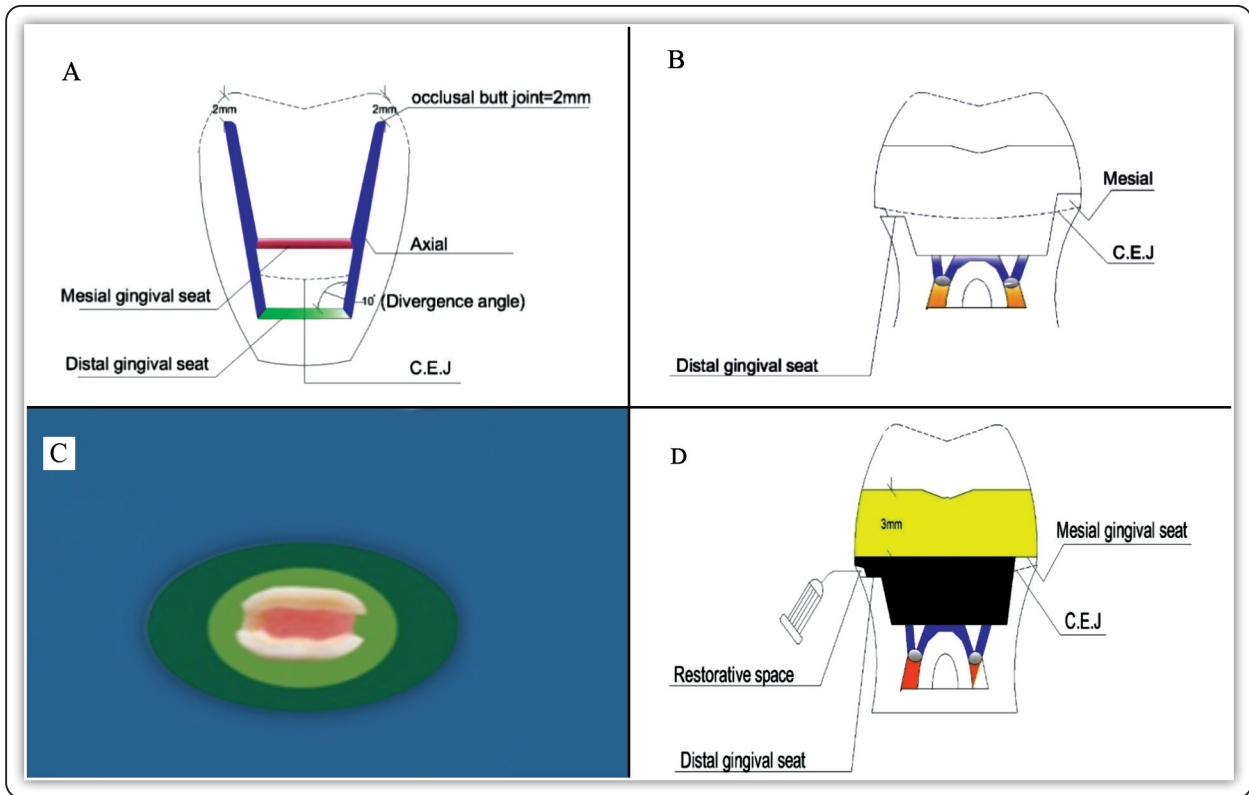


FIG (2) Showing (A) Endocrown preparation design (B), (C) & (D) Showing steps for margin elevation

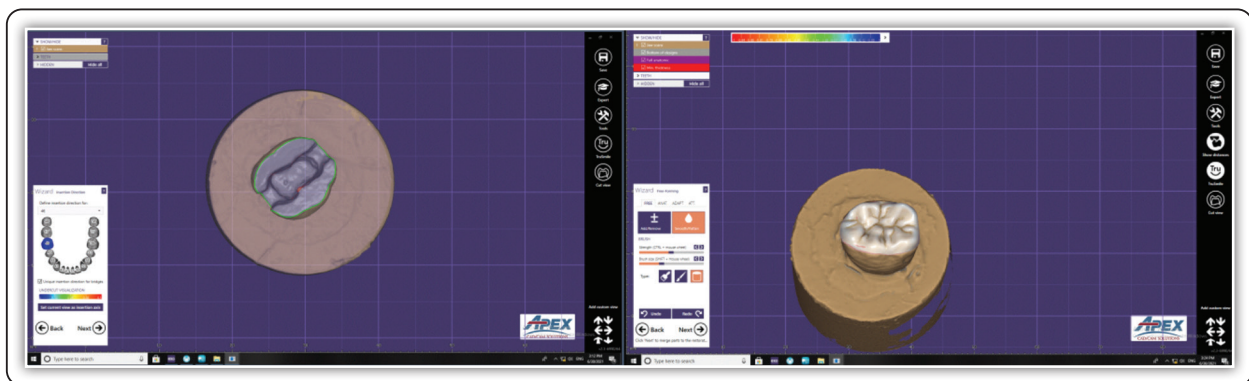


FIG (3) Fabrication of CAD/CAM endocrown restoration

Surface treatment of the restorations:

For IPS e.max: The internal surface of the restoration was etched with Porcelain Etch (DentoBond Porcelain Etch, ITENA, France) (hydrofluoric acid 10%) for 20 seconds, then rinsed with water and dried with moisture-free, oil-free air until the internal surface of the restoration has shown frosted white appearance. After that, the Porcelain

Silane coupling agent (DentoBond Porcelain Silane, ITENA, France) was brushed on the etched ceramic surface and left for 1 minute then dried well with moisture free, oil-free compressed air according to the manufacturer instructions.

For VITA ENAMIC: The intaglio of the restoration was etched with DentoBond Porcelain Etch (hydrofluoric acid 10%) for 60 seconds, then

rinsed with water and dried with moisture-free oil-free air until the internal surface of the restoration has shown frosted white appearance. After that, the restorations were cleaned using 70% ethyl alcohol in the ultrasonic cleaner. DentoBond Porcelain Silane was then brushed on the etched ceramic surface and left for 1 minute then dried well with compressed air.

Surface treatment of the tooth structure:

Teeth were washed with air-water spray and dried with air taking care not to over-dry the tooth surface. Then enamel of the prepared teeth were selectively etched with 37% phosphoric acid 30 seconds. After that the etchant was washed thoroughly with an air-water steam for double the etchant time and air dried.

Application of the cement material:

Universal resin cement (Total cem, Itena, France) dispensed straight into the cavity, covering all external including the interior surfaces of the restoration. The excess cement was promptly cleaned once each restoration was seated in place with sufficient finger pressure. Then each cemented restoration was placed under a 5 kg load and then light cured for 40 seconds.

Margin integrity evaluation:

Thermocycling and vertical marginal gap evaluation:

Samples were subjected to 5000 thermal cycles in a thermal cycler (Robota automated thermal cycle; BILGE, Turkey). (5 °C-55 °C, with a 60 seconds dwell time seconds in each bath and 5 seconds transfer time for 5000 cycles). This procedure is considered to simulate about 5years.⁽¹⁷⁾ Vertical marginal gap was evaluated by digital microscope (U500X Digital Microscope, Guangdong, China) before and after thermocycling. The measurements were determined at four predetermined points at both distal and mesial cervical margins. The mean of all readings were recorded for statistical analysis.

RESULTS

Quantitative data were presented as mean, standard deviation (SD), range (Minimum - Maximum) and 95% Confidence interval (95% CI) for the mean values (Table 1). Data were explored for normality by checking the data distribution and using Shapiro-Wilk tests. Statistical analysis of the results was performed by applying the ANOVA tests (one-way and two-way ANOVA tests) followed by Post hoc test to study the effect of time within each group (intragroup comparison) and effect of material (intergroup comparison). The significance level was set at $P \leq 0.05$. Statistical analysis was performed using the SPSS statistical package (version 25, IBM (IBM Corporation, NY, USA) SPSS (SPSS, Inc., an IBM Company) Statistics Version for Windows.

Effect of the restoration materials within each time of thermocycling;

Before Thermocycling:

Control: There was no statistically significant difference in the mean of marginal gap between Bio dentine e.max group and all groups (the means have same superscript litter (A)) ($P < 0.05$). According to the results of One-way ANOVA, the overall p-value was 0.0315 ($P < 0.05$) which means there was no significant difference between all groups in the mean of marginal gap among tooth and endocrown in the mesial region.

T-R(Tooth Restoration either composite or bioceramic interface) for all groups: There was no statistically significant difference in the mean of marginal gap between Bio dentine e.max group and all groups (the means have same superscript litter (W)) ($P < 0.05$). According to the results of One-way ANOVA, the overall p-value was 0.240 ($P < 0.05$) which means there was no significant difference between all groups in the mean of marginal gap among tooth and restoration in the distal region.

R-E(Restoration Endocrown interface) for all groups: There was no statistically significant difference in the mean of marginal gap between all groups (the means have same superscript litter (W)) ($P < 0.05$). According to the results of One-way ANOVA, the overall p-value was 0.536 ($P < 0.05$) which means there was no significant difference between all groups in the mean of marginal gap among tooth and endocrown in the distal region.

After Thermocycling:

Control: There was no statistically significant difference in the mean of marginal gap between all groups (the means have same superscript litter (A)) ($P < 0.05$). According to the results of One-way ANOVA, the overall p-value was 0.617 ($P < 0.05$) which means there was no significant difference between all groups in the mean of marginal gap among tooth and endocrown in the mesial region.

T-R(Tooth Restoration interface) for all groups: There was no statistically significant difference in the mean of marginal gap between Bio dentine e.max and all groups (the means have same superscript litter (W)). According to the results of One-way ANOVA, the overall p-value was 0.471 ($P > 0.05$) which means there was no significant difference between all groups in the mean of marginal gap among tooth and restoration in the distal region.

R-E(Restoration Endocrown interface) for all groups: There was no statistically significant difference in the mean of marginal gap between Bio dentine e.max and Bio dentine vita enamic as well as Composite e.max. While there was a statistically significant difference between Composite vita enamic and all groups (the means have different superscript litter). According to the results of One-way ANOVA, the overall p-value was 0.013 (> 0.05) which means there was a significant difference between all groups in the mean of marginal gap among tooth and restoration in the distal region.

DISCUSSION

The quality and stability of marginal adaptation is critical to the success of tooth-colored restorations, whether direct or indirect (intra-coronal and extra-coronal restorations alike). Polymerization shrinkage and stress may exceed the adhesive interface's bond strength or the tooth's cohesive strength, resulting in adhesive or cohesive failures with direct adhesive resin restorations⁽¹⁸⁾. Because resin shrinkage is confined to the cementing gap, indirect ceramic restoration is the most typical solution in large cavities⁽¹⁹⁾.

The current in vitro study was aimed at evaluating the influence of cervical marginal elevation with composite resin or biodentine on vertical marginal gap of CAD/CAM endocrown restorations.

The indirect restoration with cervical marginal elevation is a non-invasive substitute to surgical crown lengthening in large and deep cavities (near to or below the cemento-enamel junction), and it makes impression and cementation processes easier⁽²⁰⁾.

In the current study a relatively new generation of bioactive materials (biodentine) was used for marginal elevation underneath the indirect restorations due to many characteristic features such as having compressive strength of about 220 MPa comparable to dentine (290 MPa). This enables the biodentin to resist the masticatory forces. Moreover, biodentine is recommended in difficult isolation subgingival areas because it has short setting time and easy to manipulate beside there is no need for surface treatment for the tooth before placing it. This short setting time was recognized to the adding of calcium chloride to the mixing liquid⁽²¹⁾.

However, after thermocycling of biodentine groups exhibited non-significant high marginal gap results (65.32um, and 64.85um) than composite resin groups (62.49 um, and 59.04 um). This may be due to incomplete penetration of calcium

silicate materials particles (such as biodentine) to the dentinal tubules due to their particle size, This was explained by study of .EL-Ma'aïta et al which evaluated the effect of smear layer removal on the push-out bond strength between dentin and biodentine⁽²²⁾.

Moreover, viscosity of flowable resin makes them favourable in cervical margin elevation because they are easy to flow and spread over deep proximal areas, results in less voids, and thoroughly wet the bonded surface ⁽²³⁾. Recent adhesive dentistry, has overcome disadvantages of additional elimination of sound tissue needed for fitting the post into the root canal, so that need for posts and cores has become less evident. Endocrown has become an alternative option for the treatment of endodontically treated teeth ⁽²⁴⁾. Mandibular human first molars of comparable size and dimension were selected for allowing similar restoration during construction by CAD/ CAM technology. The mandibular first molars were chosen because they are commonly and early affected and the most common teeth to undergo endodontic treatment or extraction liability. I can be noted that most of its caries is located proximally.

A parallel-o-meter was used to allow accurate centralization of the teeth into epoxy resin blocks. For standardization of endocrown preparation computer numerical control (CNC machine) was used. Long-term clinical acceptance, good bonding qualities, appealing aesthetics, and full contour fabrication were all factors in the decision to utilise IPS e.max CAD. Furthermore, previous research has suggested that lithium disilicate be used to make endocrowns ⁽²⁵⁾. Vita Enamic material was the second material selected as it includes the benefits of both ceramic and composite materials. It also has a reasonable index of brittleness that allows the material to be a used as a CAD/CAM restorative material. Besides, it can be manipulated in one step without requiring additional firing such

as most CAD/CAM materials. Finally, it has higher degree of dimensional accuracy, and good bonding characteristics⁽²⁶⁾. All specimens were subjected to 5000 thermal cycles. thermocycling in automated thermocycling machine to mimic the oral conditions simulating the fluctuating and thermal changes.

Concerning the results of the current study, control group (mesial region) has increased the marginal gap (from 51um to 68um) after thermocycling but with no statistically significant difference and also present within the clinically accepted range of marginal gap. Most of groups with deep marginal elevation (either with composite or biodentine to tooth interface) are slightly better adaption than results of groups without marginal elevation. These results come in accordance with previous study of Ilgenstein et al⁽²⁷⁾. Regarding restoration-endocrown interface, the results of the present study exhibited better marginal integrity for resin material than biodentine. This finding could be clarified by the low early strength of the Biodentine, as it is a porous material during the initial setting ⁽²⁸⁾.

Another reason for better marginal integrity of composite than biodentine is that biodentine is water based material and thermal stress can cause structural changes beside the biodentine when exposed to acid etch as in the present study could interrupt the chemical setting of the material by affecting the hydration of tricalcium silicate impairing the setting of microstructure of biodentine⁽²⁹⁾. The resin material, on the other hand, produced the strongest bond to the e.max and vita enamic ceramic endocrowns with resin-luting cement (in proximal elevation). This result can be explained by the potential effect of combing two materials with a similar composition (resin composite and resin cement). The blend of these materials will construct a robust bond through their mechanical retention and chemical adhesion features⁽³⁰⁾.

Composite vita enamic group had the lowest value of marginal gap, where the mean of marginal

gap decreased after thermocycling while in the other groups the mean of marginal gap increased after thermocycling. These results may be attributed to the difference in composition and material properties of vita enamic and IPS emax press which may influence the bond strength between ceramic surface, resin cement and resin composite. This may explain why vita enamic was better in marginal integrity than emax endocrowns .

Besides these results may be due to similarity between composition between vita enamic and resin composite which contains urethane dimethacrylate, silicon dioxide (silica), bisphenol A-glycidyl methacrylate (BISGMA). While, the Vita enamic polymer infiltrated ceramic PICN (hybrid ceramic) material used in this study has an interconnected structure with a dominant ceramic network containing minor composite content⁽³¹⁾. Results of the present study come in accordance with previous study of Bankoğlu-Güngör et al which is evaluated the marginal and internal adaptations of posterior all-ceramic restorations fabricated from seven different CAD/CAM blocks ((IPS e.max CAD, Lava Ultimate, Incoris translucent Zirconia, Incoris Zirconia, Vita Suprinity, Vita Enamic, and GC Cerasmart) using light microscope and digital camera⁽³²⁾.

The limitations of current study were limited to only two types of machined ceramics and difficult to be tested intraorally (in-vivo evaluation). So that the future studies should include multiple indirect ceramic types CAD/CAM, hot pressed ceramic and 3D printed ceramics.

CONCLUSIONS

Margin elevation technique by placement of a composite filling and biodentine in the proximal box before insertion of ceramic indirect restorations resulted in marginal integrities of no difference from margins of ceramics placed in dentine.

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