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SCAN ELECTRON MICROSCOPE EVALUATION OF MARGINAL ADAPTATION OF ALKASITE, BULK-FIL RESIN COMPOSITE, RESIN MODIFIED GLASS IONOMER, AND HIGH VISCOSITY GLASS IONOMER RESTORATIVE MATERIALS

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ABSTRACT

Objective: The aim of this study was to evaluate and compare the marginal adaptation of class V cavities restored with Alkasite, Bulk-fil Resin Composite (BFRC), resin-modified glass ionomer (RMGI), and conventional high viscosity glass ionomer (HVGI) restorative materials. Materials and Methods: Fifty Class V cavities (2 mm deep, 3 mm in width, and 3 mm in height) were prepared in sound extracted human molar teeth, where the coronal margins were in enamel while the cervical margins were at CEJ. Four different restorative materials were tested (n = 10): Alkasite (Cention), BFRC (Tetric N ceram Bulkfil), RMGI (Fuji II LC), and HVGI (Equia Forte). The teeth were evaluated for their marginal adaptation with SEM after thermocycling. Results: One Way ANOVA test was used to compare among all the restorative materials and showed significant differences. Student t test was used to compare between enamel and dentin margins showing significant differences for all groups. Conclusion: Alkasite-based restorative material had the ability to ensure tooth/restoration seal and preserve margin integrity.

KEYWORDS : SEM, Alkasite, bulk-fill RC, HVGI, RMGI.

INTRODUCTION

Continuous progress in the qualities of aesthetic materials is the result of ongoing research in the field of restorative dentistry technology.[1] Due to their superior mechanical and aesthetic features, dental resin-based composites, glass-ionomers, and hybrid modifications are the most extensively utilized restorative materials.[2] One of the required characteristics for a successful and long-lasting restoration is marginal seal and integrity at the tooth-restorative interface, especially in cavities involving the cementum region. Polymerization shrinkage strains and the differential in the linear coefficient of thermal expansion (LCTE) of restorative material and tooth structure continue to

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imperil it. As a result of the seepage of oral fluids, marginal gaps may arise, resulting in secondary caries, pulpal inflammation, cuspal deviation, and postoperative sensitivity.[3,4]

For high-risk and older patients, Class V carious lesions with subgingival edges continue to be a substantial oral health issue. To restore them, a range of restorative materials were used, including composite resins and resin-modified glass ionomer RMGI.[5] For tens of years, glass-ionomer cements and their derivatives have been recommended to restore cervical lesions because they can provide chemical adhesion to the tooth substrate, fluoride release with its anti-caries effect, and adequate marginal integrity at the dentin margins that extend beyond the cement-enamel junction. CEJ.[6] Cention N was introduced as a tooth-colored material that could release fluoride, calcium, and hydroxyl ions to act as an anti-cariogenic material. It was classified as a "alkasite"3 and designated as a subgroup of hybrid-composite materials that could release fluoride, calcium, and hydroxyl ions to act as an anti-cariogenic material. It's also a dual-cured material that can be utilized for bulk-filling with or without an adhesive step, just like composites.[7]

Testing marginal adaptation, which is the interfacial distance between the restoration and the tooth structure, can be used to determine the marginal seal of a restoration to the tooth structure. The better the margins are sealed, the less leakage occurs.[8] Furthermore, marginal adaptation was chosen for this study so that a quantitative analysis of the amount and width of gaps generated at the edges and marginal abnormalities could be done. Preclinical screenings and in vitro research imitating oral circumstances can help predict how well restorative materials would work.[9] The aim of the present *in vitro* study was to compare and evaluate marginal adaptation of Class V cavities restored with Cention N with or without bonding, buk-fill resin composite and resin-modified glass ionomer at incisal and gingival margins. The null hypothesis was that the type of restorative material had no effect on marginal gaps, and the type of tooth substrate at restorative/tooth interface had no differences in marginal gaps.

MATERIALS AND METHODS

Four restorative materials were employed in this study; alkasite (Cention-N, Ivoclar Vivadent), bulk fill resin composite (Tetric N ceram Bulkfil, Ivoclar Vivadent), resin modified glass ionomer (Fuji II LC, GC), high viscosity glass ionomer (Equia Forte, GC) and the adhesive system was etch &rinse (Tetric N-Bond Universal, Ivoclar Vivadent). Fifty extracted intact human third molars were selected for this study from the Oral Surgery Clinic, Faculty of Dentistry, Mansoura University after obtaining ethical approval. Patients' age ranged from 17 to 30 years. All teeth were examined macroscopically and microscopically (20× magnification) to rule out the presence of fractures, fissures, and carious lesions. Soft tissue remnants were removed using hand scaler (Zeffiro; Lascod, Florence, Italy); then teeth were disinfected with 1% chloramine-T solution, and subsequently kept for 24 hours at 37°C distilled water in an incubator (BTC, Model: BT1020, Cairo, Egypt).

Class V cavities were prepared on the buccal surface of each tooth with dimensions 3 mm occlusogingival, 3 mm mesiodistal, and 2 mm depth using carbide burs No. 271 at high speed with air/water coolant (W&H, SN 0012845), and each bur was used to prepare five cavities.[10] The occlusal margin of the cavities was located in enamel, while the cervical margin was located in dentin at cemento-enamel junction. All margins were prepared with 90 degree cavosurface angles without bevel, and all the internal line-angles were rounded. The dimensions were measured before preparation using a ruler for the length and the width, drawn with an inerasable pen, and cavities were prepared inside it. While, the depth of the cavity was controlled during preparation with stopper in the bur and regularly checked with a marked periodontal probe.[11]

The prepared teeth were randomly divided into five groups (n=10) according to the type of material used, as follows: Group A: (Cention N), Group B (Cention N bonded with adhesive), Group C (Tetric N ceram Bulkfil), Group D (Fuji II LC), and Group E (Equia Forte). Each group was restored according to manufacturers' instructions. For group A; the prepared cavities were gently driedwith air stream. The powder/liquid ratio was 1:1, and were dispended on a mixing pad. The powder was gradually added to the liquid and thoroughly mixed for 60 s until a homogenous mass produced with a slight shine. The restorative material was immediately applied and condensed in the cavity with a spatula in one increment. Excess material was carefully removed, and the restoration was cured for 20 s using a LED curing unit (Blue phase C5, Ivoclar vivadent).

For group B; 37% phosphoric acid gel (Total Etch, Ivoclar Vivadent) was applied on the enamel and subsequently on the dentin margins for 30 s. Afterwards, the etchant was thoroughly rinsed off with water spray for 15 s, and the excess water was removed with a small cotton pellet to avoid excessive drying. Tetric-N Bond universal adhesive was applied in one thick layer and rubbed on the enamel and dentin surfaces with a micro-applicator brush for 10 s. Excess adhesive in the line angles and the solvent was removed by gentle air stream for 10 s. The adhesive was light-cured for 10 s. Cention N was mixed and delivered into the cavity with the same sequence as in group A.

For Group C; the same steps were followed for adhesive application in this group as in group B, and resin composite was inserted in one layer. Excess material was carefully removed, and the restoration was cured for 20 s. For group D; the cavities were conditioned with 10% polyacrylic acid (Dentin Conditioner, GC Corporation), applied with a micro-applicator brush for 20 s, then thoroughly rinsed with water spray for 20 s, and dried with cotton pellets to avoid desiccation. The capsule plunger of Fuji II LC was tapped for activation mixed in amalgamator device, injected in to cavity slowly using specially designed applicator, and light-cured for 20 seconds.

TABLE (1): The restorative materials used in the study

Product	Composition	Manufacturer	Lot no
Cention -N	Liquid: Dimethacrylates, initiators, stabilizers, additives and mint flavour. Powder: Calcium fluoro-silicate glass, barium glass, calcium-barium-aluminium fluoro-silicate glass, iso-fillers, ytterbium trifluoride, initiators and pigments.	Ivoclar vivadent Schaan/ Liechtenstein	Z00547
Tetric-N ceram Bulkfil	Dimethacrylates (Bis-GMA, Bis-EMA and UDMA), barium aluminium silicate glass filler, Isofiller, ytterbium fluoride and spherical mixed oxide. Initiators-Ivocerin (dibenzoyl germanium derivative), Stabilizers, Pigments	Ivoclar vivadent Schaan/ Liechtenstein	Z007P3
Fuji II LC	Powder: Amorphous Aluminofluoro-silicate glass (100%) Liquid: Polyacrylic acid (8-10%), HEMA (8-10%), and Proprietary Ingredient (5-15%)	GC Corporation Tokyo, Japan	1604218
Equia Forte	Powder: Fluoro-alumino-silicate glass, Polyacrylic acid powder, Pigment Liquid: Polyacrylic acid, Distilled water, Polybasic carboxylic acid	GC Corporation Tokyo, Japan	1602201
Tetric N-Bond	Bis-GMA, UDMA, HEMA, Phosphonic acid acrylate, ethanol, nanofiller,catalysts and stabilizer, nanofiller	Ivoclar vivadent Schaan/ Liechtenstein	Z0109C

For group E; the cavities were conditioned as in group D. The capsule of Equia Forte plunger of equia forte was tapped for activation, mixed in amalgamator device. The capsule was inserted into applicator and clicked twice to prime capsule after which they were immediately dispensed into prepared cavity. After that, each restoration was finished and polished using Enhance polishing kit (DENTSPLY-Sirona, USA) under water coolant. Finally, the samples were stored in distilled water at 37° for 24 hours in an incubator. The samples were subjected to aging by 200 thermocycles between temperatures at 5 - 55°C. The thermocycles in each bath lasted for 30 s and transfer time of 10 s. The specimens of each group were prepared for imaging with Scanning electron microscopy (JSM-6510LV, JEOL, Tokyo, Japan). They were dehydrated, mounted on aluminum stubs, and gold sputter coated. The marginal gaps were assessed at enamel and dentin margins at 500 X magnifications, and measured in micrometers (µm) at accelerating voltage of 20 KV along all the margins.

RESULTS

The data were collected and tabulated for statistical analysis using statistical package for Social Science for Windows, Version 22.0 (IBM SPSS Inc, 2013, Armonk, NY, USA). Data were quantitatively described using mean, standard deviation for parametric data after testing normality using Shapiro–Wilk test. All the groups had 10 teeth each. Group A showed a mean width of marginal gaps 1.57 µm at enamel margin which was the lowest width and 5.88 µm at dentin margin. Group B showed a mean width of marginal gaps1.8 µm at enamel margin and 4.61µm at dentin margin which was the lowest width. Group C showed a mean width of marginal gaps 21.47 µm at enamel margin, and 37.5161µm at dentin margin which were the highest widths among all groups. Group D showed a mean width of marginal gaps 7.19 µm at enamel margin, and 12.96 µm at dentin margin. Group E showed a mean width of marginal gaps 6.13 µm at enamel margin, and 20.98µm at dentin margin.

One Way ANOVA test was used to compare between all groups at enamel and dentin margins separately with post Hoc Tukey test for pairwise comparison. Student t test was used to compare between 2 subgroups for each group with continuous parametric variables. The significance of the obtained results was judged at p value < 0.05. One Way ANOVA test showed significant difference between all the studied restorative materials as presented in Table 2, figure 1. At enamel margin, there was significant difference ($p < 0.001$), and Post Hoc Tukey test exhibited no significant difference between two groups were restored with cention, and between two groups were restored with glass-ionomer materials. At dentin margin, there was significant difference ($p < 0.001$), and Post Hoc Tukey test exhibited no significant difference between two groups were restored with cention only. Student t test manifested significant differences for all the tested materials (p value < 0.001) between enamel and dentin margins.

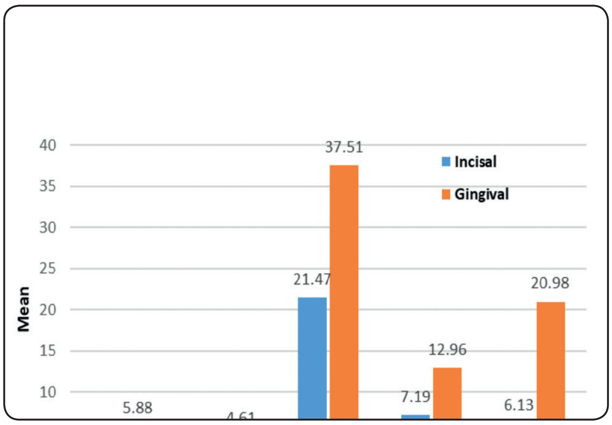

Fig. (1) : A diagram showing mean gap distances of all the groups at enamel and dentin margins.

TABLE (2): Comparison of marginal gaps in microns among different types of restoration at enamel and dentin margins in μm.

	A: Cention-N	B: BONDED Cention-N	C: Tetric N ceram Bulk-fil	D: Fuji II LC	E: Equia forte	P value
Enamel margin	1.57 ± 0.39^{A}	1.80 ± 0.77^{A}	21.47 ± 1.67	7.19 ± 0.62^{B}	6.13 ± 1.95^{B}	<0.001*
Dentin margin	5.88 ± 0.68^{A}	4.61 ± 0.94^{A}	37.51 ± 3.0	12.96 ± 2.65	20.98 ± 4.31	*0.001>
P value	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	

Similar superscripted letters denote non-significant difference between groups within same row by Post Hoc Tukey test

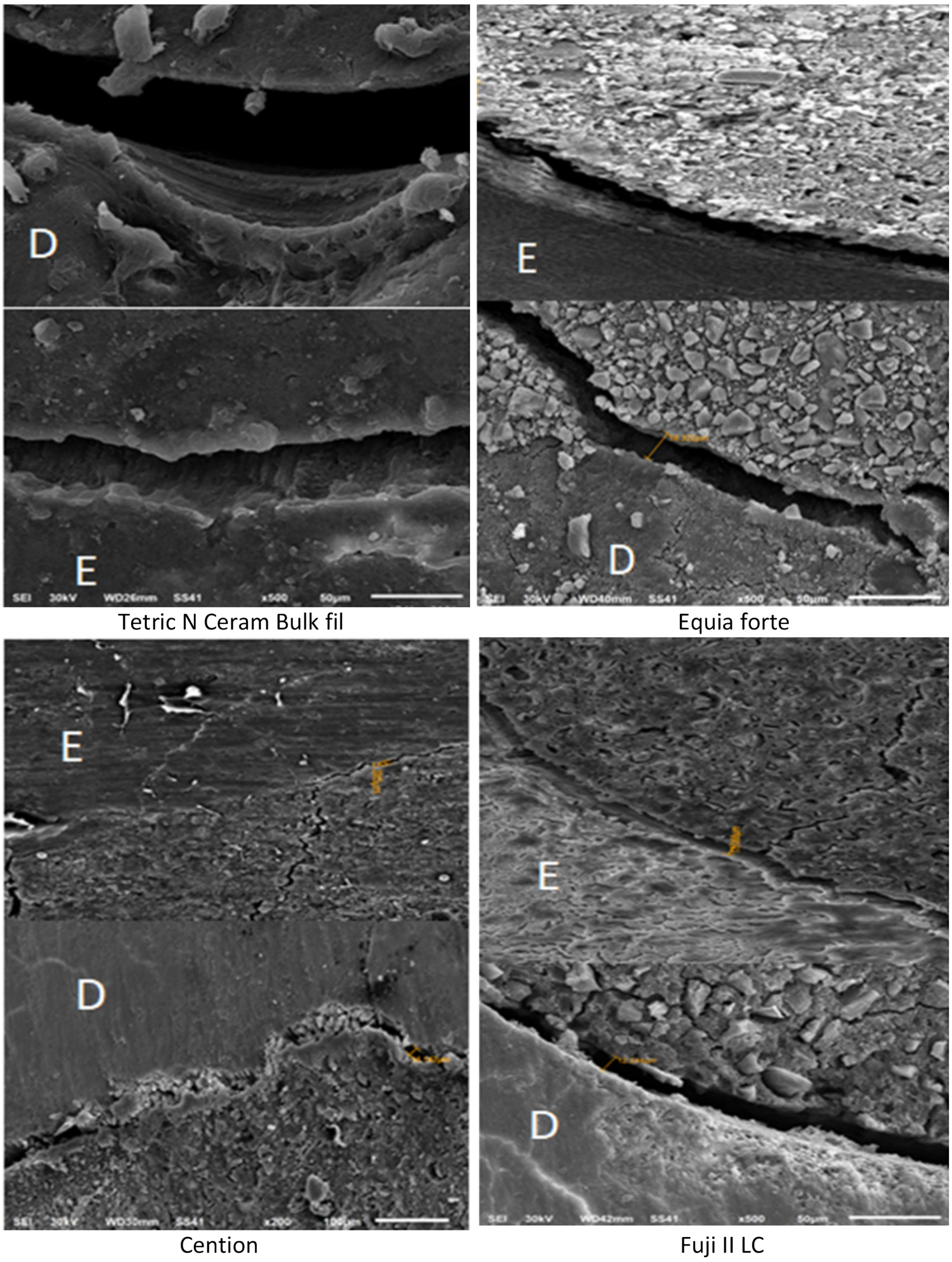

Fig. (2): SEM photographs of all the restorative materials; E: enamel, D: dentin

DISSCUSION

The degree of proximity of a restoration to a tooth surface is referred to as marginal integrity. This feature has an impact on the aesthetics and lifespan of the product.[12] Marginal adaption measurements can be used to assess the marginal seal of a restoration to the tooth structure. As a result, marginal adaptation was chosen for this study above other qualitative analysis tests to offer a quantitative examination of the amount and width of gaps produced at enamel and dentin margins. Porte, Lutz, et al.[13] pioneered quantitative marginal analysis, which was later developed by Blunck and Roulet.[14] The actual width of the gaps was measured using a scanning electron microscope (SEM) because it provides a more accurate magnified visual observation of the restorative materials' marginal adaptability, allowing for a closer examination with valid data that is directly related to microleakage and the probability of bacteria or saliva passage through the margins.[15]

The presence of an intimate seal at the tooth/restoration interface is the true problem for any restoration. It is now impossible to completely eliminate marginal gaps at interfaces.[16] A space between the tooth and the restoration may cause the marginal gap to emerge. Streptococcus mutans bacteria are tiny (0.5-1 m) and associated to tooth caries.[17] These holes allow bacteria, saliva, and enzymes to flow through quickly and easily, leading to recurrent caries and post-operative discomfort, especially in deep cavities with no enamel and cavity borders made of dentin, cementum, or both.[18] Due to the unique features of dentin, including as its tubular form and inherent moisture, bonding to it is more challenging.[19]

Restorative materials that are appropriate for clinical performance and durability should be employed to ensure the therapeutic relevance of marginal adaption. As a result, this study examined four commonly used compounds, one of which is alkasite–based, to determine which are the best options for recovering Class V. The ageing by thermocycling method was utilized to model the breakdown of composite bond in this investigation.[20]

Regarding the restoration materials used in the current evaluation, the hypothesis was rejected because they influenced the marginal adaptation in enamel and dentin and the type of tooth substrate at restorative/tooth interface had significant differences in marginal gaps. Superior marginal adaptation was found for Cention N for bonded margins or not over glass-ionomers and rein composite. This finding is in agreement with Soumita et al,[21] and Firouzmandi et al[22] who related this higher adaptation to the specially patented isofiller in Cention N. This isofiller is partially functionalized by silanes that leads to a minimum shrinkage stress and acts as a shrinkage stress reliever.[23] Also, there was no significant difference between bonded and unbounded Cention groups. This means that no significant improvement in marginal adaptation was attained with the application of bonding agent as reported by Firouzmandi et al.[22]

In the present study, glass-ionomer based groups had signficant increased gaps compared to alkasite–based groups. There was a marginal gap in enamel and dentin. On the one hand, RMGI and HVGI release fluoride ions,[24] and chemically bond to dental substrate through bonding of the carboxylic groups to hydroxyapatites of dental substrate.[25] On the other hand, RMGIC is regarded technique sensitive from insertion to final setting, and is viscous. This requires a well-trained operator. Moreover, RMGIC may deteriorate by solubility by exposure to the oral environment.[26] The literature reported studies that had failures with the use of GIC as Czarnecka et al.[27] Also, there was no significant difference between two glass-ionomer based groups due to the convergent mechanical properties and coeficient of thermal expansion.[28]

The use of bulk simplified restorative material as bulk-fill resin composite in Class V is not recommended based on the results of this in vitro study. It had the highest marginal gaps. Polymerization contraction of resin composite induces stress due to the modulus of elasticity, as the shrinkage cannot be accommodated by its viscous flow, and this is capable of causing initial gaps in the restorations margins.[29] This situation is more critical in Class V restorations due to the difficulty of adapting the material at the gingival margin.[30] Thermocycling was applied to the specimens, and repetitive contraction/expansion stresses were generated at the tooth/material interface. Resin composite has high expansion coefficient.[31] In addition, a recent systematic review concluded that RMGI was better than resin composite restorations for restoring cervical cavities.[32]

The most critical margin area was as usual at the cervical dentin, and regarding to all the tested materials there were significant increase at gingival gaps as reported in previous studies by Poggio et al and Omidi et al.[33,34] This may be attributed to the high minerals in the composition of enamel when compared with dentin, the composition of dentin at gingival area, and degree of surface energy that affects either infiltration or chemical bonding.[35] Enamel is a solid substrate for bonding, and dentin has more deficiencies due to the tubular structure and intrinsic wetness.[19]

CONCLUSION

The different restorative materials were found to be unable to close the margins with the best adaption obtained from Cention N. In the enamel and dentin cervical margins, different restorative materials behaved differently.

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