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Assessment of fracture force of CAD-CAM-fabricated overlay restorations using deep marginal elevation technique

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Abstract

Purpose
To evaluate the fracture force of CAD-CAM-fabricated overlay restorations (Feld spathic cerec blocks) and hybrid ceramic material (VITA Enamic) using deep marginal elevation technique (DME).

Materials and methods
Twenty overlay restorations were constructed in this study. The samples were divided into two main groups according to the ceramic material (n=10). The type of ceramics that was used is (feldspathic for group I and vita enamic for group II). a ceramic material which was used (10 samples each):- The first group : feld spathic cerec blocks cemented by RelyX Ultimate Clicker resin cement. The second group: VITA ENAMMIC hybrid ceramic overlays cemented by RelyX Ultimate Clicker resin cement. Each main group was subdivided into two subgroups for each type of the ceramic material according to the fracture force (n=5), One of them without deep marginal elevation and the other with a deep marginal elevation (DME) till the cemento-enamel junction (CEJ).

Results
Between the two materials there was a significant difference between the feld spathic and vita enamic materials in with and without deep marginal elevation technique.

Conclusion
VITA Enamic material has higher fracture force than feld spathic material in samples with deep marginal elevation. Feld spathic material has higher fracture force than vita enamic material in samples without (DME).

1. Introduction

Due to the massive destruction of tooth structure that occurs during caries removal and cavity preparation that causes loss of function and fracture resistance. Teeth with mesio-occluso-distal (MOD) preparations show high tooth fragility and weak resistance to masticatory forces. With the new ceramics that are introduced today with the technology of CAD/CAM are more conservative to the tooth structure and protective against the masticatory load especially with onlay restoration. Deep subgingival caries is very difficult to be managed or controlled due to the dilemma of adequate isolation clinically. The presence of saliva and blood causes a contamination and deterioration to the restoration and will affect the bonding to the tooth structure .Complete removal of the subgingival caries, perfect impression taking, ideal marginal integrity and preservation of the biologic width is very critical. Placement of the restoration margins is very important to maintain the periodontium system healthy avoiding initiation and proceeding of the periodontal diseases by surgical crown lengthening technique. An alternative atraumatic procedure is introduced to elevate the deep cervical margins which located beyond the cemento-enamel junction (CEJ) to a visible accessible and controlled position above the (CEJ) by application of composite resin increments instead of the surgical choice that affect the crown/root ratio and the periodontium of the tooth .This technique allows an appropriate rubber dam application to perfectly place the margins, sufficient light curing depth to the margins of the restoration, the maintenance of proper oral hygiene and being ultraconservative to the bone and soft tissues, this procedure is known as
"Deep Marginal Elevation"(DME) technique [1].

2. Materials and methods

The materials were used are: Hybrid Ceramic: vita enamic innovative ceramic blocks; low translucency, shade 2M2 and size C14 (VITA Zahnfabrik spitalgasse3 D-79713 Bad Säckingen Germany) , Feldspacic Ceramic Blocks: feld spathic cerec blocks; Sirona fabrikstrasse31.64625 bensheim, Germany ,RelyX™ Ultimate adhesive dual cured luting resin cements (3MESPE, Seefled, Germany),IPS Empress Direct composite restoration, Ivoclar Vivadent company, Liechtenstein, Germany and Tetric N flow bulk fill, Ivoclar Vivadent Company, Liechtenstein, Germany. Twenty overlay restorations were constructed in this study. The samples were divided into two

main groups according to the ceramic material (n=10). The type of ceramics that was used is (feldspathic for group I and vita enamic for group II). Each main group was subdivided into two subgroups for each type of the ceramic material according to the fracture force (n=5), One of them without (DME) and the other with a (DME) till the cemento-enamel junction (CEJ). Fracture force test is done by a computer controlled materials testing machine (Model 3345; Instron Industrial Product, Norwood, MA, USA) then all data were collected, tabulated and statistically analyzed**.** The extracted human molars were prepared for CAD/CAM overlays in a standardized way: The samples were subjected to uniform occlusal reduction with diamond cutting tools ((Komet Dental. Gabr. B raseler GmbH& Co.KG Trophagener Weg 25.32657 Lemgo. Germany.) to produce a uniform preparation. Before preparation, condensation silicone rubber base (Speedix putty Ivoclar Vivadent, Germany) indices were made for tooth to aid in standardization of preparation thickness, The molar tooth was prepared manually using diamond cutting stones with high speed hand piece (Sirona high speed hand piece, Germany) under water cooling. The occlusal reduction was reduced 2.5 clearances for the overlay design. This was followed by a 2.5-mm wide mesio-occluso-distal slot preparation with rounded internal line angles.Proximal margin was prepared with mesial extension below cemento-enamel junction (CEJ) by 2 mm. The (DME) technique was used to elevate the margins till the (CEJ) by using a periodontal probe (Miltex, stainless steel, Pakistan) for measuring the composite resin restorative material. The mesial extension cleaned by phosphoric acid etching (Meta etchant gel, Korea) for 30 sec enamel and 20 sec dentin according to the manufacturing instructions , washed and dried then bonded by using self-etch bond (all bond universal, pisco, USA) 15 second application according to the manufacturing instructions then cured by light cured device (Woodpecker, I LED, china). Then adding Ips Empress direct composite restoration (Ivoclar viva dent, Germany) by using snow plow technique. In this technique, flowable composite resin was placed in the proximal box and composite resin is packed on top of the flowable (about 0.5 mm thickness) and then cured. The composite was packed by using LMArte Applica (style italiano composite kit applicator ,Italy) and subgingival sectional matrix (matrices, stainless steel, Russia) to adjust the contouring then the margin was elevated 2 mm above cemento enamel junction (CEJ) then cured [2,3]. All surfaces and line angles were finished and polished. The preparation thickness was measured using the index for standardization. Designing of all overlays were carried out using a standard protocol, on the computer software: First design modes and restoration type were selected then teeth on the visual cast were determined. The Cerec Omnicam started imaging of the preparation was achieved by aligning the camera [4].Overlays were designed by using Mcxl milling unit (Dentsply Sirona). The internal surfaces of overlays were designed according to the virtual image of the dies. The integrity of the structure was visually checked before crystallization. The oven was closed and the crystallization process was started at 403 °C. The temperature was increased 60 °C every minute and it was reached the firing temperature at 770 °C. The firing temperature was last for 30 minutes. At the end, the overlays were removed from the oven when it reached the room temperature. Overlays were etched using hydrofluoric acid gel 9.5 % (BISCO-Schaumburg U.S.A) for both VITA Enamic and feld spathic CAD according to manufacturer instructions. After etching, the overlays were washed with water and dried using air spray (dental chair Roson. China). Then, overlays were brushed by silane coupling agent (BISCO-Schaumburg U.S.A) and wait for 30 seconds then it was dried with air syringe according to manufacturer instructions. Teeth mold were left clean dry; bonding agent (Adper Single Bond 3M ESPE U.S.A) was brushed to the teeth dies and light cured (wood pecker, I LED, china) for 20 seconds. RelyX-Ultimate dual cured resin cement clicker was used. One click applied on the overlay and applied on the die and loaded by the loading device. Under load 50 N [5]. The excess was removed by bond brush then curing of the samples for 40 seconds. After complete cementation of all overlays **(Figure 1)**, the samples were ready for the tests.

Figure 1: sample after cementation

3. Fracture Force test

These tests were performed using Bluehill Lite Software from Instron.

3.1. Test procedure:

All samples were individually mounted on a computer controlled materials testing machine with a load of 5 KN and they measured using computer software then they were fixed to the lower fixed compartment of testing machine. Fracture test was done by compressive mode of load applied occlusally using a metallic rod with spherical tip (5.6 mm diameter) attached to the upper movable compartment of testing machine traveling at cross-head speed of 1mm/min with tin foil sheet in-between to achieve homogenous stress distribution and minimization of the transmission of local force peaks. The load at failure manifested by an audible crack and confirmed by a sharp drop at load-deflection curve recorded using computer software. The load required to fracture was recorded in Newton.

4. Results

Between the two materials, there was a significant difference between the feld spathic and vita enamic materials in with and without deep marginal elevation technique **(Figure 2)**.

5. Discussion

The acceptable load on occlusal surface about 100N to 200N at the molar area, reaching as high of 965N in case of trauma or a sudden bite of hard foreign bodies. As a result, a fracture resistance above 1000N is needed to maintain a good clinical performance and this agrees with this study [6]. In the study of Hamburger J T, et al used a total-etch adhesive system that improved the resistance to fracture. A large variability in maximal bite force has been present. Normal bite force levels about 50 to 300N. However bite force on occlusal surface during clenching and grinding can reach up to 1100 or even 1200 N. the fracture resistance differed considerably between materials, and it appears that direct composites consider a good solution to restore teeth in heavily loaded cases and this agrees with this study [7]. In accordance to an invitro study, the failure load of teeth restored with full coverage all-ceramic crowns with 1.5-2mm occlusal thickness to be 771-1183 N. The demonstrated fracture strength also appears to exceed the reported range of human masticatory forces (585-880) [8] [9] .The highest masticatory forces in the posterior region can range from 200 to 450N and reach up to 800 N in patients with bruxism [10]. Soares CJ et al, found that teeth restored with feldspathic ceramic have less severe fractures, in contrast to bonded composite restorations and this agrees with this study [11, 12].

Roggendorf et al studied the influence of the (DME) technique application on composite inlays. They proved that, there is no difference between the tooth restored with the application of the (DME) technique and the tooth restored without the application of this technique [15].

Ilgenstein et al mentioned the influence of the (DME) technique on the marginal integrity and fracture behavior of root-filled molars restored with CAD/CAM ceramic or composite onlays. All specimens were subjected to thermomechanical loading and load-to-fracture test. They concluded that the deep margin elevation does not influence negatively the marginal integrity or fracture behaviour of root canal-treated tooth restored with ceramic onlays [13, 14]. Flowable composite is considered to be a bad choice, as they have higher polymerization shrinkage and may not be resistant to deformation under load [13, 14]. Therefore, the best option is to use a highly filled hybrid composite, because they have better mechanical properties [13]. The difficulty to adapt the highly filled hybrid composite to cavity walls in a thin layer, because of its viscosity, can be surpassed by pre-heating this type of composite. So an IPS Empress Direct, from Ivoclar Vivadent, that is a highly filled nanohybrid resin composite was used.

6. Conclusion

Within the limitation of this study:-

VITA Enamic material has higher fracture force than feld spathic material in samples with deep marginal elevation. Feld spathic material has higher fracture force than vita enamic material in samples without (DME).

Table 1: Comparison of fracture force between different materials (Vita enamic & Feld spathic) in each technique (with DME & without DME).

Fracture force		Material: Feldspathic N=10	Material: Vita enamic N=10	P value
Without DME technique	Range Mean ± SD	(1351.1-1616.9) 1483.7±139.3	(1009.2-1131.3) 1070.4±64	<0.001*
With DME technique	Range Mean ± SD	(691-875.6) 783±96.9	(955.2-964.8) 960.1±4.7	<0.001*

- Independent samples T test for parametric quantitative data between the two groups
- *: Significant level at P value < 0.05

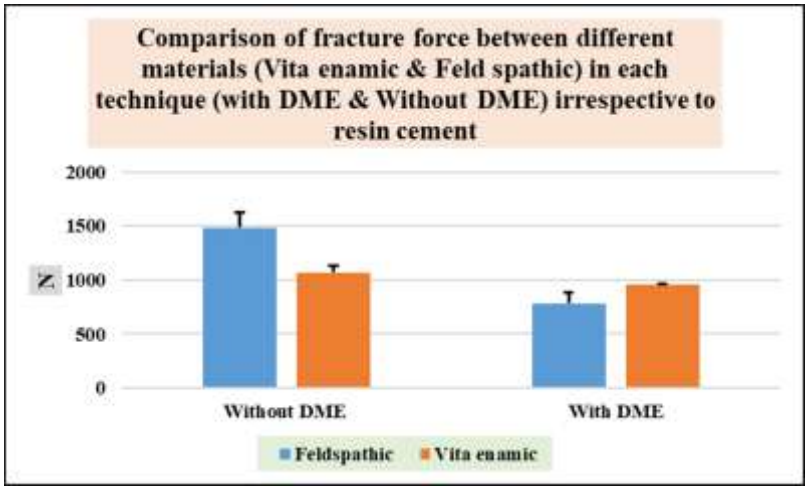

Figure (2)

7. Clinical implication

VITA Enamic material is successful using (DME) technique than feld spathic material and further researches are needed.

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