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DO MARGINAL ACQUISITION AFFECTS FRACTURE RESISTANCE OF MOLARS RESTORED WITH PRESSABLE LITHIUM-DISILICATE CERAMIC ONLAYS?

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ABSTRACT

Objective: This study evaluated the effect of deep marginal acquisition (DMA) using an ion-releasing material, resin modified glass ionomer and nano-hybrid flowable composite on the fracture resistance of molars with Class II MOD cavities restored with pressable lithium-disilicate ceramic onlays.

Materials and methods: Fifty molar teeth were randomly assigned to one of five groups (n=10/group): Enamel (EN), Cementum (CE), Cention forte (CF), Tetric-N flow (TF), and Resin modified glass ionomer (RM) groups. Specimens were prepared for a standard MOD cavity with margins located 2 mm below the CEJ for CF, RM, TF, and CE groups, while EN group had margins located 1 mm above the CEJ. DMA was used to elevate the margins to 1 mm above the CEJ. For CE group, the ceramic onlay was placed without DMA. Standardized IPS e.max press ceramic onlays were pressed from IPS e. max press ingots and all specimens were bonded using Multilink Sprint (Ivoclar Vivadent, Schaan, Liechtenstein) according to the manufacturer's instructions. All teeth were subjected to 10,000 cycles of thermocycling (5°C/55°C). The fracture resistance of each group was measured using a universal testing machine. Data was statistically analyzed using one-way ANOVA test.

Results: Fracture strength values were subjected to one-way ANOVA revealed statistically non-significant differences among experimental groups (p=0.07).

Conclusion: Within the parameters of this study, the materials had non-significant difference in fracture resistance. Therefore, collective findings suggest that these materials were suitable for DMA.

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INTRODUCTION

Every dentist faces hard medical selections whilst making plans and restoring significantly broken teeth. Deep proximal floor destruction offers extra restorative complexities. With the dearth of teeth for long lasting adhesive bonding, the presence of root concavities, and gingival tissue interferences, clinicians may sopt for adjunctive processes whilst restoring teeth with deep proximal boxes.[1] Surgical crown lengthening or orthodontic extrusion offer predictable restorative results in teeth with deep floor destruction. Considering all viable restorative alternatives gives remedy to the patient`s needs. To simplify the recuperation process, it's miles normally encouraged that teeth with harm underneath the gingiva go through surgical crown lengthening.[1]

A conservative opportunity to the previous technique is the deep marginal acquisition (DMA) method. The DMA method turned into first of all purposed through Dietschi and Spreafico.[2] DMA has been revisited and subtle through numerous authors.[3–12] The DMA technique has the ability to shop time, resources, and biologic tissue.[7] Indirect recuperation guidance and delivery have inherent complexities, in particular for onlays and inlays, which may be similarly complex through deep proximal defects.[7,8]

When utilising DMA, a simplified guidance layout offers upward thrust to extra plausible enamel and recuperation inner surfaces. According to the literature, DMA is normally finished with resin-primarily based composite and an indirect restoration bonded occlusally.[13] Another alternative elevation material, one this is water-primarily based totally, and hydrophilic located withinside the subgingival region along with the open-sandwich method is logical to be used when performing DMA.[14,15]

Study on the weakening of tooth following MOD cavity preparations and the effect of restorations in strengthening the remnant tissue have been conducted experimentally.[15] The force that may induce fracture of the tooth-restoration complex has been determined using fracture resistance test. This enables a suggestion of the preparation design and restorative material that provide the greatest resistance to fracture.[16]

Then us refer question which the appraisable restorative material can be used to elevate the margin for final restoration fabrication? Therefore, this present study aimed to evaluate the effect of deep marginal elevation using an ion-releasing material, resin modified glass ionomer and nano-hybrid flowable composite on the fracture resistance of molars with Class II MOD cavities restored with pressable lithium-disilicate ceramic onlays.

The null hypotheses tested will be that there is no significant difference in fracture resistance between ion-releasing material, resin modified glass ionomer cement and nano-hybrid flowable composite used for marginal elevation of molars with Class II MOD cavities restored with pressable lithium-disilicate ceramic onlays.

MATERIALS AND METHODS

Materials Utilized in the current study

1. RMGI (Fuji II LC, Hasunuma-cho, Itabashi-ku, Tokyo, Japan).
2. Tetric-N Flow (Ivoclar Vivadent AG, Shaan, Liechtenstein).
3. Cention Forte (Ivoclar Vivadent AG, Schaan, Liechtenstein).
4. IPS e. max press (Ivoclar Vivadent AG, Shaan, Liechtenstein).

Brand names, specifications, manufacturers, compositions and application steps of the restorative materials are listed in **Table 1**.

Study Design

This laboratory study evaluated fracture resistance of pressable lithium-disilicate ceramic onlays using one independent variable: restorative material used for marginal elevation (RMGI, Cention Forte and Tetric N-Flow).

TABLE (1) Restorative materials used in the current study.

Brand	Specifications	Composition	Manufacturer	Batch Number	Steps of Application
IPS e.max press	Lithium di-silicate	SiO^2, Li^2O, K^2O, MgO, ZnO, Al^2O^3, P^2O^5 and other oxides	Ivoclar Vivadent, Schaan, Liechtenstein	Y34812	1. The internal surface of ceramic will be etched with hydrofluoric acid <5%. 2. Internal surfaces of all restorations will be conditioned by applying a thin coat of universal priming agent (Monobond plus, Ivoclar Vivadent) with a brush for 60 seconds. 3. All restorations will be cemented using Multilink Sprint (Ivoclar Vivadent, Schaan, Liechtenstein) according to the manufacturer's instructions.
Tetric-N Flow	Light-cured, flowable composite	Barium glass, UDMA, Bis-GMA, ytterbium trifluoride, TEGDMA, mixed oxide (SiO_2/ZrO_2), barium-aluminium-fluorosilicate glass	Ivoclar Vivadent, Schaan, Liechtenstein	805753	1. Etch proximal box wall with N-Etch for 15s. 2. Rinse thoroughly for 20s and dry for 3s. 3. Apply the adhesive and rub for 10s then dry for 3s. 4. Light cure for 20s. 5. Place Tetric-N Flow and light cure for 20s.
Cention Forte	Self-cured, glass ionomer	UDMA, initator, glass filler, pigments	Ivoclar Vivadent, Schaan, Liechtenstein	290841	1. Actively scrub and agitate the primer for 10s. 2. Dry with compressed air until a glossy thin immobile layer remains. 3. Activate the capsule. 4. Extrude directly by capsule applier. 5. Self-cure, optionally speed up the process by light cure for 15s.
Fuji II LC	Light-cured, resin-modified glass ionomer	Polyacrylic acid 20-30%, 2-HEMA 30-35%, Distilled water 20-30%, Initiator	Hasunuma-cho, Itabashi-ku Tokyo, Japan	1008051	1. Activate the capsule. 2. Mix it with an amalgamator for 10s. 3. Injected directly by capsule applier. 4. Light cure for 20s.

UDMA, urethane dimethacrylate; Bis-GMA, bisphenol A-glycidyl methacrylate; TEGDMA, triethylene glycol dimethacrylate.

Specimen Preparation

Fifty non-carious, cracks-free extracted human molars were acquired in the current study, the teeth were collected from the outpatient clinic of faculty of Dentistry, the collected teeth were extracted for periodontal disease reasons. The collection of teeth was subjected to infection control standards approved by the Faculty of Dentistry Ethical committee. After removal of soft tissue remnant with a hand scaler, teeth were stored in 1% chloramine-thymol solution (Chloramine-T) for 72 hours at room temperature and then stored in distilled water until use. Teeth were cleaned using a rubber cup and fine pumice water slurry.

The specimens had their roots embedded in cylindrical polymerization of vinyl chloride PVC ring (1.4 × 2 cm) with the usage of an auto-polymerizing acrylic resin (Acrostone, Cairo, Egypt), up to three mm underneath the cementoenamel junction (C.E.J). To mimic the periodontium, roots of the specimens have been demarcated three mm underneath C. E. J through the usage of a purple pencil, then dipped into melted wax to supply a 0.2-mm to 0.3-mm layer about same to the common thickness of the periodontal ligament.

The specimens have been set up in acrylic resin cylinders with the usage of a centralization manual device. After acrylic resin setting, every specimen became eliminated from the cylinder. The wax spacer became eliminated from the foundation floor and the usage of a warm water and wax knife. Polyether impression (Impregum soft, 3M Oral care, St. Paul, Minnesota) became introduced into acrylic resin alveolus. Excess polyether fabric became eliminated with a scalpel blade to offer a flat floor three mm underneath the CEJ of every specimen.[16]

The specimens were divided randomly into five main groups of 10 specimens each as follows: Group 1: enamel margin (EN); Group 2: cementum margin (CE); Group 3: Cention Forte margin (CF); Group 4: Tetric N-Flow margin (TF); and Group 5: RMGI margin (RM) as shown in **Figure. 1**.

Cavities were cut using coarse diamond and finishing diamond burs (Onlay Prep-Set, Intensiv, Viaganello-Lugano, Switzerland) for preparation of standardized class II MOD onlay cavities, in a high-speed handpiece (Sirona T3, Bensheim, Germany) under copious air-water cooling. One operator performed all the steps of preparation using the recommended sequence of specific diamond instruments. To ensure cutting efficiency, each used diamond instrument was replaced after four preparations.

All dimensions of cavity designs have been standardized, in order that the pulpal depth became 2.5mm far from the occlusal surface. The occlusal isthmus width became 2.5 mm, and buccolingual widths at the distal and mesial boxes have been additionally 2.5 mm. The gingival depth of every proximal box became 1.5 mm and the axial wall height became 2 mm. In addition, the palatal cusp became decreased via way of means of 2 mm in line with the anatomical form of the occlusal surface, and the palatal margin became completed as 1 mm rounded shoulder design.

For the enamel margin group, the gingival margin of the preparation was placed 1 mm above the CEJ on the enamel tooth structure. In the remaining four groups, the preparation was end 2 mm below the CEJ in cementum. All teeth in the Cementum margin group, Cention Forte margin group, Tetric N-Flow margin group and RMGI margin group were had 2 mm of deep margin elevation to the CEJ.

Restoration procedure for proximal box elevation

Three different restoration materials were selected for this study. Hence, it was used according to the manufacturer's instruction. All polymerization performed in this study was accomplished using a Bluephase N light-curing unit (Ivoclar Vivadent, AG, Shaan, Liechtenstein). For controlling the light output of the Bluephase N, a radiometer (Bluephase Meter II, Ivoclar Vivadent, AG, Shaan, Liechtenstein) was used to prove that the power was always at 1000 mW/cm^2.

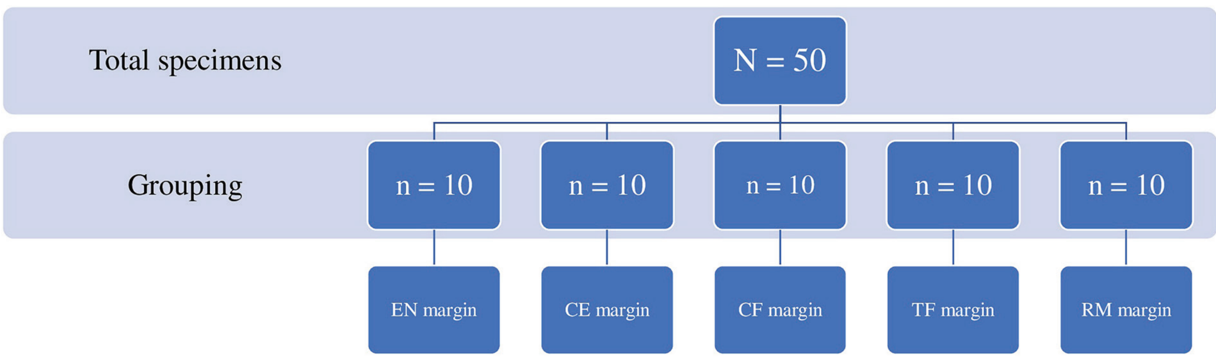

Fig. (1) Flowchart showing experimental sequence and allocation of groups.

Specimens in the Cention Forte, Tetric N-Flow, and RMGI marginal groups underwent the deep marginal elevation to raise the gingival margin 3 mm, resulting in a material gingival floor location 1 mm above the CEJ using Tofflemire matrix band (Henry Schein, Melville, NY, USA).

Regarding Group 3 (Cention forte marginal group) place in a single 3 mm increment, conditioning of the proximal box by Cention Primer. Afterward activated and mixed of capsule, the material was injected into the deep proximal box with nominal manipulation to minimize voids and allowed to self-cure.

Regarding Group 4 (Tetric N-Flow marginal group) place in a single 3 mm increment, etch and rinse adhesive system used for all specimens group comprise N-Etch later Tetric N-Bond Universal. Afterwards the material was placed in the deep proximal box followed by light polymerized.

Regarding Group 5 (RMGI marginal group) place in two 1.5 mm increments, after activated and mixed of capsule, the material was injected into deep proximal box, it is vital to submerge the tip end of the capsule under material surface to prevent any air bubble formation followed by light polymerized.

Digital impression and fabrication of ceramic onlays

Following specimen preparation and margin elevation, fifty preparations was scanned with an intraoral scanning device (Cerec Omnicam, Dentsply Sirona, Charlotte, NC, USA). Furthermore, fifty pressable lithium-disilicate ceramic onlays were pressed from IPS e. max press ingots. A technician fabricated all restorations using a standardized technique following the manufacturer's instructions.

Adhesive bonding of Onlay restorations

All procedures were performed according to the following manufacturer's instructions. The restorations are tried-in using the try-in paste to ensure proper marginal fit. Thereafter removed possible residua of the try-in paste from the cavity and the restoration. After try-in procedure, the internal surface of each onlay was cleaned by sandblasting.

The internal surfaces of all onlays have been etched with hydrofluoric acid <5% (IPS ceramic etching gel, Ivoclar Vivadent AG) for 20 seconds. Then, the internal surfaces of all restorations have been conditioned by applying a thin coat of universal priming agent (Monobond plus, Ivoclar Vivadent) with a brush for 60 seconds. All restorations have been cemented using Multilink Sprint (Ivoclar Vivadent, Schaan, Liechtenstein) according to the manufacturer's instructions. All margins were covered with Liquid Strip to avoid oxygen inhibited layer formation followed by light Polymerized. Finally, smooth out the cement lines using finishing and polishing strips (OptraPol, Ivoclar Vivadent).

Fracture resistance test

All the specimens will be subjected to thermocycling for a total number of 10,000 cycles between 5°C and 55°C to simulate thermal changes that occur within the oral cavity. The dwell time at each temperature will be 30 seconds, and the transfer time from one bath to the other will be 2 seconds.

After a week of distilled water storage since luting procedure, all samples were subjected to axial compressive loading in a universal testing machine (Instron 3345, Canton, Massachusetts) using a metal sphere of 8-mm diameter applied vertically in contact with the cusp slopes at a crosshead speed of 0. 5 mm/min until failure to evaluate level of failure. The force required to induce fracture was recorded in Newton (N).

Statistical analysis

Statistical analysis was performed for fracture resistance, data was statistically analyzed using Shapiro-Wilk and one-way ANOVA tests. Shapiro-Wilk test was used to test for normality distribution of force at maximum compressive stress. Values of $p < 0.05$ were accepted as statistically significant. The data from the fracture resistance tests were graphically displayed as box-and-whisker plots.

RESULTS

The Shapiro-Wilk test was used to test normality distribution of force at maximum compressive stress (Newton) and it was non-significant for all groups of the study. Additionally, one-way ANOVA revealed statistically non-significant differences among experimental groups (p=0.07) within force at maximum compressive stress (Newton): comparison between EN, CE, CF, TF, and RM groups (1673 ± 442, 1540 ± 380, 1702 ± 430, 1690 ± 323 and 1650 ± 380 respectively) as shown in **Table 2**.

TABLE (2) Comparison of force at maximum compressive stress (N) between EN, CE, CF, TF and RM groups

	EN group	CE group	CF group	TF group	RM group	P value
Force at maximum compressive stress (N)	1673 ±442	1540 ±380	1702 ±430	1690 ±323	1650 ±380	0.07

Data expressed as mean ± SD
SD: standard deviation
P: Probability *: significance <0.05
Test used: One way ANOVA

DISCUSSION

Our study evaluated the effect of deep marginal acquisition (DMA) using an ion-releasing material, resin modified glass ionomer, and nano-hybrid flowable composite on the fracture resistance of molars with Class II MOD cavities restored with CAD/CAM ceramic onlays. Also, this study searched for an answer to the question of whether the appraisable restorative material can be used to elevate the margin for final restoration fabrication.

Fracture resistance was the outcome measure to evaluate each material's performance. The results of this study revealed that there were no significant differences in fracture resistance among experimental groups. Therefore, the null hypothesis that there would not be significant difference in fracture resistance between ion-releasing material, resin modified glass ionomer, and nano-hybrid flowable composite used for marginal elevation of molars with Class II MOD cavities restored with CAD/CAM ceramic onlays was accepted.

Mange's study's title refers to a conflict between long-held beliefs and the placement of indirect restoration margins on direct restorative materials rather than sound tooth structure.[17] According to fears about margin raised restorations resulting from the added restorative material interface between ceramic and direct restorative material, using the DMA procedure has faced resistance.[3] In spite of the fact that Kielbassa's systematic review on deep marginal elevation demonstrated that a number of different restorative materials can successfully maintain clinically acceptable margins when used in combination with the DMA procedure, it is recommended for high-quality clinical trials to prove bench-top results.[18]

Compared to the other four sample groups, the cementum margin group in this current study showed a lack of ceramic structural integrity while having lofty occluso-gingival ceramic onlay heights. This discovery reveals a possible additional advantage of DMA beneath ceramic onlays, which is that the process of placing a direct restoration on the gingival floor automatically reduces the onlay's proximal portion's occluso-gingival height. Additionally, reduced heights of proximal ceramic onlays are hardly linked with ceramic fracture based on logistic regression extrapolation of the data from this study, and this agrees with the Vertolli TJ, et al.[19] study.

The fracture strength of ceramic restorations was not impacted by deep marginal elevation, despite the current study's findings indicating that there may not be a significant difference in fracture strength between restorations with and without DMA. The findings of previous in-vitro research on the fracture strength of teeth repaired in combination with DMA are consistent with the present findings.[4]

The proximal extensions of indirect restorations are shorter, which may have a beneficial impact on the strength of the restorations with DMA. This makes it easier to fully seat the restoration into the preparation margin.[20] Long-term molar stress minimization may also benefit from improved marginal adaptation.[21]

Every specimen used in the present study fractured between 1626 and 2018.76 N. Regardless of the DMA materials utilized, fracture resistance was close to that of the control group. Within the constraints of this study, DMA can withstand stresses from typical mastication and a maximum biting force which ranges from 600 N to 1200 N.[22] Furthermore, a look at the data suggests that these materials were appropriate for DMA.

In a similar vein, it was difficult for us to accurately mimic the oral environment and clinical reality of placing a restoration. The major goal of adding the DMA procedure into routine practice is to remove the inherent challenge of recording a deep margin with an impression, visually or otherwise. The processing of the specimens was done under perfect circumstances (in other words, without interruption of access and also without contamination). Due to their moisture forgiveness and chemical adherence to dentin, materials like GI or RMGI may provide improved clinical results based on the clinical circumstances.[13,14,23] Since a flowable composite has a larger polymerization shrinkage and could not be load-resistant, it is still not recommended.[6,8] Nevertheless, applying our findings to clinical circumstances is suggested with great care.

Additional study is needed before patients may be given particular deep marginal elevation techniques. The success of DMA is supported by in-vitro data, but a clinical trial might highlight accurate data that can be relied upon for box elevation. The most current evidence of DMA drawbacks is an in vivo 12-month study indicating significant bleeding on probing as a result of work-related.[24]

The recorded voluntary maximum axial biting forces in dentate women and men, which ranged from 480 N to 788 N, were significantly less than the mean fracture strength values of this current study (1626–2018 N).[25] The voluntary maximal axial biting force is higher than the normal masticatory forces, which range from 17 N to 450 N.[6,8] Bruxism patients frequently generate uncontrollable forces in a range from 400 N to 1100 N.[26] Although chewing involves simultaneous axial and lateral motions, the stated in-vitro results are based on axial loading only. Therefore, to ensure good clinical performance, a fracture resistance of more than 1100N is recommended, which is supported by our study.

There were some differences amongst the specimens in terms of fracture strength. Consequently, two reasons may be used to account for this. There were some differences amongst the specimens in terms of fracture strength. Consequently, two reasons possibly account for this. In some specimens, human molars were utilized and kept in tap water, while in other specimens, they had been extracted six months earlier or only a few days earlier. According to the literature, extracted teeth that have been maintained for more than two months have significantly less microhardness.[27]

In view of the above, this might partially account for the difference in fracture resistance. Additionally, despite the fact that each molar had a somewhat varying size, standardized preparations were carried out to ensure that the indirect restorations were all the same size. Thus, a little variation in the volume of tooth structure served to support the indirect restorations. In order to minimize both reasons' influence on the study's results, the specimens were randomly divided into five groups.

Comparing Yttria stabilized zirconia ceramic material to lithium di-silicate; it has a fracture toughness of 9 to 10 MPa $m^{1/2}$, high-strength polycrystalline ceramic material with a flexural strength of more than 1000 MPa, and is glass-free.[28–30] In their investigation, Saridag S, et al.[31] discovered that zirconia-based onlays were more resistant to compressive forces than lithium disilicate-based onlays.

The elastic resin cement used in adhesive restorations has a tendency to flex under load, which increases its resistance to fracture. So, the formation of an uncompromised adhesive-tooth-ceramic contact is therefore important to the success of ceramic inlays.[32] Additionally, the fracture strength values of molars treated with ceramic onlays may be impacted by the elastic modulus of the luting agent. Cubas GB, et al.[33] reported that partially ceramic prostheses' fracture strength values improved when luting agents with vastly higher elastic modulus were used.

There are also certain restrictions on this study. The molars were subjected to a constant vertical force that was not typical of clinical loading.[34] A range of off-axis loading forces are applied to the ceramics during the masticatory process, which includes both vertical and lateral forces.[35] The fatigue failures seen in clinical situations could be more closely simulated by cyclic loading. To evaluate the fracture strengths of different ceramic restorations with and without DMA, further in vitro testing, including stress distribution analyses, tension tests, and clinical trials, must be carried out.

Lastly, a laboratory investigation cannot mimic the complexity of the oral environment or overcome the challenge of isolating the clinical operative field for difficult-to-access molar treatments. Therefore, to verify new methodologies and confirm laboratory results, randomized-controlled clinical investigations with suitable recall periods are required.

CONCLUSION

Within the parameters of this study, the materials had no significant difference in fracture resistance. Therefore, collective findings suggest that these materials were suitable for DMA.

Clinical relevance

Ceramic onlays without DMA may be a viable approach for the restoration of molars with subgingival MOD cavities. Therefore, further testing of ceramic onlays without DMA is needed. Moreover, dental professionals may elect DMA in appropriate clinical situations.

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