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Evaluate the Shear Bond Strength for Alkasite in Comparison with other Esthetic Restorative Materials

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Abstract

Aims: To assess and compare the shear bond strength of alkasite restoration, as well as, to compare the shear bond strength between alkasite with and without bonding. **Materials and methods:** Twenty-five permanent maxillary premolars were used in which, with diamond disks, their buccal surfaces were flattened until a clear superficial dentinal surface could be seen. Samples were randomly assigned to five groups (n=5). 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 inomer cement. Following the recommendations of the manufacturers, cylinders of the five restorative materials were bonded to the buccal surfaces. Following 24 hours storage at 37°C. The evaluation of shear bond strength was employed by the use of the universal testing machine. Under a stereomicroscope (×20), the fracture mode was determined. Data were statistically analyzed using a nonparametric independent sample Kruskal-Wallis test at the confidence level of 95%. **Result**: There were statistical differences among groups and there was a significant difference between the alkasite with and without bonding. **Conclusion**: Alkasite with bonding showed a higher shear bond strength in comparison with GIC and resin-modified GIC, but still lower than that of nanohybrid composite Moreover, the shear bond strength of alkasite highly improved with the use of bonding.

تقييم قوة رابطة القص للألكاسيت بالمقارنة مع المواد التعويضية الجمالية الأخرى

الملخص
الأهداف: تهدف الدراسة الى تقييم ومقارنة قوة رابطة القص للترميمات الالكاسيت ، وكذلك ، لمقارنة قوة رابطة القص بين الكاسيت مع أو بدون استخدام اللاصق. **المواد وطرائق العمل**: تم استخدام خمسة وعشرين سنا من الضواحق العلويه الدائميه. حيث تم جعل أسطحها الشدقية مسطحة بقرص ماسي حتى تم الكشف عن سطح عاج سطحي واضح. تم تقسيم العينات بشكل عشوائي لخمس مجموعات (لكل مجموعه خمسه اسنان) اعتماده على الماده المستخدمه للترميم. المجموعة 1: ألكاسيت بدون لاصق ، المجموعة 2: ألكاسيت مع مادة لاصقة ، المجموعة 3: مركب راتنجي نانو هجين ، المجموعة 4: اسمنت شاردي الزجاجي, مجموعة 5: إسمنت زجاجي معدل بالراتنج. تم لصق أسطوانات من المواد الترميمه الخمس بسطح الشدق وفقًا لتعليمات الشركات الصانعة. بعد 24 ساعة من التخزين عند 37 درجة مئوية. تم استخدام تقييم قوة رابطة القص عن طريق استخدام آلة اختبار العام. وتم تحديد وضع الكسر تحت مجهر مجسم بتكبير 20 *. تم تحليل البيانات إحصائياً باستخدام عينة مستقلة غير معلمية باختبار Kruskal-Wallis بمستوى ثقة 95٪. **النتائج**: توجد فروق احصائية بين المجموعات وكان هناك فرق معنوي بين الكاسيت مع وبدون استخدام اللاصق. **الاستنتاجات**: يُظهر الكاسيت مع الترابط قوة رابطة قص أعلى من الاسمنت الشاردي الزجاجي والإسمنت الزجاجي المعدل بالراتنج ، ولكن لا يزال أقل من المركب الراتنجي النانو هجين علاوة على ذلك ، تحسنت قوة رابطة القص للكاسيت بشكل كبير باستخدام اللاصق.

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INTRODUCTION

Various restorative materials can be used to repair damaged teeth. The purpose of a restorative material is to restore the biological, functional, and aesthetic qualities of the tooth structure. In dentistry, a variety of direct filling materials are available, including composite material, glass ionomer cement (GIC), and amalgam. Resistance to masticatory forces (compressive and flexural) is one of the most crucial factors that ensure the durability and efficacy of restorative materials. Every one of these restorative materials has benefits and drawbacks, so making the right choice will be essential for clinical success(1). A main affecting factor for maintaining a restoration chemically bonded to the tooth structure is its ability to withstand shear stresses (that can be defined as the stresses created at the interface between restoration and tooth surface) which are caused by perpendicular or parallel forces acting on the tooth surface(2).

Alkasite restorations (Cention n) were introduced in 2016 as a tooth-colored, basic filling material for bulk direct placement in retentive cavity preparations with or without the application of adhesive bonding(3).

Alkasite is a new category of filling material, considered as a sub-group of resin composite. It`s a urethane dimethacrylate (UDMA) based restoration. It comes in powder and liquid restorative form. The powder contains various glass fillers, initiators, and pigments, whilst the liquid is made up of dimethacrylates and initiators(4).

Alkasite contains special potent fillers including a load of glass, aluminum, and fluorosilicate barium of calcium and fluorsilicate glass of calcium, with a particle size of range 0.1-35 µm which keeps shrinkage stress to a minimum. The fillers act as shrinkage stress relievers which minimize shrinkage force. This is attributed to the material being partially silanised.

The alkasite is a bioactive restorative material for direct restorations, it is dual curable, light curing is additional and optional, and available in VITA shade A - 2, radiopaque (3). This reparative material is designed to be used as temporary and permanent restorations in Class I, II, or V, it does not require a bonding agent however the alkasite can be used with or without adhesive; adhesive could be avoided but the prepared cavity would require a retentive preparation (convergence) similar to that used with amalgam. If used with an adhesive, the cavity preparation is accomplished according to modern principles of minimally invasive dentistry (5).

Further knowledge of alkasite restoration in comparison with other commonly used restorations regarding bond strength is necessary. For this study the null hypothesis stated that the shear bond strength was not significantly different among different groups of restorations and between alkasite used alone or was used with bonding.

MATERIALS AND METHODS

Materials used in this study, their composition, and manufacture information are listed in Table (1).

Table (1): composition and manufacturer of the materials used in the study

materials	composition	Manufacturer
Cention n	UDMA, DCP, Aromatic aliphatic-UDMA PEG-400 DMACa-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 alumino 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 Liechtenste
Cavity conditioner	Poly acrylic acid	(GC Corp., Tokyo, Japan)

A twenty-five-sound maxillary permanent first premolar teeth caries free, non-restored, extracted for orthodontic purposes for patients with age in between 16-25 years were selected for use in this study. The teeth had been cleaned from calculus deposits and adhering soft tissues with the use of hand scaler. The teeth were polished with pumice and water using a prophylaxis rubber cup and rinsed with water. Each tooth were examined for the presence of cracks under stereomicroscope (optika microscopes;Italy) and the ones that displayed any flaw were excluded from the study. The teeth were stored in normal saline at room temperature (23±2°C) until the day of use[(6).]

The teeth had been randomly divided into 5 groups (n=5) according to the type of restoration used.

The 25 samples were mounted by self-cure acrylic resin and with the help of molds of 2.5cm diameter and 2cm height for standardization. The mold was mounted on surveyor and the teeth were placed with the help of surveyor vertical arm in such way that the buccal surfaces were parallel to the surface of the acrylic resin block with enamel exposed up word. A diamond disk was used to reduce and flatten the buccal surfaces by 1mm such that the clear superficial dentinal surface could be seen on the middle and cervical third. Wet silicon carbide paper was then used to polish the prepared dentine surfaces[7].

A translucent plastic mold tube (2mm in height and 3mm in diameter) was stabilized on the dentine surface with the aid of orthodontic wax[8].

Then the samples were randomly divided into five groups based on the tested restorative materials as follows:

Group I: alkasite without adhesive.

Alkasite was prepared in accordance with the recommendations provided by the manufacturer transferred to the translucent plastic tube and applied to the dentin surface using a plastic tool and stainless-steel condenser. The specimens were left undisturbed for four to five minutes until the material was set[9].

Group 2: alkasite with adhesive.

The dentine surfaces were covered with bonding Tetric-N Bond universal adhesive (Ivoclar Vivadent, Schaan, Liechtenstein) using a disposable micro brush. The surface was gently thinned by oil-free air for five seconds and light cured using a light-emitting diode (Woodpecker LED.H) curing unit with a standard mode and energy output of 800 mW/cm2 at a distance of 2mm for 20 seconds. alkasite was mixed and delivered into the mold with the same sequence as in group 1(9).

Group 3: Nanohybrid composite.

The dentine surfaces were covered with bonding agent Tetric-N Bond universal adhesive using disposable microbrush and light cured for 20 seconds. The translucent plastic tube was filled with Tetric-N Ceram nanohybrid composite resin (Ivoclar Vivadent, Schaan, Liechtenstein) restorative composite materials in 2 mm increments at room temperature (23 ± 1 °C) and were light-cured for 20 seconds(10).

Group 4: Glass ionomer cement.

Cavity conditioner (GC Corp., Tokyo, Japan) was applied to the prepared surfaces for 10 seconds with a cotton pellet, then the conditioned surfaces were washed with water and dried. One level scoop of the powder and one drop of the liquid were placed on a mixing paper pad. The powder was mixed with the liquid according to the manufacturer's instructions within 25 seconds until achieved a homogenous mass then applied and packed in one increment into the translucent plastic tube with a condenser. Afterward, it was left to set for 5 minutes(11).

Group 5: Resin-modified glass ionomer cement.

Cavity conditioner (GC Corp., Tokyo, Japan) was applied to the prepared surfaces for 10 seconds with a cotton pellet, then the conditioned surfaces were washed with water and dried. One level scoop of the powder and two drops of the liquid were placed on a mixing paper pad. The powder was divided into two halves and mixed with liquid according to the manufacturer's instructions within 25 seconds until a homogenous mass was achieved and applied and packed in bulk into the translucent plastic tube with a condenser. Afterward, it was polymerized for 20 seconds using an LED curing unit at a distance of 2mm(11).

The translucent plastic tube then was cut off gently with a scalpel and carefully removed from cured restorative materials then specimens were stored in an incubator with distilled water (Jard incubator, Syria) before testing at 37 ± 1 °C for 24 h.

The SBS was measured by a universal testing machine (Gester, Gester International Co. China). Load was applied with a chisel blade in a perpendicular direction to the restoration-tooth interface at a crosshead speed of 0.5mm/minute until bond failure occurs. The SBS (measured in MPa) was estimated by dividing the force value obtained after the debonding of the samples (measured in N) by the bonding area (mm^2)(12).

The shear bond strength equation is:

SBS=F/A

Where: SBS= Shear bond strength (Mpa).

F=force value at failure (N).

A(area)=πr^2

π =3.14

r= bonding area radius.

The mode of failure for all samples was evaluated under a stereomicroscope (optika microscopes;Italy) at x20 magnification. The mode of failure had been classified to: adhesive (at the dentin-restorative material interface), cohesive (within the dentin substrate or restorative material), and mixed (a combination of both adhesive and cohesive failures)(13).

The statistical analysis of the shear bond strength results obtained in this study was done using the SPSS (Statistical Package for the Social Science, version 25.0) The data were statistically analyzed using a nonparametric 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.

RESULTS

Descriptive statistic including the mean and standard deviation (SD) of shear bond strength in (MPA) for the different types of restorative material and Independent-Samples Kruskal-Wallis test was performed to analyze the presence of statistically significant differences as shown in Table: (2). The results showed that there were statistically significant differences among all groups tested in the present study ($P \leq 0.05$).

Table (2): Descriptive statistic & Independent-Samples Kruskal-Wallis Test Summary of SBS of the tested groups

groups	Mean value & SD	minimum	maximum	Sig.
Alkasite without bonding	0.8042±0.22128	0.55	1.11	
Alkasite with bonding	5.7984±1.51688	4.06	8.08	
Nanohybrid composite	11.4098±3.23479	8.81	16.47	
GIC	5.2694±2.65645	1.45	8.43	
RMGIC	4.8470±0.79600	4.34	6.22	.001

To determine the level of significance that was obtained, the Dune New Multiple Range Test showed that the SBS of the nanohybrid composite was significantly higher than all other types of restorative materials ($p \leq 0.05$) as shown in Figure (1).

To determine the effect of bonding application on SBS for alkasite restoration, the Wilcoxon test showed that there was a significant difference between the Alkasite with and without bonding ($p \leq 0.05$) as shown in Table (3).

The failure mode of the shear bond test of all specimens of groups observed under a stereomicroscope as shown in Figure (2) revealed:

- Adhesive failure for all Group I sample
- Groups 2 and 3 samples showed mixed failure. (Group 2 exhibited failure within the material of the mixed failure),
- Groups 4 and 5 exhibited predominantly adhesive failure,

Table (3): Wilcoxon showed the difference between Alkasite with and without bonding for SBS

groups	Mean value & SD	Sig.
Alkasite without bonding	0.8042±0.22128	0.043
Alkasite with bonding	5.7984±1.51688	

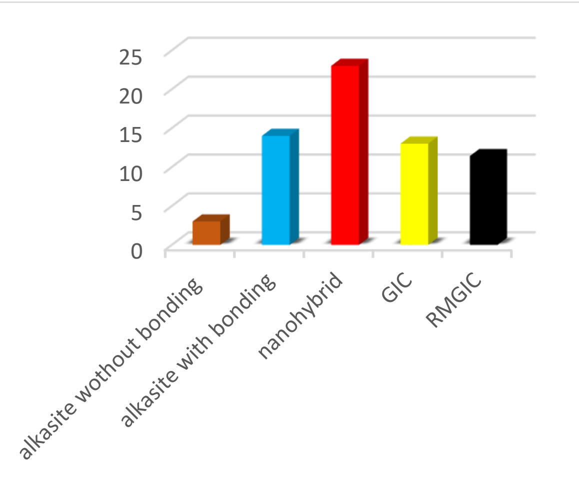

Figure (1): Column graph for Dune Multiple Range test showed the shear bond strength of the tested restorative materials.

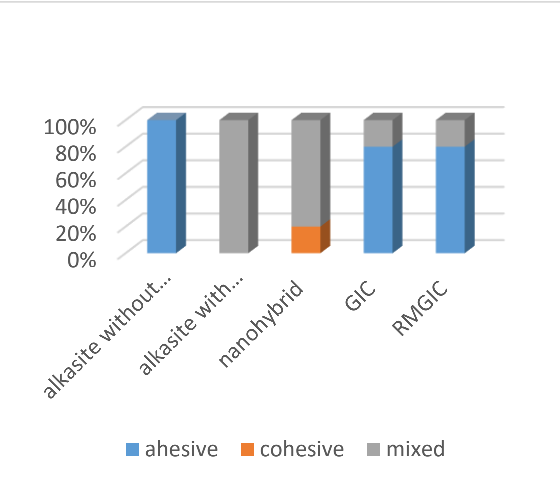

Figure (2): Failure mode distribution of tested restoration

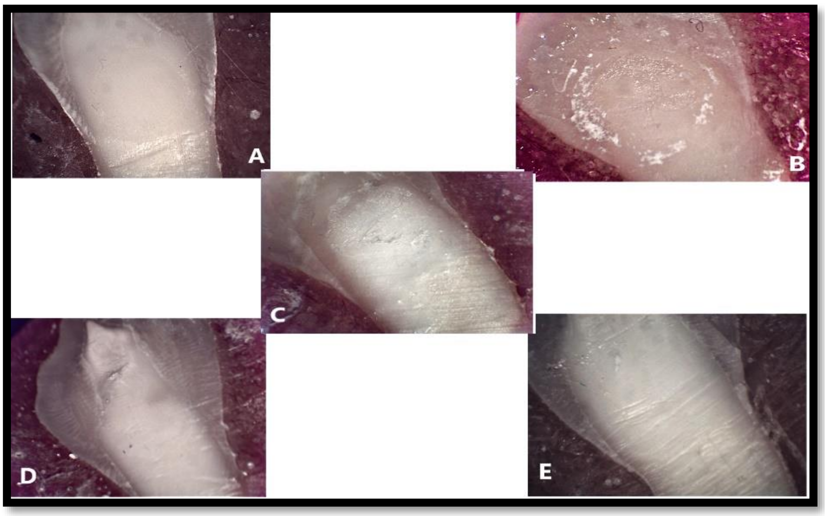

Figure (3): mode of failure (A) alkasite without bonding (B) alkasite with bonding (C) nanohybride composite (D) GIC (E) RMGIC

DISCUSSION

The SBS measurements are basic ways to assess how well restorative materials adhere to dentin. Stress is transferred differently between a restored tooth and an intact tooth. Various type of forces applied on the restoration will result in the restoration compressing, tensile, or shearing along the tooth restoration interface, which will result in a complex stress distribution that combines compressive, tensile, and shear stresses.

Bond strength values are a broad method to assess the efficiency of bonding dental restorations to dentin. Of different kinds of tests, the SBS test highlights the strength at the bonded interface since it is less technique-sensitive than the other tests(14).

The null hypothesis was rejected since there were significant differences across materials in bonding values and failure patterns. All materials tested with an adhesive showed higher SBS values

The Mean Shear Bond strength values collected in this study is: nanohybrid composite > alkasite with bonding> GIC> RMGIC > alkasite without bonding as shown in Table (2). Higher shear bond strength suggests better bonding of material (nanohybrid) to tooth. In this study, SBS of alkasite without bonding obtained was 0.8042 Mpa. It exhibited the least bond strength

The alkasite with bonding and nanohybrid groups had the greatest SBS values, the majority of failure mods in these groups were mixed due to the use of universal adhesives which develop a firm bonding to dentin. The chemical reaction between the Tetric N- Universal Bond acidic functional monomer and the calcium in dentin result in promoting adhesive wettability and micromechanical retention; as well as, higher resin monomer content in alkasite that promotes strong co-curing with the adhesive[15].

In comparison to GIC and RMGIC (5.2694 and 4.8470 Mpa respectively), alkasite with bonding demonstrates to have a greater SBS (5.7984 Mpa). The unique composition of alkasite, which includes a hydrophilic dimethacrylate resin, such as PEG-400 DMA, in the liquid, can be attributed for the higher binding strength. This dimethacrylate resin may have had a substantial impact on binding strength. Additionally, it might minimize shrinkage pressures on the tooth-restorative interface by acting as a shrinkage stress reducer[16].

Regarding the GIC and RMGIC group, the use of cavity conditioner with the polyacrylic acid (Table 1) on the dentin surface results in demineralizes the surface dentin and removal of both smear layer and intertubular plugs.

The SBS results for RMGIC are explained by the presence of light activating monomer (HEMA) with its higher wetting ability. The network of exposed collagen is penetrated by the HEMA of hybrid ionomers, creating a thin layer of micromechanical retention at the interface. This may be accelerating by the use of light-curing materials as well as by ion exchange at the interface between dentin and glass ionomer[17].

For the GIC the bond occurs as a result of the creation of hydrogen bonds between the free carboxyl groups of the restoration and the bound water on the tooth's surface. The cations in the tooth and the anionic functional groups in the cement gradually replace these hydrogen bonds with real ionic ones. This would result in the slow formation of ion-exchange layer between the tooth and the restoration[18].

The current findings for alkasite without bonding, however, are easier to understand (0.8042 Mpa) because neither polyacrylic acid nor acidic monomers are present in this substance. These results validate the systematic application of an adhesive system[19].

These result came in agreement with Eligeti et al. (2021) (20) who evaluate the SBS of alkasite with adhesive and recent tooth-colored restorative materials to dentin and conclude that alkasite with adhesive exhibited higher SBS and is statistically significant when compared to RMGIC

This result of this study also agreed with Naz et al. (2021) [13] who compared physical and mechanical performance including SBS alkasite with glass ionomer cement (GIC) and nano-hybrid composite and found for shear bond strength, alkasite and nanohybrid composite have significantly high values than GIC.

Most failures for the alkasite with bonding and nanohybrid groups were mixed (as shown in Figure (2) because of the strong bond to dentin created by universal adhesives, while the majority of the other groups (GIC, RMGIC, and alkasite without bonding) show adhesive failures.

The final mean values of SBS are determined by several variables, and no one study appears to replicate another one in this area. The state of mineralized dentine, the method of etching, the kind of adhesive bonding and composite utilized, the depth of dentine, the moisture conditions of the substrate, the curing mode, and the amount of time spent storing the restoration thereafter are a few of the identified parameters impacting the bond strength of any restorative material[(21),(22).]

CONCLUSION

Given the limitations of this study, alkasite with bonding provided a resin-dentin shear bond strength that was higher than GIC and resin-modified GIC, but still lower than SBS of nanohybrid composite. Moreover, the shear bond strength of alkasite highly improved with the use of bonding

Conflicts of Interest

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

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