Microtensile Bond Strength, Marginal Leakage, and Antibacterial Effect of Bulk Fill Resin Composite with Alkaline Fillers versus Incremental Nanohybrid Composite Resin

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Abstract

Objective This study aimed to investigate the microtensile bond strength (μTBS), microleakage, and antibacterial effect of bulk fill resin composite with alkaline fillers (alkasite) (alkaline fillers such as barium aluminum silicate glass and ytterbium trifluoride) in comparison to incremental nanohybrid resin composite.

Materials and Methods μTBS was evaluated by using 30 human mandibular molars. Teeth were randomly divided into three groups (C): nanohybrid resin composite (C0), self-cured alkasite (C1), and dual-cured alkasite (C2). Each group was subdivided into two subgroups according to the bulk thickness: 4 mm (T1) and 6 mm (T2). The occlusal enamel of teeth was removed and the resin composite was applied to a flat dentin surface. Then, teeth were sectioned into beams to be tested under tension. For microleakage testing, mesio-occlusal class II cavities were prepared in 15 molars and divided into three groups as mentioned before. Following this, cavities were restored, thermocycled, immersed in a dye, sectioned mesiodistally, and then dye penetration was assessed. The antibacterial effect of both tested materials was evaluated using agar disc diffusion and broth dilution methods against chlorhexidine as a control positive group.

Results There was no significant difference in μTBS between all tested groups. Bulk fill self-cured alkasite showed the lowest microleakage value followed by bulk fill dual-cured alkasite and incremental nanohybrid resin composite, respectively. Also, cervical microleakage showed significantly higher mean value than the occlusal one. The antibacterial effect of alkasite was less than chlorhexidine. Alkasite showed maximum broth clarity at lowest tested bacterial concentration.

Conclusion Resin composite with alkaline fillers was characterized by good μTBS and marginal integrity with weak antibacterial effect.

Keywords
- alkasite
- microtensile bond strength
- microleakage
- antibacterial effect

Introduction

Contemporary resin composite materials are typically based on dimethacrylate resins that harden by free radical polymerization.[1] Visible light activation is the primary way to trigger the polymerization reaction.[2] Basically, polymerization occurs by adding dimethacrylate monomer molecules resulting in rapid growth and cross-linking of polymer chains.[3] Unfortunately, the emitted light energy dramatically decreases when transmitted via resin composite material resulting in a gradual decrease in its degree of polymerization especially at an increasing distance from the irradiated surface.[4] This decrease in the degree of polymerization jeopardizes physical properties and increases the elution of residual monomer from

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the resin composite material. Also, it may result in premature failure of a restoration that may affect the pulp tissue adversely.[5] Therefore, to overcome all these drawbacks, incremental application of resin composite material was used as a gold standard method for resin composite application.[6] In general, the maximum increment thickness was determined as 2 mm.[7] However, it was found to be time and effort consuming and may imply a risk of air bubble incorporation or contamination between the increments. Therefore, manufacturers introduced types of resin composites material "bulk fill" which are believed to be curable to a maximum increment thickness of 4 mm.[8]

One of the drawbacks of the available bulk fill resin composite is having maximum curing depth not more than 4 mm.[9] Beyond fast processing and adequate curing in large increments, bulk fill resin composite requires additional features, such as bioactivity.[10] So, a self-/dual-cured resin composite material with alkaline fillers categorized as "alkasite" was introduced to the market as bulk fill material. It was claimed that this material contains alkaline glass fillers capable of releasing substantial levels of fluoride. Besides this bioactivity, the manufacturer claimed that the material was characterized by an increased degree of polymerization in increment thickness more than 4 mm, due to its availability in both self-/dual-cured modes.[11] As a trial to investigate these manufacturer's claims, the aim of the current study was directed at evaluation of microtensile bond strength (µTBS), marginal integrity, and antibacterial effect of this bulk fill resin composite material with alkaline fillers.

Materials and Methods

Materials' description, composition, manufacturers, and batch numbers are presented in ►**Table 1**.

Microtensile Bond Strength Test

Thirty human impacted mandibular third molars freshly extracted for orthodontic distalization from patients in the age range 20 to 30 years were collected and used for preparation of µTBS testing samples. Then, teeth were thoroughly washed under running water to remove blood and mucous, scaled to remove calculus and remnants of periodontal ligaments, and polished with fine pumice and soft rubber cups at conventional speed. Teeth were used with approval from the Research Ethics Committee of Faculty of Dentistry, Suez Canal University, Egypt (number 16/20170. Removal of the occlusal enamel and exposing of deep dentine was performed after fixing of each tooth in an acrylic resin block using automated diamond saw (Isomet 4000, Buehler Ltd., Lake Bluff, United States). Exposed dentin surfaces were further polished for removal of any debris with 600-grit silicon carbide sandpaper for 60 seconds. Then, samples were divided into three groups according to used resin composite material (n = 10), where C0, nanohybrid resin composite; C1, self-cured Cention N; and C2, dual-cured Cention N. Each group was further subdivided into two subgroups according to the thickness of the resin composite material, where T1, 4 mm and T2, 6 mm.

The occlusal surface of each tooth was etched and the adhesive system (Futurabond M+, Voco GmbH, Germany) was applied according to the manufacturer's instructions. For all teeth, resin composite was packed on the occlusal surface using a Teflon mold especially constructed for each thickness (8 × 8 × 4 and 8 × 8 × 6). Composite buildup of C0 group was done incrementally using nanohybrid resin composite. For preparation of C1 and C2 samples, Cention N was prepared by manual mixing of one measuring scoop of powder and one drop of liquid according to manufacturer's instructions. Where samples of C1 group were chemically cured and those

Table 1 Materials' description, composition, and manufacturers

Materials	Description	Composition	Manufacture	Batch numbers
Meta Etchant	Etchant gel	Nondripping gel consistency 34.9% phosphoric acid Blue color for visual control	Meta Biomed Co., Ltd.; Cheougja City, Chungbuk, Korea	1906071
Futurabond M+	Universal adhesive	Hydroxyethyl methacrylate (10–25%), BIS-GMA (10–25%), ethanol (10–25%), acidic adhesive monomer (2.5–5%), urethane dimethacrylate (2.5–5%), catalyst, and camphorquinone	Voco GmbH	1801228
Grandio	Nanohybrid resin composite shade A2	Resin: Bis-GMA, TEGDMA. Filler: Ba–Al–Si glass/silica nanoparticles. Inorganic filler loading is 89% by weight and 71.4% by volume with a particle size range of 20–40 nm	Voco GmbH	1702120
Cention N	Resin composite with alkaline fillers Cention N shade A2	Powder: calcium fluorosilicate glass, barium glass, calcium–barium–aluminum fluorosilicate glass, isofillers, ytterbium trifluoride, initiators, and pigments. Cention N contains 78.4 wt% or 57.6 vol% of inorganic fillers Liquid: dimethacrylates, initiators, stabilizers, and additives	Ivoclar Vivadent; Schaan, Liechtenstein	X40020

of C2 group were light activated using light curing unit (Elipar S10; 3MESPE, St. Paul, Minnesota, United States).

Each sample was mounted in the gripping attachment and serially sectioned perpendicular to the bonded interface using 0.3-mm-thick diamond-coated disc mounted in microsaw (Isomet 4000, Buehler Ltd.) under copious coolant. The resultant beams were 0.9 ± 0.1 mm in thickness and 6 ± 1 mm in length for T1 group and 8 ± 1 mm for T2 group. A digital caliper (Mitutoyo, Japan) was used to check the thickness and length of all beams.[12]

The prepared beams were used for assessment of µTBS using universal testing machine. Each beam was aligned in the central groove of the Geraldeli's jig and glued in place by its ends using cyanoacrylate-based glue (Zapit, DVA Inc, United States). The jig was in turn mounted into the universal testing machine (Instron, Massachusetts, United States) with a load cell of 500 N, at a cross-head speed of 0.5 mm/min, until failure of the specimen occurred. Bond strength was calculated in Mega Pascal (Bluehill Lite software, Instron).[13]

Microleakage Assessment

Fifteen human impacted mandibular third molars freshly extracted for orthodontic treatment from patients in the age range 20 to 30 years were collected and cleaned. Standardized mesio-occlusal cavities were performed (5 mm buccolingual width, 2 mm in depth, and 2 mm axial depth). Teeth were then randomly assigned to three experimental groups ($n = 5$) according to the resin composite material (C0, C1, and C2) as mentioned in µTBS test. Tofflemire metal matrix holder was securely adjusted to encircle the prepared cavity of each tooth after fixing of each one in acrylic resin mold.[14] All samples were etched and the adhesive system (Futurabond M+, Voco GmbH, Germany) was applied according to manufacturer's instructions. Restoration of samples of C0 group was done incrementally using Grandio nanohybrid resin composite and polymerized according to manufacturer's instructions. For restoration of C1 and C2 samples, Cention N was applied as bulk according to manufacturer's instructions. As described for microtensile testing samples of C1 group were chemically cured and those of C2 group were light activated using light curing unit.

All restored samples were thermocycled for 1,000 cycles in a water bath at 5°C followed by 55°C.[15] After thermocycling, each tooth's apex was sealed with wax and its entire surface was covered with two layers of nail varnish.[16] All teeth were immersed in 0.1% methylene blue stain for 24 hours at room temperature, then removed and rinsed thoroughly under running water and sectioned mesiodistally. Dye penetration along both occlusal (O) and gingival margins (G) was evaluated at ×50 magnification with a stereomicroscope (Nikon MA100 stereomicroscope, Japan). Each image of the restoration was captured and transferred to a computer equipped with the image analysis software program (Omnimet Buehler, United States), where the leakage was assessed in microns.

Evaluation of Antibacterial Effect

Resin composite discs were prepared for the tested groups (C0, C1, and C2) ($n = 5$) using a specially constructed flat Teflon mold with a diameter of 6 and 2 mm thickness.[17] *Streptococcus mutans* serotype c that was isolated carious dentin (ATCC25175 type strain) was incubated for 24 hours at 37°C in incubator.[18] Preparation of resin composite discs was achieved through packing of each material within the mold, covering its top and bottom surfaces with celluloid papers, and pressing it in between two glass slaps to ensure a standard flat smooth disc surface. Resin composite discs for both C0 and C2 groups were light cured as mentioned before, meanwhile those related to C1 group were self-cured. Finally, Chlorhexidine HCl applied on filter paper of the same dimensions of the discs in a concentration of 0.075 ppm was used as a control positive group (C +ve).

Agar diffusion test using a base layer containing 15 mL nutrient agar reinforced with 2 g of sucrose and 2 g of glucose "0.4 sugar concentration % " per 100 mL was used to culture the bacteria.[19] Agar was evenly spread in a sterile petri dish. In each petri dish, four wells equivalent to the diameter of discs were made using the blunt end of a micropipette tip. Each dish involved disc representing to the tested groups. A total of 100 µL of bacterial suspension was poured over the agar surface with a micropipette and spread evenly. The culture plates were placed in incubator at 37°C and their antibacterial activity was evaluated after 48 hours. After incubation, the plates were removed from the incubator and the diameter of bacterial inhibition zones was measured in millimeters using a digital caliper. Measurements were taken at the greatest distance between two points on the outer limit of the inhibition zone formed around the wells. This measurement was repeated three times and the means were calculated for each well.[17]

Broth dilution method was used as a confirmatory method to the antibacterial effect of both C1 and C2 groups. *Streptococcus mutans* strain was cultured on Mueller–Hinton agar and incubated for 24 hours. For the preparation of the broth, five different bacterial concentrations were serially diluted by normal saline (10^6, 10^5, 10^4, 10^3, and 10^2 CFU/mL), where tubes that contain higher bacterial concentrations appear more turbid than tubes with lower bacterial concentration. Chlorhexidine HCl in a concentration of 0.075 ppm was used as a C +ve, meanwhile tubes of broth with different concentrations without adding of any tested materials were used as a control negative group (C −ve). The broth was used for filling of 20 sterile tubes which were distributed into four groups (C1, C2, C −ve, and C +ve] five tubes each, where each group involving the five different concentrations. For each of C1 and C2 groups, five resin composite discs were prepared as previously mentioned in the agar diffusion method. Later on, one resin composite disc from each group was immersed in one tube from each broth concentrations. After incubation of all tubes at 37°C for 48 hours, a change in broth turbidity was observed and is considered as an indicator for the antibacterial effect.[20]

Statistical Analyses

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov–Smirnov's and Shapiro–Wilk's tests, data showed parametric (normal) distribution. Two-way analysis of variance (ANOVA) test was used to test the interactions between different variables. One-way ANOVA followed by post hoc Tukey's test was used to compare between more than two groups in nonrelated samples. Independent sample *t*-test was used to compare between two groups in nonrelated samples. The significance level was set at $p \le 0.05$. Statistical analysis was performed with IBM SPSS statistics version 20 for Windows.

Results

Microtensile Bond Strength Results

Two-Way ANOVA

Data in ►**Table 2** show the results of two-way ANOVA analysis for the interaction of different variables. The results showed that material had no statistically significant effect. Also, thickness had no statistically significant effect. The interaction between the two variables also had no statistically significant effect.

Effect of Different Resin Composite Material on µTBS at 4 mm (T1) Thickness

Resin composite with alkaline fillers (Cention N) (dual-cured) (C2) group showed the highest µTBS value to dentine followed by resin composite with alkaline fillers (Cention N) (self-cured) (C1) group and nanohybrid resin composite (Grandio) (C0), respectively, with no statistically significant difference between them.

Effect of Different Resin Composite Material on µTBS at 6 mm (T2) Thickness

Resin composite with alkaline fillers (Cention N) (self-cured) (C1) group showed the highest µTBS value to dentine followed by nanohybrid resin composite (Grandio) (C0) group and resin composite with alkaline fillers (Cention N) (dual-cured) (C2) group, respectively, with no statistically significant difference between them.

Effect of Resin Composite Thickness on µTBS at

Nanohybrid resin composite (Grandio) (C0): Six-mm-thickness (T2) subgroup showed µTBS mean value slightly higher than 4-mm-thickness (T1) subgroup with no statistically significant difference between them.

Self-cured resin composite with alkaline fillers (Cention N) (C1): Four-mm-thickness (T1) subgroup showed µTBS mean value higher than 6-mm-thickness (T2) subgroup with no statistically significant difference between them.

Dual-cured resin composite with alkaline fillers (Cention N) (C0): Four-mm-thickness (T1) subgroup showed µTBS mean value higher than 6-mm-thickness (T2) subgroup with no statistically significant difference between them (►**Table 3**).

Microleakage

Two-Way ANOVA

Data in ►**Table 4** show the results of two-way ANOVA analysis for the interaction of different variables. The results showed that material type had a statistically significant effect. Marginal position also had a statistically significant effect.

Table 2 Results of two-way ANOVA for the effect of different variables on microtensile bond strength

Source	Type III sum of squares	df	Mean square	F	Significance
Corrected model	507.390[a]	5	101.478	1.077	0.398
Intercept	23,185.200	1	23,185.200	245.963	0.000
Mode of curing	129.592	2	64.796	0.687	0.513
Thickness	42.293	1	42.293	0.449	0.509
Mode of curing[b] thickness	335.505	2	167.752	1.780	0.190
Error	2,262.310	24	94.263		
Total	25,954.900	30			
Corrected total	2,769.700	29			

Abbreviations: [a]ANOVA, analysis of variance; df, degrees of freedom = ($n - 1$).
[b]Significant at $p \le 0.05$.

Table 3 Mean and SD values of microtensile bond strength of different groups

Variables	Microtensile bond strength						
	Light-cured composite (C0)		Self-cured composite (C1)		Dual-cured composite (C2)		*p*-Value
	Mean	SD	Mean	SD	Mean	SD	
4 mm (T1)	24.76[aA]	11.47	31.54[aA]	9.07	34.66[aA]	11.56	0.376
6 mm (T2)	25.64[aA]	8.85	27.54[aA]	10.14	22.66[aA]	6.07	0.252
p-Value	0.895		0.530		0.074		

Abbreviation: SD, standard deviation.
Note: Means with the same letter are not significantly different, $p < 0.05$.

Table 4 Results of two-way ANOVA for the effect of different variables on microleakage

Source	Type III sum of squares	df	Mean square	F	Significance
Corrected model	11,754,039.100[a]	5	2,350,807.820	98.637	0.000
Intercept	46,732,608.300	1	46,732,608.300	1,960.838	0.000
Material type	5,546,067.800	2	2,773,033.900	116.353	0.000
Marginal position	6,193,472.033	1	6,193,472.033	259.870	0.000
Material type[b] marginal position	14,499.267	2	7,249.633	0.304	0.741
Error	571,991.600	24	23,832.983		
Total	59,058,639.000	30			
Corrected total	12,326,030.700	29			

Abbreviations: [a]ANOVA, analysis of variance; df, degrees of freedom = (n − 1).
[b]Significant at $p \leq 0.05$

Effect of Resin Composite Material on the Microleakage Results of

Nanohybrid resin composite (Grandio) (C0): Occlusal margin showed the lowest microleakage mean value with a statistically significant difference with gingival mean value (►**Fig. 1**).

Resin composite with alkaline fillers (Cention N) (self-cured) (C1): Occlusal margin showed the lowest microleakage mean value with a statistically significant difference with gingival mean value (►**Fig. 2**).

Resin composite with alkaline fillers (Cention N) (dual-cured) (C2): Occlusal margin showed the lowest microleakage mean value with a statistically significant difference with gingival mean value (►**Fig. 3**).

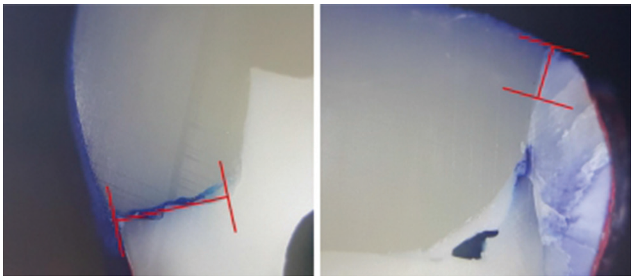

Fig. 1 Depth of dye penetration at gingival and occlusal margins in Grandio composite.

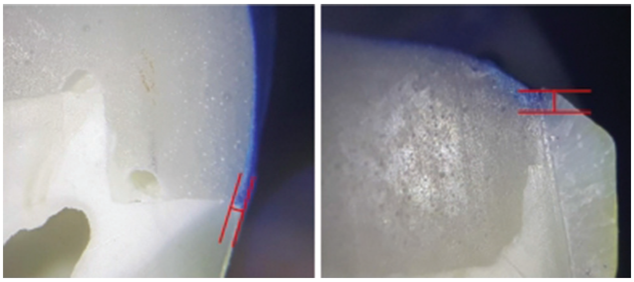

Fig. 2 Depth of dye penetration at gingival and occlusal margins in self-cured Cention N.

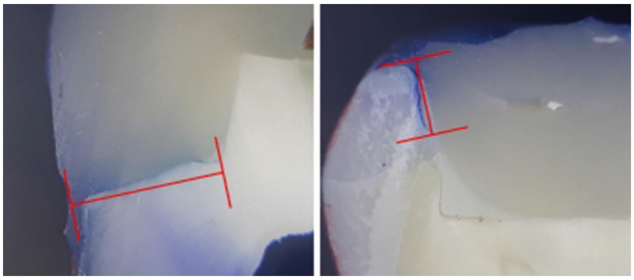

Fig. 3 Depth of dye penetration at gingival and occlusal margins in dual-cured Cention N.

Effect of resin composite material on the microleakage results of

Gingival margin: Nanohybrid resin composite (Grandio) (C0) group showed the highest microleakage mean value, followed by resin composite with alkaline fillers (Cention N) (dual-cured) (C2) group, meanwhile the lowest microleakage value was found in resin composite with alkaline fillers (Cention N) (self-cured) (C1) group. There was a statistically significant difference between C0, C1, and C2 groups **(►Table 5)**.

***Occlusal margin*:** Nanohybrid resin composite (Grandio) (C0) group showed the highest microleakage mean value, followed by resin composite with alkaline fillers (Cention N) (dual-cured) (C2) group, finally the lowest microleakage value was found in resin composite with alkaline fillers (Cention N) (self-cured) (C1) group. There was a statistically significant difference between C0, C1, and C2 groups.

Antibacterial Effect Results

Agar Disc Diffusion Results

Dual-cured resin composite with alkaline fillers (Cention N) (C2) group showed comparable inhibition zone diameter mean value (11 ± 2.74 mm) followed by chlorhexidine (C +ve) group (10.40 ± 1.34 mm) and self-cured resin composite with alkaline fillers (Cention N) (C2) group (10.60 ± 1.67 mm), respectively. Meanwhile, nanohybrid resin composite (Grandio) showed no inhibition zone. There was no statistically significant difference between C +ve, C1, and C2 groups, but there was a statistically significant difference between C0 and each of C +ve, C1, and C2 group (►**Fig. 4**).

Table 5 Mean and SD of microleakage values for different tested groups

Variables	Microleakage						
	C0		C1		C2		*p*-Value
	Mean	SD	Mean	SD	Mean	SD	
Gingival	$2,233.40^{aA}$	308.63	$1,221.40^{aC}$	83.94	$1,652.60^{aB}$	95.79	<0.001
Occlusal	$1,382.40^{bA}$	118.45	303.80^{bC}	40.79	695.00^{bB}	125.80	<0.001
p-Value	<0.001		<0.001		<0.001		

Abbreviation: SD, standard deviation.
Note: Means with the same letter within each row are not significantly different, $p < 0.05$.

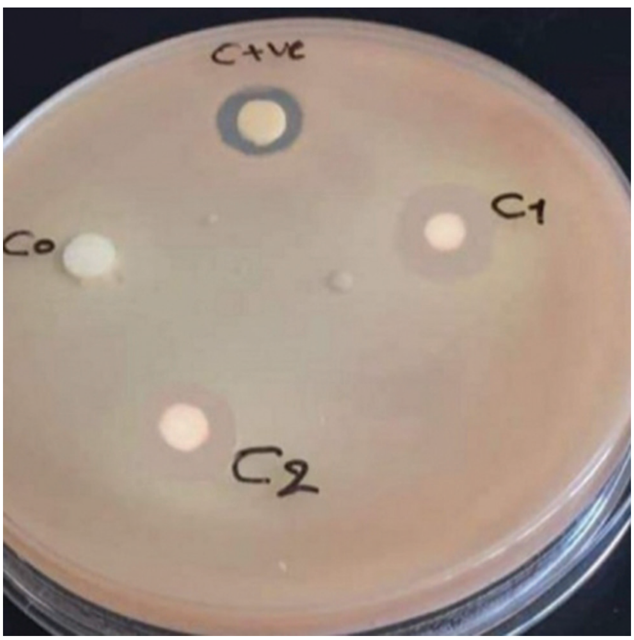

Fig. 4 Image of bacterial growth inhibition zones on agar plate inoculated with *Streptococcus mutan*.

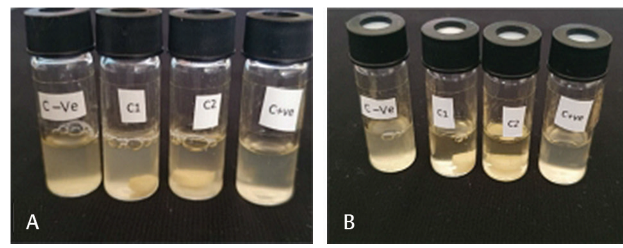

Fig. 5 Broth turbidity at highest (**A**) and lowest (**B**) bacterial concentrations.

Broth Dilution Results

Massive reduction in bacterial turbidity was noticed in chlorhexidine (C +ve) group tubes at all bacterial concentrations. While self- and dual-cured composites resin with alkaline fillers (Cention N) showed no change in broth turbidity at 1 × 106 and 1 × 105 CFU/mL concentrations of bacterial strains. However, they showed a gradual decrease in bacterial turbidity at lower bacterial concentrations 1 × 104, 1 × 103, and 1 × 102 CFU/mL. Consequently, their maximum broth clarity was noticed for the lowest bacterial concentration 1×10^2 CFU/mL bacterial strains (►**Fig. 5**).

Discussion

Microtensile Bond Strength

In the present study, bond strength assessment was performed using µTBS as it corresponds more reliably with clinical outcomes than microshear bond strength test.[21] For better control of regional differences, only beams from the central part of each sample were chosen.[22] Also, the peripheral beams may not have the same thickness of the dentin and a better distribution of pressure at the true interface.[23]

For the current test, the bonded area of samples is small stick shaped, around (0.9 mm × 0.9 mm) ± 0.1 which is critical for producing better stress distribution at the adhesive joint, minimizing cohesive failures in tooth substrate or composite,[22] and length of 8 ± 1 was used in the current study due to the increased bulk thickness of composite samples. In this analysis, bond strength to dentin was measured at the level of deep dentin on a flat dentin layer,[24] as this type of resin composite restoration is fabricated specially for large deep cavities.

Concerning the effect of different resin composite materials on mean µTBS regardless of bulk thickness, the results of µTBS showed that self-cured Cention N (C1) has slightly higher µTBS mean value without significant difference with nanohybrid resin composite. This might be because that Cention N is a self-curing resin composite material, so its curing depth is theoretically unlimited, besides the presence of the stress reliever isofiller.[10] This result come in agreement with Mandava et al (2017), who reported that there was no significant difference between nanohybrid composite and another commercially available bulk fill composite (Filtek bulk fill).[25] On the contrary, the results come in disagreement with Taneja et al (2016), who found that bulk fill resin composite showed significantly higher µTBS in comparison to incremental nanohybrid resin composite. This difference might be due to that they used sonic bulk fill which have special chemistry, viscosity, and modifiers that react to sonic energy. As sonic waves are applied through the handpiece, the modifiers cause the viscosity of the composite to drop up to 87%. This increases the flowability, quick placement, and precise adaptation of the composite to the cavity walls. Composite returns to a more sticky and nonslumping state as the sonic energy is stopped.[26]

Regarding the effect of bulk thickness for all tested materials, 4-mm bulk thickness is slightly higher in µTBS mean value than 6-mm bulk thickness with a statistically nonsignificant difference between them. This slight increase in µTBS might be related to high polymerization contraction stresses created during curing of a large volume of resin composite in 6-mm-thickness samples, but the lack of significant difference between them might be due to that all the specimens had the same low C-factor that is referred to bonding of resin composite materials to flat dentine surface. This result come in agreement with Sagsoz et al (2016), who reported that there is no significant difference in µTBS recorded for resin composite used in different thicknesses.[27] But the result come in disagreement with Silame et al (2017), who reported that the 2-mm increment restorations in box-shaped cavities yielded higher µTBS than 4-mm increment restoration for both conventional and bulk fill composites.[28] This result might be due to that they used molars with class I cavities which is different from the flat occlusal surface used in the current study. Also, the result comes in disagreement with Taneja et al (2016), who reported that both nanohybrid composite and sonic bulk fill resin composite showed higher µTBS at 4 mm than at 6 mm with significant difference between them. This might be due to the insufficient light curing at 6 mm depth that resulted from the increased distance from the light source. This might have resulted in insufficient polymerization of the base of sonic bulk fill resin composite at 6 mm depth.[26]

Microleakage

Dye penetration is an *in vitro* method developed to investigate marginal leakage along the tooth restoration interface.[29] Methylene blue dye was used in this study as its molecular size is ~1 nm which is smaller than the diameter of the dentinal tubule, so it can penetrate through gaps between restoration and tooth.[30] The total depth of dye penetration along the tooth restoration interface was measured by an image analysis software program, which is a more accurate method than the visual (scores) method.[31]

Evaluating the effect of different resin composite materials on microleakage regardless of marginal position showed that self-cured Cention N has a statistically significantly lower microleakage value than the dual-cured one. This result might be attributed to using self-cured resin composite material with a slow polymerization rate which may be an effective way to reduce the risk of marginal microleakage at the tooth restoration interface.[32] So that both self- and dual-cured Cention N showed statistically significantly lower microleakage values than nanohybrid resin composite. Also, these results could be explained based on that Cention N contains a shrinkage stress reliever (isofiller) with a low modulus of elasticity that acts like a microscopic spring, attenuating the forces generated during polymerization shrinkage.[10] The difference in results between µTBS and microleakage values might be attributed to higher C-factor values related to microleakage samples which were prepared as class II cavities, meanwhile samples prepared for µTBS were bonded to flat dentin surfaces that can affect the developing stresses when cavities are restored with resin composite.[33]

Evaluation of the effect of marginal position regardless of the material revealed that there was a significant difference between both gingival and occlusal microleakage values in all tested materials, where microleakage at the gingival margin was significantly higher. This result could be due to that the gingival margin is one of the weakest links of class II resin composite restoration due to inadequate enamel thickness. Also, this could be attributed to enamel microfractures that occurred in many restorations along gingival margins immediately after polymerization of resin composite bonded to etched enamel surfaces.[34]

Antibacterial Effect

The agar diffusion method was used in the current study for evaluating the antibacterial efficiency of Cention N resin composite material. Multiple articles confirmed that this method is characterized by being an effective and easy way for antibacterial effect detection.[35] Chlorhexidine was used as a control positive material as it is considered the gold standard chemical plaque control agent.[36]

Agar disc diffusion test showed that there was no antibacterial effect for nanohybrid resin composite. This result might be due to the absence of any antibacterial substances in conventional nanohybrid resin composite.

Although there was a nonsignificant difference in the antibacterial effect of chlorhexidine and both of self-cured and dual-cured Cention N in terms of inhibition zone diameter, the inhibition zone around Cention N was less clear than that noticed around chlorhexidine. So, another confirmatory test was done using broth dilution which is another accurate confirmatory way. This method depends on the fact that broth turbidity made by bacteria is decreased by the antibacterial agent, so multiple bacterial dilutions could be used for detecting the antibacterial effect depending on the level of the turbidity clearance. The results of broth dilution method at high bacterial concentrations for both self-cured and dual-cured Cention N showed no decrease in broth turbidity. But at low bacterial concentrations, they showed a marked decrease in the broth turbidity with an almost clear appearance which was comparable to that of the C +ve group.[20] This weak antibacterial effect could be attributed to that there is a positive correlation between the amount of fluoride released and the amount of antibacterial effect.

Although the results indicated that Cention N is characterized by a weak antibacterial effect in comparison to chlorhexidine, this effect could be of value in minimizing the caries recurrence at tooth restoration interfaces.

Conclusion

Under the limitations of the current study, the following could be concluded:

1. µTBS of bulk fill resin composite with alkaline fillers "either self- or dual-cured" material is comparable to that of incremental nanohybrid resin composite.

2. Microleakage of resin composite with alkaline fillers is significantly better than the conventional nanohybrid resin composite restorations in short-term aging. Also, occlusal microleakage is better than cervical one.
3. Resin composite with alkaline fillers is characterized by weak antibacterial effect in comparison to chlorhexidine.

Conflict of Interest

None declared.

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