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Research Article

An *in Vitro* Comparative Evaluation for Internal and Marginal Integrity and the Degree of Monomer Conversion of Alkasite Restorative Material

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ABSTRACT

Aims: To compare and evaluate marginal and internal adaptation and to assess the degree of conversion of alkasite restoration in relation with other restorative materials. **Methods:** on the buccal surface of 25 maxillary premolars a class V cavities were prepared. The teeth were randomly divided into five groups (n=5) that restored as: Group 1: alkasite without adhesive, Group 2: alkasite with adhesive, Group 3: Nanohybrid composite, Group 4: Glass ionomer cement, and Group 5: Resin modified glass ionomer cement. The teeth underwent 5000 cycles of thermocycling between 5° and 55°. Then, silver nitrate solution was infiltrated and Micro-Computed tomography analysis was performed using (LOTUS inVivo). For evaluating degree of conversion, 15 specimens in the form of a disc were prepared from Alkasite, nanohybrid composite and resin modified glass ionomer (n=5). All samples were analyzed using (FTIR) in an ATR Mode in three intervals (after 20 second. 24 hours and 7 days). The data had been analyzed using the Kruskal-Wallis, Dune and Wilcoxon tests at a 0.05 significance level. **Result:** A significant difference in marginal and internal adaptation were observed among restorations ($p < 0.05$). Superior marginal and internal adaptation was obtained in this study for alkasite whether with or without bonded over nanohybrid composite. However, RMGIC and GIC show more adaptation values among other tested groups. Also degree of monomer conversion percentage varied among restorations at different intervals**. Conclusion**: alkasite restorations wither with or without bonding have higher marginal and internal adaptation in comparison with nanohybrid composite but lower than that of GIC and RMGIC. Also alkasite restoration showed higher degree of conversion when compared with nanohybride composite and RMGIC after 20 second and 24 hours of polymerization

Keywords: Alkasite, Marginal and Internal Adaptation, Degree of Conversion, Micro-CT.

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INTRODUCTION

The contemporary dental professional has variety direct filling materials restorations ranging from silver amalgam to modern bulk fill composites. These materials' capacity to withstand stress, durability, integrity of marginal sealing, and aesthetics are the key areas of concern.[1] Dental amalgam considered as the most versatile filling material that had been successfully used by dental clinicians as a durable, low-cost direct restoration for the past 200 years. However, due to growing worries about mercury's effects on the environment and public health, its usage is declining on a global scale.[2]

Composite resins are widely used as a direct reparative material for the anterior teeth and as a posterior restoration as the focus on aesthetic dentistry has increased.[3] Although composite resins' mechanical characteristics, abrasion resistance, and aesthetic qualities have considerably improved during the past few years, their shrinkage caused by polymerization is still a concern. Secondary caries, marginal discoloration, postoperative sensitivity, and microleakage are all effects of polymerization shrinkage, which finally restricts the use of composite resins in direct restorations.[4] Glass ionomer cement (GIC) is another direct restoration that has the benefits of chemical adhesion to tooth structure, good biocompatibility, superior esthetics, and long-term fluoride release providing cariostatic effect. However, it also has some drawbacks, including a slow setting rate, low fracture toughness, susceptibility to moisture contamination, and poor wear resistance.[5]

In order to reduce secondary caries and interfacial gap throughout the last two decades, the development of dental restorative materials with exceptional physical and biological properties has received significant research attention. A powder-liquid composite based material made of bulk-fill resin with alkaline fillers (alkasite) was introduced into the market.[6] Alkasite restorations (Cention n), a tooth colored, basic filling material for bulk placement in retentive preparations with or without the use of an adhesive was first became available in 2016.[4] It's a new category of filling material, considered as a sub group of resin composite. It`s is a urethane dimethacrylate (UDMA) based restoration. The powder contains various glass fillers, pigments and initiators, while the liquid is made up of dimethacrylates and initiators. It comes in powder/liquid restorative form.[7]

Alkasite contain a special potent isofillers include load of glass, aluminum and fluorosilicate barium of calcium and fluorsilicate glass of calcium, with a particle size of range 0.1-35 µ which keep shrinkage stress to a minimum. The isofillers act as a reliver of shrinkage stress which minimize shrinkage force. This is attributed to the material being partially silanised.[8]

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The alkasite is a radiopaque, bioactive restorative material that is dual curable and available in VITA shades A2. It is a restorative material for direct restorations.[4] This restorative material is designed to be used in Class I, II or V as temporary and permanent restoration. Retentive cavity preparation (with undercuts) as that used with amalgam fillings is necessary if used without adhesive.[9] Evaluations using micro-computed tomography are recognized as a reliable replacement for the conventional sectioning approach for the evaluation of internal and marginal adaption and microleakage with various infiltration procedures. Another advantage is the fast assessment of nondestructive tomography methods.[10]

Resin based composite material (RBC) works through a procedure known as polymerization, in which A polymer chain of three-dimensional networks is produced by the interactions of the composite monomers. The degree of conversion (DC) is defined as the percentage of double bonds that change from c=c to c-c single bonds.[11] Ideally, during the polymerization phase, all of monomers in composite resin are transformed into polymers, but Monomer do not 100% convert into polymer after polymerization, leaving unsaturated free monomers so Methacrylate after polymerization still have double bonds in the finished product with conversion rates between 55% and 75%.[12]

The physical and mechanical characteristics of dental composites are directly influenced by the (DC). Due to unreacted monomer remaining in the polymer's cross-linked structure, composite resins with low monomer conversion rates exhibit undesirable properties like increased bacterial colonization, discoloration, lower bond strength, low wear resistance, margin breakdown, water sorption, decreased hardness, and decreased durability.[13] Because resin composite technology is developing quickly and new products are coming out on the market every year, it is crucial for academics and clinicians to understand the different properties of the materials they use in restoration, so further knowledge of alkasite restoration in comparison with other commonly used restorations is necessary. The objective of the current study was to compare an alkasite restoration's internal and marginal adaption. In relation with other restorative materials and to evaluate the degree of monomer conversion of alkasite restoration in relation with nanohybrid composite and resin modified glass ionomer cement restorative materials. The null hypothesis for this study stated that there was no significant difference in internal and marginal adaptation, as well as in degree of conversion among different group of restorations.

MATERIAL AND METHODS

Information on the materials utilized in this study, including information on their composition and manufacturer (Table 1)

Marginal and Internal Adaptation: Twenty-five sound maxillary permanent first premolar teeth caries free, non-restored, extracted for orthodontic purposes were mounted in cold cure acrylic with the help of polyvinyl chloride (PVC) retentive ring (which was 2 cm in height and 2.5 cm in diameter) was used as a mold. Each tooth was mounted in the mold with the aid of a surveyor (Qualye Dental, England). The acrylic resin was poured into the mold after the tooth's axis was properly positioned, and the tooth was inserted longitudinally in the center of the mold to a depth 2 mm apical to the cemento-enamel junction before the dough stage. To prevent the resin polymerization from overheating after initial polymerization, the samples were submerged in distal water.[14]

Standardized class V cavity preparation were created on the buccal surfaces. (2mm height, 3mm width, 2mm depth) with the cervical margin 1mm above the cemento enamel junction (the occlusal and cervical margins of the preparations were completely in enamel). In order to prepare the buccal surface of the tooth, a high-speed hand piece was attached to the surveyor's arm (Qualye Dental, England) in such a way that the bur's long axis was perpendicular to the buccal surface. A medium grain No. 835diamond bur (ecoline, Germany) was used underneath water coolant.[15]

The cavity was positioned one millimeter (mm) above the tooth's cemento-enamel junction. Round bur was used for finishing the cavity form with a low speed hand piece.[14] According to the type of restoration to be tested, the teeth were divided randomly into five experimental groups each with five teeth:

Alkasite without adhesive (Group 1): The created cavities were gently dried using air stream. One scoop of powder and one drop of liquid of alkasite were dispensed on a mixing pad, the powder was progressively added to the liquid and properly mixed for 60 seconds in accordance with the manufacturer's instructions. The substance was instantly applied and bulk-placed in the cavity using a plastic instrument (supplied by the manufacturer). The extra material was carefully removed, and then the restoration was given time to set for 5 minutes.[16]

Alkasite with adhesive (Group 2): Cavities were gently dried with air stream. Tetric-N Bond universal adhesive (Ivoclar Vivadent, Schaan, Liechtenstein) was placed in one layer and rubbed over the prepared cavity surfaces for 20 seconds using a micro-applicator brush. A gentle, air stream was used for 10 seconds to remove extra adhesive. The adhesive was cured using an LED curing unite (Woodpecker LED.H) with 800 mW/cm^2 light intensity for 20 seconds according to manufactural instruction. Light output was measured using a radiometer (DTE model LM-1 woodpecker). The identical procedure as in group 1 was followed when mixing and administering alkasite into the cavity.[17]

Nanohybrid composite (Group 3): Tetric-N Bond universal adhesive (Ivoclar Vivadent, Schaan, Liechtenstein) was placed in one layer and rubbed over the prepared cavity surfaces for 20 seconds using a micro-applicator brush. A gentle air stream was used for 10 seconds to

Table 1: Composition and manufacturer of the materials used in the study.

Materials	Composition	Manufacturer
Cention N	UDMA, DCP, Aromatic aliphatic-UDMA PEG-400 DMA Ca-F-Silicate glass, Ba-Al silicate glass, Ca-Ba-Al fluorosilicate glass, YtF3,isofiller (78.4 wt%)	(Ivoclar Vivadent, Schaan, Liechtenstein)
Tetric-N® Ceram	Bis-GMA, Bis-EMA UDMA Ba glass; YbF3; mixed Oxide; prepolymer (80%wt%)	(Ivoclar Vivadent,Schaan, Liechtenstein)
GIC (GC Fuji)	Fluro-alumin-silicate glass, Polyacrylic acid powder Polyacrylic acid Polybasic carboxylic acid	(GC Corp., Tokyo, Japan)
GIC (GC Fuji II LC	Polyacrylic acid, HEMA, 2,2,4 TMHEDC, TEGDMA Fluoro-alumino-silicate glass	(GC Corp., Tokyo, Japan)
Tetric N-Bond Universal	dimethacrylate resins, HEMA, Ethanol, Water , MCAP (methacry-lated carboxylic acid polymer), Fillers, Initiators	(IvoclarVivadent,Schan Liechtenstein)
Cavity conditioner	Poly acrylic acid	(GC Corp., Tokyo, Japan)

remove extra adhesive. The adhesive was cured using an LED curing unite (Woodpecker LED.H) with 800 mW/cm2 light intensity for 20 seconds according to manufactural instruction. Tetric-N Ceram nanohybrid composite resin (Ivoclar Vivadent, Schaan, Liechtenstein) was applied in one increment then light cured for 20 seconda according to manufacturer instructions.[18]

Glass ionomer cement (Group 4): A cavity conditioner (GC Corp., Tokyo, Japan) was applied to the prepared cavities for 10 seconds with cotton pellet, then the cavities were washed with water and dried. Restorative glass ionomer cement (GC Fuji 2(GC Corp., Tokyo, Japan) was used. One scoop of powder and one drops of liquid were placed on a mixing paper pad. The powder was divided and mixed with the liquid within 25 second accordance to direction of manufacturer's until achieve a homogenous mass then applied and packed in one increment into the cavities with a plastic instrument. Afterwards excess material was removed and the samples were left to set for 5 minutes.[19]

Resin modified glass ionomer cement (group 5): A cavity conditioner (GC Corp., Tokyo, Japan) was applied to the prepared cavities for 10 seconds with cotton pellet, then the cavities were washed with water and dried. Restorative resin modified glass ionomer cement (GC Fuji II LC(GC Corp., Tokyo, Japan) was used. One scoop of powder and two drops of liquid were placed on a mixing paper pad. The powder was divided and mixed with the liquid within 25 second accordance to direction of manufacturer's until achieve a homogenous mass then applied and packed in one increment into the cavities with a plastic instrument. And was polymerized for 20 s using a LED curing unit.[20]

All samples with restored cavities then were stored in incubator with distilled water (Jard incubator, Syria) before testing at 37±1°C for 24 h.[21] Thermocycling was performed on all samples in accordance with the International Organization for Standardization (ISO) TR11405 standard, for 5,000 cycles between 5 and 55 °C with a dwell time of 30 seconds. And 10 seconds transfer time.[22] For removing the smear layer, the samples were soaked in 17% EDTA for 5 minutes. Then all samples were painted with two coats of nail varnish applied to the whole tooth, with the exception of the bonded interface and 1 mm of the surrounding region.[23] Next, silver nitrate was used to fill microgaps. The teeth were immersed in upside down position in a 50% ammoniacal silver nitrate solution for 12 hours (Precipitated silver nitrate functioned as a contrasting medium on micro CT imaging). Then the teeth were rinsed with distilled water for 5 minutes and kept at room temperature 23±2°C.[24]

For micro-computed tomography the sample was mounted into a holder on stage that was made specifically for samples scanning to ensure stability of each tooth. The sample was mounted in such a way so the X-ray beam was perpendicular to the sample surface, and maintain a constant distance between the x-ray source and the sample. To prevent the dehydration and micro-cracking of the sample at the time of scanning, a few drops of water were added on the samples to prevent dehydration.[25]

The next step is the actual scanning, which is done utilizing an in vivo X-ray Micro-Computed Tomography (micro-CT) scanner (LOTUS inVivo, Behin Negareh Co., Tehran, Iran). A flat panel detector and a cone beam micro-focus X-ray source are also features of LOTUS-inVivo. The X-ray tube voltage were set to 90 kV and current 77 A. The frame exposure duration was set to 0.25 seconds by 2 magnifications to provide the highest possible image quality. An aluminum (Al) filter (0.5mm) was used to cut off the softest X-rays. A trial sample scanned was necessary to determine the time required per scan in high resolution for each sample. After a trial scan, we get a standardization of the scanning system to have an average duration time for scanning approximately 30 minutes. Slice thicknesses of reconstructed images were set to 25 micrometers. The LOTUS-inVivo-ACQ program managed all of the protocol parameters. LOTUS inVivo-REC was used to reconstruct the captured 3D data using the common Feldkamp, Davis, and Kress (FDK) technique.[26]

Degree of Conversion: Three types of resin based restorations were used to prepare 15 samples (5 for each group) in this study, alkasite (Cention-N), nanohybrid composite (Tetric-N Ceram) and resin modified glass ionomer (GC Fuji II) ULC/ Gold Label)

All samples were prepared according to the mixing method recommended by the manufacturer, all the restorative materials were loaded in a single increment into a cylindrical metal mold (6mm in diameter and depth of 1mm) which placed on glass slide and the loaded material was covered with transparent celluloid strip to ensure smooth surface of the sample. Glass plate used to apply pressure to provide uniformity of the sample surface.[27]

All specimens were analyzed using the attenuated total Reflection Fourier Transform Infrared spectroscopy (FTIR) in an ATR Mode-Diamond device of a model ALPHA, LASER1, Bruker, Germany in the College of Dentistry, University of Mosul.

-FTIR Measurement before light curing: The paste of nanohybrid composite and the mixed specimens of both (alkasite and RMGIC) were measured after five minutes from start mixing process.[28]

-FTIR Measurement after light curing: All samples were measured after polymerized with light-curing unit LED F woodpecker (Guilin Woodpecker Medical Instrument Co., Ltd.; Guangxi, China) with tip diameter of 8mm and irradiance of 1200 mW/cm^2 for 20 seconds. One millimeter thickness of glass slide was used to standardize the distance between the composite surface and the light cure tip, which was positioned perpendicular to the specimens.[29]

Another measurement had been taken after samples storage for 24h at 37 °C in a lightproof container (to stop any additional polymerization from transitory light) contain artificial saliva in an incubator.[30] The final measurement took place after 7 days of specimen storage. The absorbance peaks of the polymerized and unpolymerized resin were compared in order to determine the DC of dimthacrylate resin based composite. The sample was placed in close proximity to the diamond crystal (Bruker Alpha), and when the sample was penetrated by infrared light, the beam that was reflected from the sample's and crystal's boundary was totally diverted to the infrared spectrometer's detector. The absorbance rate were recorded at wavelength of 400-4000 cm^{-1}and resolution 4cm^{-1}.[31] The degree of polymerization of a resin-based composite can be determined by comparing the absorbance intensity ratios of the carbon double bond peak at 1637 cm and that of an internal peak at 1608 cm(double bond of aromatic carbon).[32] The ratio of the residual double bonds (RDB) of the monomer to the polymer in the composite was determined using the following equation.:

$$RDB\% = (1 - R\ cured / R\ uncured) \times 100$$

R is the ratio of aromatic and aliphatic C=C bonds.

The statistical analysis of the marginal and internal adaptation results obtained in this study was done using the SPSS (version 25) The data were statistically analyzed using non parametric independent sample Kruskal-Wallis test at the confidence level of 95% and the Dune Multiple Range test utilized to compare the effect of each variable and statistical difference between groups of the study. Also Wilcoxon test was applied to show the difference between Alkasite with and without bonding in marginal and internal adaptation.

RESULT

Marginal and internal adaptation: Descriptive statistic including mean and standard deviation of marginal and internal adaptation detected by calculating gabs volume in cubic millimeter and gabs penetrated

by silver nitrate for each group. Independent-Samples Kruskal-Wallis test was performed to analyze the presence of statistically difference. Results of revealed that all groups examined in the current study had statistically significant differences. ($P < 0.05$) (Table 2).

To determine the level of significant that obtained, Dune New Multiple Range Test showed that total gab volume value of RMGIC was significantly less than all other types of restorative materials (Table 3).

To determine the effect of bonding application on marginal and internal adaptation for alkasite restoration, Wilcoxon test showed that there was no significance difference between the Alkasite with and without bonding. ($P>0.05$) (Table 4)

Figures (1) show representative analyzed 2D and 3D Micro-CT images for the sample of the restorative material in different views.

Fourier Transform Infra-Red Spectroscopy test (FTIR): Comparing the peaks of the functional groups in organic compounds before and after the photochemical reaction (Figure 2). where before the light radiation value of carbon-carbon double bonds that indicates the origin of all double bonds in the molecule.

The most light-cure dental filling composites have absorption bands of 1628–1640 cm^{-1} and the C-C aromatic absorption band at 1600–1612 cm^{-1} which did not take part during the polymerization. As a result, residual double bonds (RDB) were assessed as a need for the long-term stability of polymeric networks and the availability of unreacted components. Three resin-based restorations were examined utilizing

Table 2: Descriptive statistic and Kruskal-Wallis of marginal and internal adaptation of the tested groups.

Groups	mean±SD	minimum	maximum	Sig.
Alkasite without bonding	0.48±0.23	0.27	0.86	
Alkasite with bonding	0.78±0.25	0.55	1.04	
Nanohybrid composite	1.14±0.49	0.63	1.79	0.001
GIC	0.28±0.1	0.19	0.43	
RMGIC	0.2±0.07	0.12	0.28	

Table 3: Dune Multiple Range test showed the marginal and internal adaptation of the tested restorative materials.

Groups	1	2	3
RMGIC	4.2		
GIC	7.6		
Alkasite with bonding		13.2	
Alkasite without bonding		17.4	
Nanohybrid composite			21.6

Table 4: Wilcoxon showed the difference between Alkasite with and without bonding in marginal and internal adaptation.

Groups	mean±SD	Sig.
Alkasite without bonding	0.48±0.23	0.08
Alkasite with bonding	0.78±0.25	

Table 5: Degree of conversion mean value (%).

Group	DC_1%	DC_2%	DC_3%	DC_4%
Alkasite	45.76	61.36	93.24	98.65
Nanohybrid composite	---	52.38	87.98	99.8
RMGIC	39.45	55.46	88.73	98.1

DC_1% represented DC for materials paste for five minutes without radiation exposure.
DC_2% represented DC for materials paste after 20 seconds radiation exposure.
DC_3% represented DC for materials after 24 hour storage in artificial saliva.
DC_5% represented DC for materials after 7 Days storage in artificial saliva.

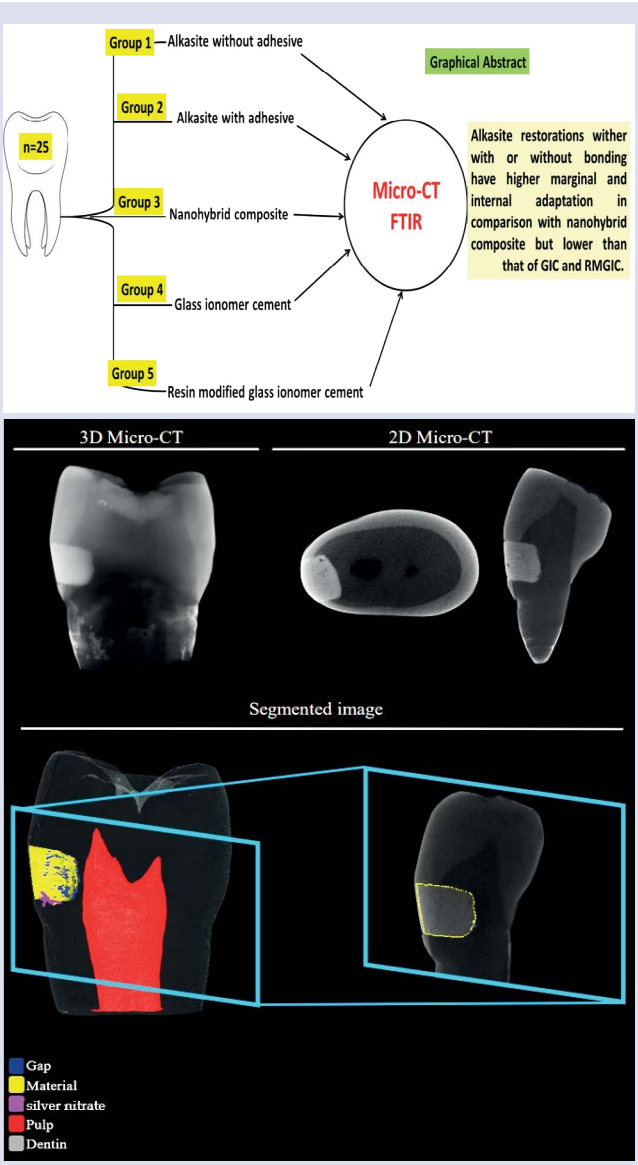

Figure 1: The analyzed 2D, 3D and segmented Micro-CT images for samples

FTIR-ATR spectroscopy to examine RDB. The band corresponding to the aliphatic double bond at 1637 cm^{-1} decreased or even disappeared, indicating the conversion of the monomer to polymer. The percentage of the degree of conversion from monomer to polymer for the materials under study was calculated according to the previously mentioned equation and the results for all materials (Table 5) as follows:

DISCUSSION

The human tooth's capacity for regeneration is limited. It becomes crucial to restore the lost dental structure in order to keep the tooth's form, functionality, aesthetics, and clinical lifespan. Studies conducted over the years have shown that conventional restorative approaches and materials are insufficient to completely seal the tooth's margin from fluid infiltration, which can result in post-operative sensitivity, marginal discoloration, compromised marginal integrity, and secondary caries. Modern restorative materials must have strong adhesion with the dentinal surface in order to resist the various dislodging stresses occurring on the tooth.[33,34]

A contemporary dentist can choose from a variety of direct filling materials. The main performance limitations with these materials right

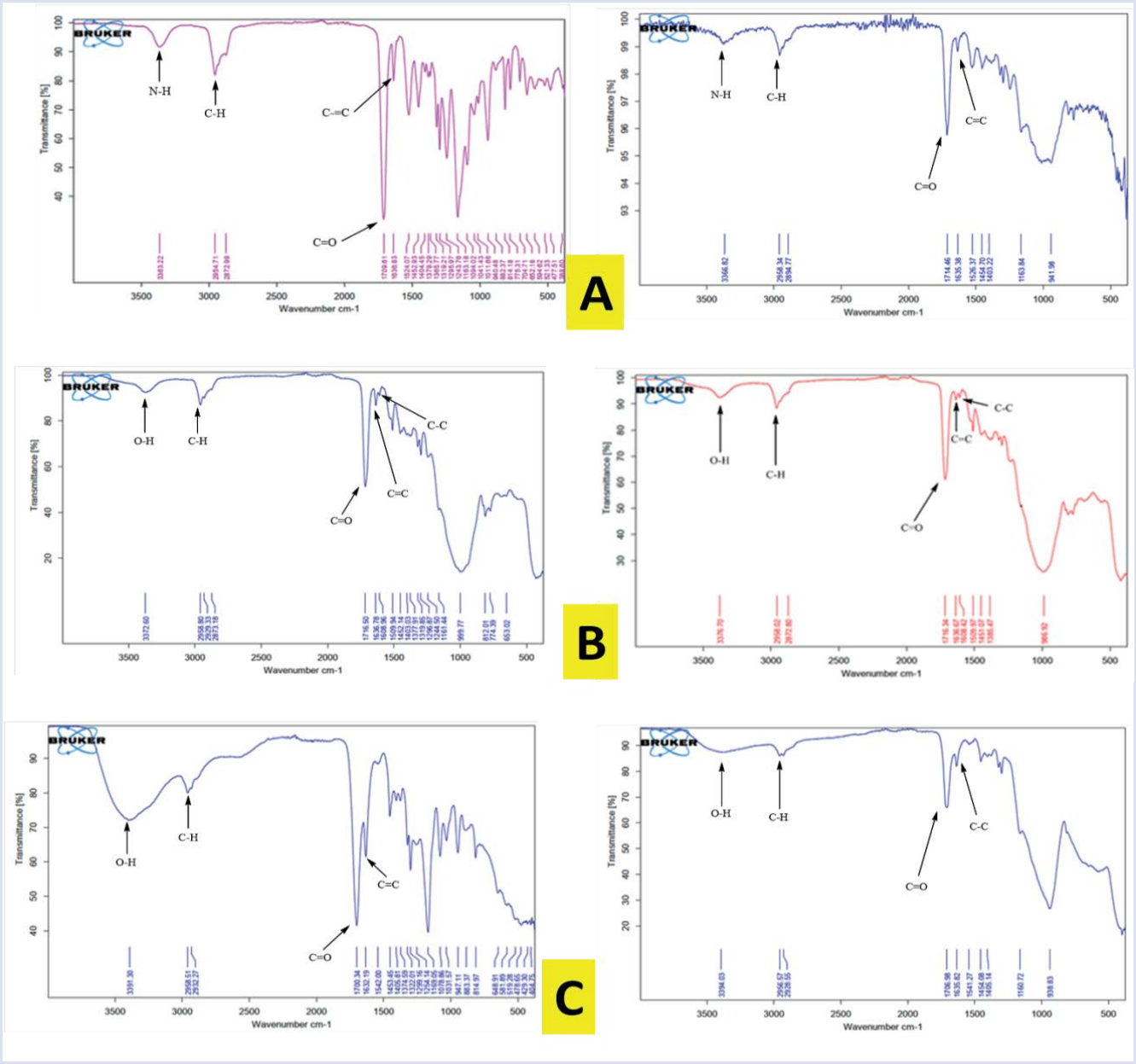

Figure 2: degree of conversion before polymerization and after polymerization A-alkasite B- nanohybrid composite C- RMGIC

now are their ability to tolerate stress, durability, mediocre sealing integrity, and aesthetics.[35] Marginal integrity refers to how close a restoration is to the surface of a tooth. The restorations appearance and durability are influenced by this aspect. To evaluate the marginal seal of a restoration to the tooth structure, marginal adaption measures can be employed.[36]

Internal adaptation on other hand is one of the most important factors that may affect the durability and strength of a restoration because of microgap creation caused by localized bond failure at the tooth-restorative interface. One of the primary issues with resin based restorations is polymerization shrinkage, which can result in the creation of micrgaps at the external and interior tooth restoration surfaces.[37] It is more difficult to measure inner adaptation than marginal microleakage because the material has greater difficulty adapting to the deepest empty region compared to other contact points.[38]

To ensure the therapeutic relevance of marginal and internal adaptation, restorative materials with the right clinical performance and durability should be used. In order to establish the best possibilities for recovering class V cavity preparation. This study analyzed three regularly used and one recently introduced restorative materials, which is alkasite in two conditions, one with and one without bonding. The null hypothesis was rejected when it came to the restoration materials used in the current study since their effects on the internal and marginal adaption at the restoration/tooth interface were significantly different. In this study, the nanohybrid composite displayed the highest gab volume among the other four groups.

Microgaps may emerge at the tooth restoration interface as a result of composites' higher polymerization shrinkage caused by their high C-factor.[39] RMGIC and GIC show the less mean of gab volume among other tested groups. (0.2810 and 0.1951 mm respectively) as shown in Table (2), such differences could be related to the nature of the material where the tension caused by induced polymerization shrinkage can be reduced since RMGI has a lower modulus of elasticity than composite

resin. A substance with a low modulus of elasticity can flow plastically and relax under tension more easily during polymerization.[40]

According to studies[41] and[42] RMGI cements and composite resins both absorb water. Hygroscopic expansion after water sorption may help to partially reduce polymerization shrinkage in the humid oral environment. Hygroscopic expansion can therefore be employed to reduce marginal gaps brought on by polymerization shrinkage. The manner by which a restorative material can absorb water is regulated by diffusion throughout the resin matrix. The hydrophilicity/hydrophobicity of the resin matrix and the filler level/resin content ratio regulate the diffusion coefficient of water sorption. Numerous research demonstrated that the investigated nanofilled composite resin has less water sorption than the investigated RMGIC, and this related to the fact that the RMGI cement's hydrophilic resin matrix (HEMA) and polyacrylic salt network.[20]

Superior marginal and internal adaptation was obtained in this study for alkasite whether with or without bonded (0.7800 and 0.4752 mm respectively), over nanohybrid composite (1.1374 mm) was recorded in this study as shown in Table (2). Interfacial gap development is correlated with polymerization stress and degree of conversion. The filler/resin ratio and resin content have an impact on DC. Alkasite and the nanohybrid composite don't have the same resin content (Table 1). The alkasite (Cention -N) is a UDMA-based polyme, whereas the nanohybrid composite used in this study (Tetric N-Ceram) is a Bis-GMA-based composite resin. Compared to UDMA monomer, Bis-GMA monomer has a lower DC but a larger molecular weight and viscosity. Panpisut and Toneluck[43]discovered that alkasite had a greater monomer conversion rate (which is also consistent with the findings of this study). As a result, it is expected that alkasite will have a higher microleakage score. However; There are additional factors that might make up for the increased DC.

Additionally, this finding is consistent with earlier research by Samanta *et al.*[7] who stated that alkasite has a shrinkage stress reliever that lessens polymerization shrinkage and microleakage because of its low modules of elasticity (10 GPa) which related to the alkasite contained of patented isofiller filler acting as a stress reliever for shrinkage. Therefor; by reducing the shrinkage force, which what causes higher adaptation and result in low volumetric shrinkage and minimal microleakage. Similar to this study, a work done by Recen and Yazkan[44] who investigated microleakage of different self-adhesive restorative materials and the concluded that due to the improved ability of enamel and dentin sealing, alkasite with adhesive might be a better substitute for nanohybrid composite. The result of this study disagree with George and Bhandary[45] who compared and evaluated the microleakge of alkasite. GIC and resin composite and found that Alkasite has higher sealing ability since it experiences less microleakage than GIC and composite restorations.

Also, comparing conventional alkasite and bonded alkasite, with the use of bonding, our results did not provide an obvious improvement in marginal and internal adaptability as shown in Table (4) ($P>0.05$). It demonstrates that the adhesive resin's ability to provide micromechanical retention has no effect on the marginal adaption of cavities that have been repaired with this material. The universal bonding greater capacity to bond to dental margins and smear layers may be related to its hydrophilic character and ability to moisten the tooth surface, which are correlated with the presence of a hydrophilic dimethacrylate (polyethylene glycol dimethacrylate) in its resin composition (Table 1).[6] This result came with agreement with what was reported by Firouzmandi.[46]

As usual, the cervical dentin was the most vulnerable edge area, and for all the materials examined, gingival gaps significantly increased, as described in other research by Omidi *et al.*[47] This might be explained due to the little or complete absence of enamel which contain higher mineral content as compared to dentin. The gingival border of the cavity compose mainly of dentinal structure with a tubular shape and innate wetness that affects the quantity of surface energy and deteriorate chemical bonding or infiltration (dentin has more flows than enamel, which is a powerful substrate for bonding).[48]

Adequate polymerization of all resin based restorations is key elements impacting their clinical efficiency. An essential technique for estimating the physical, mechanical, and biological aspects of composite resin restorations is the degree of conversion. Superior physical and mechanical qualities can only be attained with a higher degree of polymerization.[49] It's possible for inadequate polymerization to cause minor microleakage, coloring, and weaken bonding in resin composite restorations. A lesser degree of conversion may also result in more released unreacted monomer, which would make the restorations less biocompatible. Functional groups that haven't fully cured can also serve as plasticizers, resulting in restorations with worse mechanical qualities. Additionally, oxidation and hydrolytic breakdown brought on by monomer trapped in the restoration may accelerate wear and create discoloration.[50]

In order to determine the extent of the reaction, the residual carbon=carbon double bond in resin based restorations was evaluated. By employing FTIR-ATR, the DC was measured. As it detects the c=c stretching just before and after composite resin has cured, FTIR is a commonly utilized as an acceptable and reliable approach[51]. In this investigation of three different types of restorative materials using FTIR-ATR, double bonds were still present for resin compounds to be examined. It was seen that the beam's shape changed when its intensity at 1637 cm^{-1} decreased and the remaining bundles appeared as predicted, whether for the monomer or the polymer as seen in figure (2).[52]

In the present study, alkasite exhibited higher DC% as compared to the nanohybrid composite and RMGIC after 20 second of light curing (61.36%) and after 24 hours' storage (93.24%) as shown in Table (5). Therefore, the null hypothesis that there was no significant difference in degree of conversion among different group of restorations was rejected.

The matrix resin used in nanohybrid composite (Tetric® N Ceram) is a combination of urethane dimethacrylate (UDMA) and bisphenol A diglycidyl ether dimethacrylate (Bis-GMA), but its composition is dominated by Bis-GMA. The Bis-GMA, which has bigger and heavier molecules than other matrix resins, dominates the composition of the material. A strong hydrogen bond between the hydroxyl groups (-OH) on the carbon backbone of bis-GMA and the presence of aromatic rings in its structure lead to the assumption that it is the most viscous monomer currently available[53]. Tetric® N's UDMA monomer Ceram is a low viscous monomer, however because to the weak hydrogen connection between the amine group and the hydroxyl groups in UDMA, it has a significantly lower viscosity and is more flexible than Bis-GMA. Therefore, The mobility of monomers in the polymerizing process of Tetric® N Ceram can be decreased by raising the concentration of bis-GMA which in turn decrease DC.[27]

The primary base monomer contained in alkasite is urethane dimethacrylate (UDMA), which has a significantly lower viscosity and more flexibility than Bis-GMA (which makes the majority of base resin monomer in the tested nanohybrid composite (Tetric® N Ceram) this might be the main reason that alkasite has a higher DC than nanohybrid composite in this study which was also agreed with Gomes de Araújo et al.[54] whose objective was to assess degree of conversion and maximum rate of polymerization using micro-Raman spectroscopy of seven different dental composites including alkasite and concluded that Monomer composition and characteristics of filler particles greatly influenced the DC of the tested resin based composite

The above findings were disagree with Puspitasari *et al.*[55] who assessed monomer conversion of alkasite compared with resin modified glass ionomer cements and conventional composite, and concluded that . alkasite exhibited monomer conversion higher than the composite but lower DC than RMGIC and attributed the cause to the fact that the primary base monomer contained in RMGIC(GC Fuji II) is 2-hydroxyethyl methacrylate (HEMA) which is a low molecular weight monomer and demonstrated greater monomer conversion than alkasite and composite[56]. With storage for a week, the composite's DC value rose (as shown in Table (5). This is due to the fact that the polymerization process in light-activated composites continues for some time after the light source has been removed, and the DC exhibited a progressive rise following light exposure and storage in saliva.[57] This outcome, which was in agreement with Gahse *et al.*[58] who demonstrated that a resin composite conversion rate with water storage rose considerably after one month. The current study may not accurately represent the oral environment because it was an in vitro investigation with a limited sample size. Therefore, more research with a larger sample size and in vivo settings is required also using far better resolution, such as that seen in nano-CT, may make it possible to more accurately detect interfacial gaps.

CONCLUSION

Alkasite restorations wither with or without bonding show higher marginal and internal adaptation in comparison with nanohybrid composite but lower than that of GIC and RMGIC. There was no difference in marginal and internal adaption between alkasite with bonding and alkasite without bonding. Alkasite restoration showed higher degree of conversion when compared with nanohybride composite and RMGIC after 20 second and 24 hours of polymerization

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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