Abrasive resistance and microhardness of self-adhesive (Surefil one) and conventional bulk fill composites: An- in vitro study

Maryam Fakher Ibrahim [(1)], Bahar Jafaar Selivany[(1)], Abduloma Baraka Ali [(2)]

Aims and objectives To evaluate abrasive resistance and microhardness of self-adhesive Surefil one and conventional bulkfill composites Beautifil bulk restorative and Filtek one bulk fill restorative.

Materials and Methods: For the abrasive resistance test, thirty composite discs (4 mm hieght×8 mm width) in each group (n=10) were fabricated. GI: Beautifil bulk restorative, GII: Filtek One Bulk fill restorative and GIII: Surefil one self-adhesive. By placing the material in a mold in a single increment then curing. A custom-made toothbrush simulator was employed for wear testing. The samples weighted before and after the brushing to measure the weight loss. For the microhardness test, thirty cylindrical specimens (6 mm× 8 mm) (n= 10) were fabricated to assess the microhardness, top and bottom surfaces were tested using Vicker Hardness test. The results were analyzed with a one-way ANOVA test, the post-hoc comparisons were examined in Tukey test.

Results: Abrasive Resistance results, Surefil one (9.52gr) and Beautifil bulk (4.16gr) showed an increase in weight after brushing, while Filtek one bulkfill (-0.85gr) showed a decrease in weight.Microhardness test results, Beautifil bulk showed the highest number of VH (74.83) followed by Surefil one (70.61) and Filtek one bulkfill (62.95).

Conclusion: Beautifil bulk was more resistant to abrasion in comparison to Surefil one self-adhesive and One bulk fill. The great weight loss was observed in One bulk fill. Great weight gain was observed in Surefil one self-adhesive. Beautifil bulk showed the highest VH number compare to Surefil one self-adhesive and One bulk fill. Filtek one bulk fill showed low resistance and low hardness number.

Key-words: Bulk fill, Self-adhesive, Abrasive resistance, Microhardness. Composite, surefil one.

[(1)]college of Dentistry, University of Duhok, Duhok, Iraq.
[(2)] Al Mustfa University College/ Department of Dentistry .
Correspondent Name: -Maryam Fakher Ibrahim, Email:Maryam.fakher2@gmail.com

INTRODUCTION:

The standard filling material in dental offices for anterior and posterior restorations is now resin-based composites. The durability of direct composite restorations in posterior teeth is comparable to that of amalgam restorations, according to long-term clinical investigations. [1] Additionally, advancements in composite technology have made application simpler. For example, instead of using composites in layers that are 2 mm thick, bulk-fill composites can be applied in layers that are 4-5 mm thick due to their low polymerization shrinkage stress and high reactivity to light curing. [2]The strong color translucency of these materials facilitates deeper light penetration; nevertheless, if the cavity is deeper than the maximum depth of cure (4 mm), a second layer must be applied. The reduction in light curing time and the increase in cure depth are both caused by the novel polymerization initiating technique. These materials' low shrinkage and high filler content result in very low polymerization shrinkage stresses, enabling the application of thicker layers.[3] These bulk-fill composites are a safe alternative to conventional posterior composite restorations, according to clinical data extending up to 10 years.[4] Another step toward simplification was the development of self-adhesive composites that did not require the use of an adhesive, reducing the amount of

time that blood or saliva contamination could compromise the restoration. To facilitate bonding with enamel and dentin, reactive diluents were typically modified with acidic moieties. This method was commercialized as self-adhesive flowable composites, but many laboratory studies have called into question whether these materials are a viable alternative to composites that require a separate adhesive.[5] The inconsistent clinical efficacy of self-adhesive restorative materials, particularly in load-bearing areas, has not resulted in a breakthrough.[6] Alternately, acidic groups might be added to the structural monomers to increase adhesion. This strategy is achieved to the fullest extent in the polyacids used in glass ionomer cements.[7] However, because polyacids lack polymerizable groups, they are unable to contribute to the radically polymerized network. Recent research has resulted in the formulation and patenting of a modified polyacid system of high molecular weight (MOPOS), which combines the self-adhesive properties of traditional polyacids used in glass ionomer cements with the crosslinking power of structural monomers used in composites.[8] The initiator system is described by the manufacturer as a combination of the photoinitiator camphorquinone and a persulfate, as well as two reducing agents that are used in both the dark and light curing processes. This results in both bulk curing (in the dark) and light curing of the surface areas. [1] The microhardness test is one of the most used in vitro tests because it can indicate whether the restorative material will be resistant to wear, which is one of the forces that damage the tooth-restoration complex during chewing. Studies have revealed that both tests.

generate findings with lower values according to depth, that is, with increments of composite resin in increasing thickness, as happens in bulk-fill composite resins, and that this analysis is indirectly related to the degree of conversion. [9] Composite restorations are subjected to repeated mechanical forces and chemical effects in the process of mastication. Wear happens when forces are applied to the composite that are greater than its mechanical strength. The anatomical contour of the composite restorations is lost due to occlusal wear. Therefore, a composite resin's wear resistance is crucial for the long-term effectiveness of restorations. This is why an important need for dental restorative material is wear resistance equivalent to that of natural teeth. [10]

Materials and methods

Materials used in this study are shown in Table 1.

Abrasive Resistance test:

Samples preparation

Using locally produced cylindrical stainless steel molds with an 8 mm diameter, 4 mm height, to fabricate thirty composite samples for each group of 10, (n=10). The mold was set on a glass slide and a transparent strip. To prevent oxygen from interfering with the polymerization of the composite's superficial surface, the composites were placed in the mold in bulk condensed form and somewhat overfilled. Another glass slide was pushed against the matrix and removed before curing in order to extrude the extra composite resin and create a flat surface. The tip of the light cure was 8mm in diameter and placed in contact with a transparent strip and cured with (Flexi Light R&S – France) for 20 seconds according to the manufacturer's instruction (figure 1 A,B,C,D,E) for each group with the light intensity of 1200 mW/ as measured with a commercial dental radiometer (Denshine, China) 11. After curing, the samples were carefully taken out of the molds, marked with an arrow to distinguish the top from the bottom, and polished by trimming any excess with sheets of 1200 grit silicon carbide using an automatic machine (Buehler Metaserv, Grinder, Polisher, England), followed by sonication to remove residue of polishing figure. Following that, each group was conditioned in distilled water for 7 days at 37 °C following the abrasive wear test conditioning indicated in ISO/TR 14569. Samples were then dried in air oven for an hour at 37°C 11. After each group was given a number using a permanent marker, then samples weighed using an analytical balance with a precision of 0.01 g. Each sample's initial mass (M1) was ascertained in this manner. After that, samples were loaded with 200 g into the base of the specially

Table 1: Materials used in this study are shown below.

N	Composite	Manufacturer	Composition	Filler load
1	Beautifil bulk restorative	Shofu	Bis-GMA, UDMA, Bis-MPEPP, TEGDMA, S-PRG filler based on fluoro-alamino-silicate glass	87% wt 74.5% vol
2	Filtek One bulk fil restorative	3M	non-agglomerated 20nm silica filler non-agglomerated 4-11nm zirconia filler, aggregated zirconia/silica cluster filler, ytterbium trifluoride filler consisting of agglomerate 100nm particles. AFM ,AUDMA, UDMA and 1, 12-dodecane-DMA	76.5% wt 58.4% vol
3	Surefil one self-adhesive	Dentsply sirona	Aluminium-phosphor-strontium-sodium-fuoro-silicate glass, water, highly dispersed silicon dioxide, acrylic acid, polycarboxylic acid (MOPOS), ytterbium fuoride, bifunctional acrylate (BADEP), self-cure initiator, iron oxide pigments, barium sulfate pigment, manganese pigment, camphorquinone, stabilizer	77% wt 58%vol

designed tooth brushing simulator with a pea-sized amount of Colgate toothpaste on the brush, and brushing was stimulated for 100 minutes, representing a 1.3-year stimulation duration 11 (figure 2). The brush heads were changed for each sample. After finishing the tooth brushing process, the samples were taken out, rinsed with tap water, and placed in an ultrasonic water bath for 1 minute. After air drying for an hour at 37°C in the oven, the samples were weighed again using an analytical balanced to determine the final mass (M2) and mass loss (%) was reported for each material post-abrasion using the following equation:

$W\% = ([M2 - M1]/M1) \times 100\%$

Microhardness test

Samples preparation

Thirty composite samples, each composite with ten samples (n=10), were created using cylindrical silicon molds with diameters of 8 mm, and heights of 6 mm. A glass slide was used to hold the mold. The composites were inserted in bulk condensed form and slightly overfilled within the mold before being covered with a transparent strip to prevent oxygen from interfering with the polymerization of the composite's superficial surface 9. Another glass slide was pressed against the matrix and removed before curing to extrude the excess composite resin and achieve a flat surface. For each group, the tip of the light cure was placed in contact with a transparent strip and cured with (Flexi Light R&S - France) for 20 seconds according to the manufacturer's instructions with a light intensity of 1200 mW/cm2 as measured with a commercial dental radiometer (Denshine, China). After curing, the samples were carefully removed from the molds and an arrow was drawn to distinguish the top and bottom of the samples. The samples were then polished by trimming any excess with 1000-1200 grit silicon carbide sheets using an automatic machine (Buehler Metaserv, Grinder, Polisher, England), followed by sonication for 3 minutes to remove polishing residue, and then stored in a dark container in the air at 37°C for 24 hours 12. Each specimen's microhardness was measured on the top and bottom with a digital vicker hardness at 100 g (0.98 N) of load and 15 seconds dwell time. Six measurements were taken, three on the top surface and three on the bottom surface of the samples. The icker numbers were computed using the Digital Microhardness Tester (Time group Inc, China). The Vickers number (VHN) was calculated according to the following formula: VHN = 1.854(F/), Where F is the applied load (measured in Newton -force) and is the area of the indentation (measured in square millimeters).

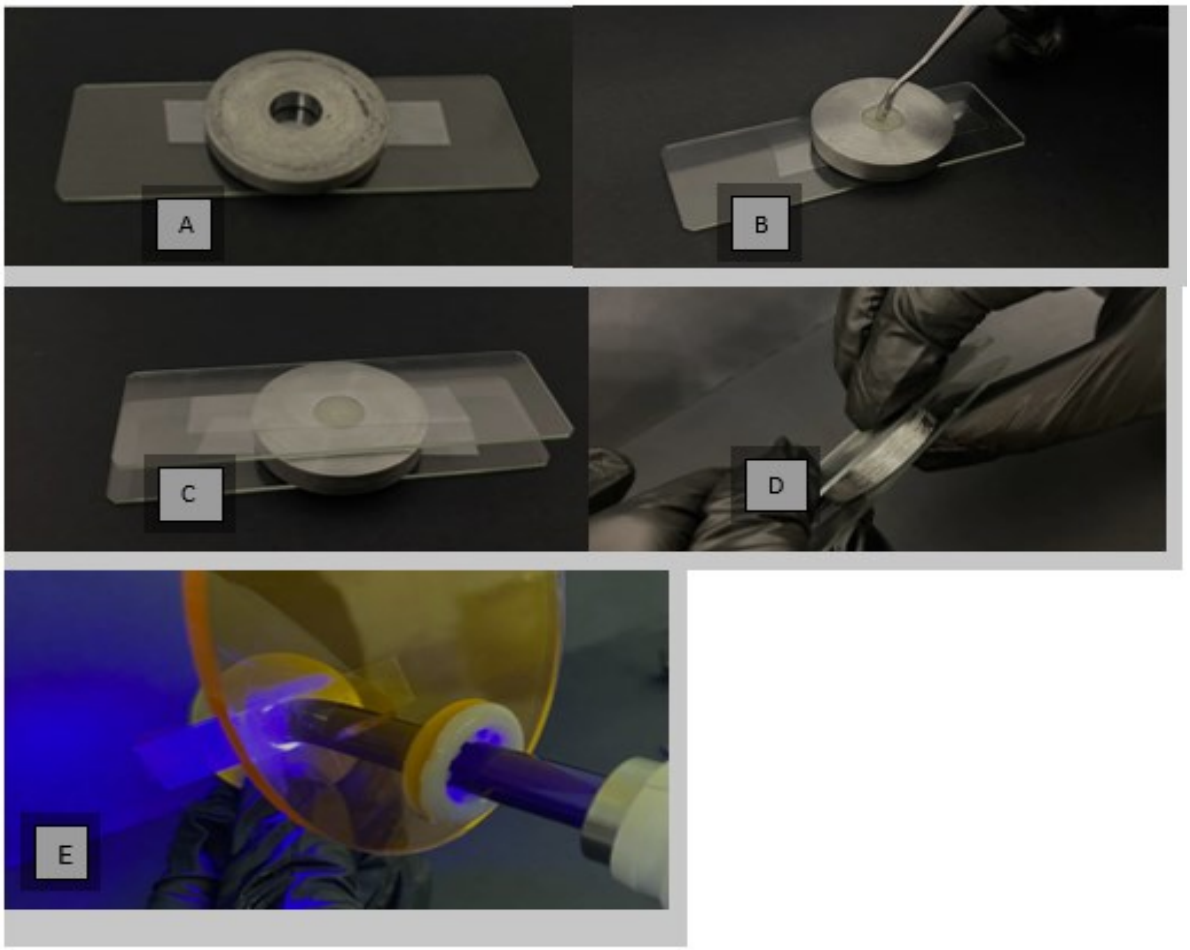

Figure 1: Steps of samples preparation **A.**Placement of the mold over a strip and a glass slide, **B,** Composite placing in bulk technique and condensation, **C,**Placing another strip and a glass slab over the filled mold,**D,**Pressing by fingers to extrude the excess material,**E,**Curing for 20 seconds with the tip in contact with the translucent strip.

Figure 2: Custom-made tooth-brushing simulator.

Results

Abrasive Resistance Test

The data in (table 2) illustrates the comparison of percentage change of weight which showed a statistically significant difference among study groups. In Beautifil bulk restorative and Surefil one adhesive group, it was found that there was an increase in weight after tooth brushing. While, for One bulk fill restorative it was found that there was a decrease in weight after tooth brushing. (Figure 3) represent graphs of percentage change of weight among composite types. (Table 3) demonstrate the comparison between study groups and it was found that there was a statistically significant difference between composite groups.

Table 2: Comparisons of percentage change of weight among composite types

Composite	No	Time		Percentage change (gr)		p-value
		Before brushing (M1) Mean (SD)	After brushing (M2) Mean (SD)	% Mean (SD)	95% CI	
Beautifill Bulk Restorative	10	0.44 (0.02)	0.46 (0.02)	4.16 (3.19)	1.88 to 6.44	<0.0001
One bulk Fill Restorative	10	0.465 (0.008)	0.461 (0.007)	-0.85 (1.10)	-1.64 to -0.06	
Surefil one self-adhesive	10	0.36 (0.02)	0.40 (0.01)	9.51 (4.28)	6.45 to 12.58	
ANOVA one-way was performed for statistical analyses.						

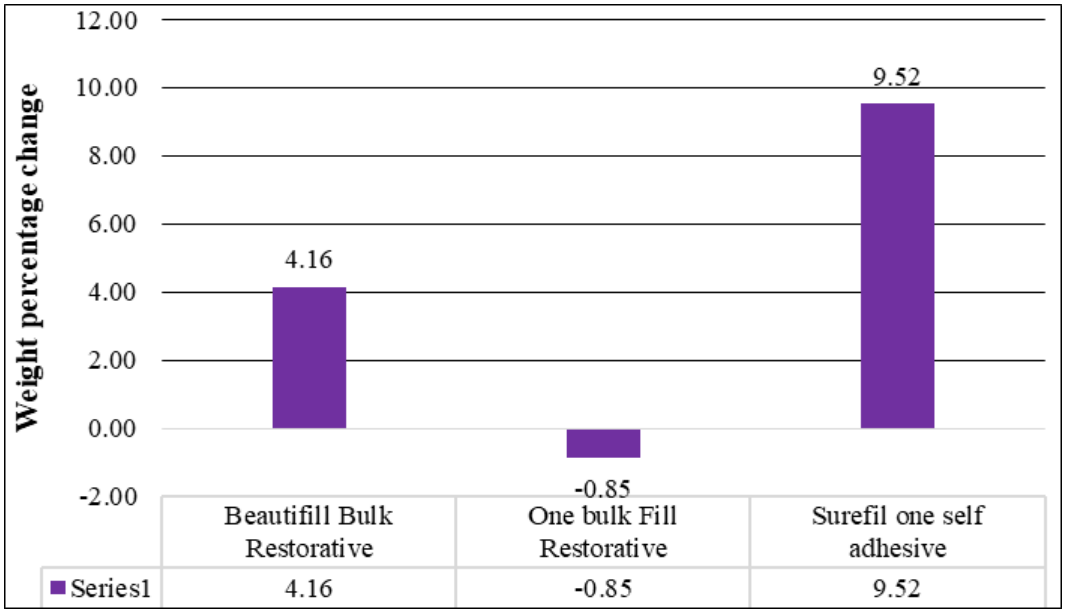

Figure 3: Percentage change of weight of composite types (gr).

Table 3: Comparisons of percentage change of weight between composite types

Experimental groups		Mean (SD)	Mean (SD)	p-Value
Beautifill Bulk Restorative	One bulk Fill Restorative	4.16 (3.19)	-0.85 (1.10)	0.0039
Beautifill Bulk Restorative	Surefil one self-adhesive	4.16 (3.19)	9.51 (4.28)	0.0020
One bulk Fill Restorative	Surefil one self-adhesive	-0.85 (1.10)	9.51 (4.28)	<0.0001
The Tukey test was performed for pairwise comparisons.				

Microhardness study:

(Table 4) and (figure 4) illustrate the comparison of microhardness and there was a statistically significant difference among the study group. Beautifill bulk showed the highest number of hardness while One bulk fill has the lowest number of hardness. (Table 5) illustrate a significant difference between Beautifil bulk and One bulk fill, and between Surefil one and One bulk fill. While, there was no significant difference between Beautifil bulk and Surefil one.

Table 4: Comparison of microhardness among composite groups.

Composites	Hardness (F/D^2)				p-value
	Number	Mean	Std Dev	95% CI	
Beautifil bulk	10	74.83	8.32	68.88 to 80.79	0.0005
One bulkfill	10	62.95	3.87	60.18 to 65.72	
Surefil one	10	70.61	4.81	67.17 to 74.05	
ANOVA one-way was performed for statistical analyses.					

Table 5: Comparison of microhardness between composite groups

Composites		Mean (SD)	Mean (SD)	p-Value
Beautifil bulk	One bulkfill	74.83 (8.32)	62.95 (3.87)	0.0004
Surefil one	One bulkfill	70.61 (4.81)	62.95 (3.87)	0.0212
Beautifil bulk	Surefil one	74.83 (8.32)	70.61 (4.81)	0.2721
The Tukey test was performed for pairwise comparisons.				

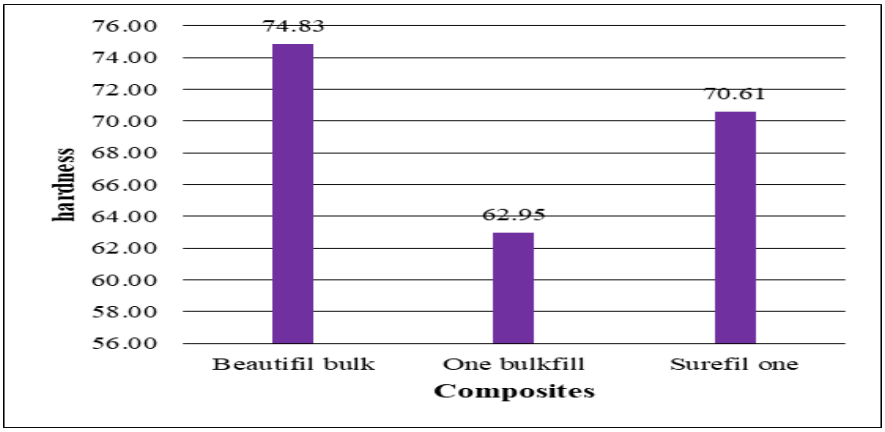

Figure 4: Hardness of composites.

Discussion:

Abrasive resistance test:

To increase the longevity of a restoration, the decision of which composite resin to use during a specific restorative procedure must consider its mechanical properties [13]. In this context, in vitro material property evaluation is critical because it simulates the ability of this material to withstand stress in the oral environment without fracturing or wearing. [14] Significant advancements in the properties of dental composites have been made in recent years; however, composite wear remains a concern. [15] The surface properties of restorative materials play a significant role in the long clinical life of restoration in this regard. Wear is reflected in the oral cavity by tearing away of the organic matrix, exposure of inorganic content, and loss of smaller filler particles due to chewing and toothbrushing in our daily lives. [11]. Although in vitro studies do not replicate the exact oral environment, they are useful in predicting the clinical performance of the most recent restorative materials.[16]When assessing material loss due to wear, it has been found that mean total volumetric wear measures are more accurate than mean maximum wear depth measurements. The lifespan of composite resin restorations is connected to effective curing techniques, in addition to the concentration and size of filler particles and resin formulation, which determine wear properties.[17]Low degree of conversion, increased cytotoxicity, lower hardness and strength, low modulus of elasticity, poor wear resistance, marginal microleakage, and bond failure are all possible effects of ineffective curing processes. Since the abrasive process caused by simulated toothbrushing is a significant contributor to wear in vitro and can mimic a clinical condition, it is regarded as a model that has already been established in the literature. [18] According to Sexson and Phillips (2015), the patient conducts nearly 15 cycles of daily toothbrushing throughout each session. Thus, if oral hygiene maintenance is based on two brushings every day, approximately 10,000–14,600 cycles are performed by the end of a year. [19] 12,250 cycles of simulated brushing were carried out for this study, which is equivalent to 1.3 years of brushing for a healthy person.[11] Colgate Total 12 (Colgate, Brazil), a dentifrice that contains silica in its formulation and is regarded as having low abrasiveness, was used in this investigation. [19] And each group was conditioned in distilled water for 7 days at 37 °C following the abrasive wear test conditioning indicated in ISO/TR 14569. Samples were then dried in air oven for an hour at 37°C [11]. Concerning to the Abrasive resistance test results, in this study, there was a significant difference found between groups, which showed that One bulk fill restorative material presented greater mass loss than other groups (0.85 gr). While, both Beautifil bulk restorative (4.16 gr) and Surefil one self- adhesive restorative (9.52 gr) as illustrated in table 2, showed an increase in weight. These results might be connected to the characteristics of each material. The findings of this study concur with those of [20](shimokawa etal., 2019), who found no connection between filler content and wear rate despite Beauti-

fil bulk having the highest filler content. The increased filler volume and improved bonding between the filler and matrix component may be the cause of the improved wear resistance. Triethylene glycol dimethacrylate (TEGDMA) can also improve wear resistance because it improves the interaction between the filler and matrix and the polymerization process, which lessens the impact of water sorption [21]. The polyether backbone of TEGDMA makes it more flexible, which may enable greater molecular interaction and, consequently, better polymerization. As a result, the degree of conversion is raised, sorption is decreased, and the structure becomes stiffer [11]. Contrarily, the ultimate weight of the composite restoratives was larger than that of the Surefil one self-adhesive and Beautifil bulk restoratives. This is because composite restoratives are unstable after polymerization and constantly interact with their environment.Water diffuses into the matrix and causes the main interaction, which results in two diametrically opposed phenomena. Water may leach free, unreacted monomers and ions from certain composites [22]. Leachable components' elution leads to the material's further shrinkage and weight loss. The second possibility is that some composites' water sorption is increased by cyclic temperature variations.In contrast, hygroscopic water absorption causes the material to inflate and gain weight. An inverse association between filler loading and water sorption was found in a prior study that looked at the degree of hygroscopic expansion in resin-based composites. Reduced water absorption into the matrix occurs as filler volume increases. [23] According to filler loading, Beautifil bulk has around 87%, One bulk fill has about 76.5%, and Surefil one has about 77%. Hence, the results of the present study agree with the study of (Li et al., 2021)[24] while disagreeing with the study of (Bayrak et al., 2022).[25]

Microhardness test:

The parameters of the filler (size, weight, and volume) and the resin's chemical composition have an impact on the hardness, a mechanical attribute that denotes a material's resistance to indentation or penetration. [26]There has been evidence of a significant correlation between filler content and mechanical attributes like hardness and elastic modulus.[27] The advantages of this technique include its relative simplicity, reproducibility, and lack of destructiveness.[28] Indentation is a useful research tool for many different systems across size scales (macro to nano) and several scientific disciplines, thanks to advancements in instrumentation as well. Due to these factors, Vickers testing was used to determine the degree of hardness of the materials investigated for this study.[29] When the top surface of the specimens was taken into account in the current in vitro study, the bulk-fill materials examined displayed various MH values. These results are consistent with earlier research comparing various bulk-fills.[30] According to the vicker hardness data, all groups' top surface values were statistically higher than their bottom surface values. Regardless of the composites assessed, light scattering by the filler particles and resinous matrix as well as the distance from the guide tip of the light-curing unit affect the irradiance that reaches the bottom surfaces.[13] It is well known that light enters the composite resin layer and is partially absorbed, partially scattered, and inversely proportional to the distance of the light-curing unit guide tip.[31] Microhardness may also be influenced by other elements such as the type and size of filler particles and the testing methodology.[32] Furthermore, noted that when the light source's tip made contact with the specimen surface, a greater microhardness value was recorded. Additionally, according to a study, [33], the ideal distance between the end of the light source and the specimen's surface is 0 mm, meaning that the light source's tip should be in direct contact with the surface. In this study, the specimen's surface was in direct contact with the light source's tip, with just a Mylar strip separating the two. In this study, Beautifil bulk showed the highest microhardness number (74.83 VHN) because of its high filler content (87% vol) followed by Surefil one (70.61 VHN) (77% vol) and One Bulk fill restorative (62.98 VHN) (76.5% vol). Different composite characteristics are affected by filler properties such as size, volume and weight. With increasing filler volume,

the flexural strength and modulus of elasticity, as well as hardness, improve (Szastch and Ilie, 2013). As Beautifil bulk has the highest filler content among the others it showed the highest MH number, although Surefil one has higher filler content than One bulk fill it showed higher MH number than One bulk fill this may be due to the presence of the reactive glass filler in its composition as it contributes to the strength and abrasive resistance of the composite. The results of the study agree with the study of (Al-Azmi et al.,2017) , [34]and (Bayrak et al., 2022), [25] while disagreeing with the study of (Li et al., 2021).[24]

Conclusion:

Beautifil bulk was more resistant to abrasion in comparison to Surefil one self-adhesive and One bulk fill. The great weight loss was observed in One bulk fill. Great weight gain was observed in Surefil one self-adhesive. Beautifil bulk showed the highest VH number compare to Surefil one self-adhesive and One bulk fill. Filtek one bulk fill showed low resistance and low hardness number. Further studies are required to ensure whether these differences can negatively influence the behavior of in vivo restorations.

Conflicts of interest

The author reported no conflict of interest.

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