EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 69, 1679:1686, April, 2023

Print ISSN 0070-9484 • Online ISSN 2090-2360

Conservative Dentistry and Endodontics

Submit Date : 16-02-2023 • Accept Date : 20-03-2023 • Available online: 10-04-2023 • DOI : 10.21608/edj.2023.194215.2448

SHEAR BOND STRENGTH OF A NEW SELF ADHESIVE RESIN COMPOSITE RESTORATIVE MATERIAL (AN IN-VITRO STUDY)

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ABSTRACT

Aim: Evaluation of shear bond strength of a new self adhesive resin composite restorative material.

Materials and methods: A total of 30 freshly extracted human intact molars were selected. All teeth are mounted in acrylic blocks, The occlusal surfaces of all selected molars were grinded at a level just below the dentino-enamel junction (DEJ). The prepared 30 molar divided into three groups of ten specimens each (n=10). The first group SR1 (Surefil one composite without adhesive application), the second group SR2 (Surefil one composite with adhesive application), and the third group FL (Filtek One Bulk Fill Restorative with adhesive application). Split teflon mold has dimensions of (6 mm width-4 mm height) was used to obtain disks of the tested materials, by placing the mold on the prepared dentin surface and each material applied inside the mold. After cyclic loading fatigue using Robota chewing simulator, shear bond strength of every specimen was measured using Universal testing machine. One-way ANOVA followed by Tukey post hoc test was used to compare between the different groups.

Results: There was a statistically significant difference between (SR1) and both of (SR2) and (FL) groups, where (($P < .05$). While there was no statistically significant difference between (SR2) and (Fl) groups.

Conclusion: (Surefil one) without adhesive application has limited shear bond strength than other tested groups. Adhesive application improved the shear bond strength of (Surefil one) self adhesive composite.

KEYWORDS: Shear bond, self adhesive, composite

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INTRODUCTION

A major development in the field of direct restoration is the material with self-adhesive properties, omitting the need for a specific adhesive protocol, which saves time and makes them easier to use. Another advantage of these materials is their ability to be used in situations where cavity isolation and moisture contamination control are doubtful. Bulk-filling technique is a simple technique that makes restorative procedures easier by decreasing the number of increments required to fill an entire cavity and reducing the time of application of the restoration.[1] Recently, bioactive or smart materials which are new self-adhesive resinous materials combining bulk-fill and fluoride releasing properties were introduced. They differ in composition from glass ionomer family and can perform clinically better than them.[2]

Dentsply Sirona introduced Surefil oneTM, a self-adhesive composite hybrid. It allows dentists to fill cavities in a single visit without the need for etching, bonding, or layering. The crosslinking power of structural monomers found in resin composites is combined with the self-adhesive capabilities of traditional polyacids known from glass ionomers in this modified polyacid. The formulation contains amide-based crosslinkers that make the formulation hydrolytically stable, resulting in a composite-like three-dimensional network that significantly increases the mechanical strength of Surefil oneTM. Glass fillers, resins, and polyacids all polymerize with the formulation’s crosslinkers. [3]

As a result of insufficient adhesion between the tooth and restoration, resulting in microleakage, gap formation, loss of restoration retention, and pulpal irritation, long-term clinical success of a restoration necessitates a durable junction between the restorative material and the hard tooth structure. [4]

Dentin is a less desirable substrate for bonding than enamel. Bonding to dentin is hampered by the tubular structure of the dentin, the outward migration of dentinal fluid, and the formation of smear layers following caries treatment. [5] The bond strength of resin composites to dentin could be evaluated using a variety of methods, including flexural and tensile strength. [6,7] Shear bond strength (SBS) is, on the other hand, regarded as a simple and widely used method for determining the bond strength of restorative materials. [7,8]

As a result, the goal of this study was to assess the shear bond strength of a new self adhesive resin composite restorative material. The null hypothesis was that there is no difference in shear bond strength between self adhesive and conventional bulk fill composites.

MATERIALS AND METHODS

Ethical regulation

The Ethics Committee of the Faculty of Dentistry at Minya University in Egypt approved this study (Meeting no. 93 & Decision no. 697).

Table 1 displays information on the materials used for tooth restorations

Teeth selection

A total of 30 freshly extracted human intact molars were collected from the outpatient clinic of Minia University Dental Hospital which were extracted for periodontal reasons. The teeth were cleaned from soft and hard tissues attachments and immersed in sodium hypochlorite solution for 30 min. The teeth were washed under running water and immersed in 0.1% thymol solution (Formula e Acao, Sao Paulo, Brazil) to be tested one month following extraction.[9]

Teeth mounting and preparation

In the study, Teflon mold that were partially split and had dimensions of 15 mm in diameter and 25 mm in height were used. Each tooth was then submerged in acrylic resin up to the level of the

TABLE (1). The specification, composition, manufacturer, and lot number of the materials used in this study:

Materials	Specifications	Composition	Manufacturer	Lot number
Surefil one™	Self adhesive resin composite -hybrid	Aluminium-phosphorus-strontium-sodium-fluoride-silicate crystals. HEMA(hydroxyethylmethacrylate) Water. Highly dispersed silicon dioxide. Acrylic acid Polycarboxylic acid. Ytterbium fluoride. Bifunctional acrylate. Self-braking initiator. 4-tert-butyl-N,N-dimethylaniline. Iron oxide pigments. Barium sulphate pigment. Manganese pigment. Camphorquinone (photoinitiator). Stabiliser.	Dentsply Sirona, UK.	291E79
Filtek™ One Bulk Fill Restorative	Bulk fill light cured resin composite	**The Resin System:** BIS-GMA, BIS-EMA PEGDMA and TEGDM, AUDMA and 1, 12-dodecane-DMA. **The Filler System:** non-agglomerated/non-aggregated 20 nm silica filler and a ytterbium trifluoride filler, filler loading is about 76.5% by weight (58.4% by volume).	3M, ESPE, Elipar, USA	032830
Single bond universal adhesive	One step self-etch adhesive	10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), HEMA, Vitrebond Copolymer, Filler, Ethanol, Water, Initiators, Silane.		527602

cemento-enamel junction (CEJ) after the mould had been filled with a self-curing resin. Each tooth was mounted using a dental surveyor (Ney Dental Surveyor, Anaheim, CA, USA) to make sure it was centered and completely parallel to the long axis of the tooth.

In order to achieve a flat surface, the occlusal surfaces were flush with the acrylic surface, the occlusal surfaces of all chosen molars were ground at a level just below the dentino-enamel junction (DEJ) perpendicular to the long axis of the tooth using a high-speed diamond disc (KG Sorensen, Sao Paulo, SP, Brazil) Fig. (1A). To establish a standardised, consistent smear layer, the exposed dentin surface was then polished with 600-grit silicon carbide paper. The prepared specimens were kept in a spherical Teflon mold, which gave them additional stability and made manipulating them easier.

Grouping of the specimens

The prepared 30 molar divided into three groups of ten specimens each (n=10). The first group SR1 (Surefil one composite without adhesive application), the second group SR2 (Surefil one composite with adhesive application), and the third group FL (Filtek One Bulk Fill Restorative with adhesive application).

Restorative procedures

Bonding procedure

The prepared dentin surfaces were thoroughly rinsed with water to remove the debris and dried using mini sponge. Single bond universal adhesive (3M, ESPE, Elipar, USA) was used for bonding of two groups (SR2 and FL). The bonding procedure was done according to the manufacturer's instructions. The bond was applied on the prepared dentin surface by micro brush (Dental Bond Brush, Unipack, China) , followed by light agitation for 20s then gently air dried for 5s for through evaporation of the solvent, and light cured for 20 seconds, 1470 mW/cm^2 intensity (3M, Elipar, Deep Cure-S LED Curing Light USA).

Application of restorative materials:

Split teflon mold has dimensions of (6 mm width-4 mm height) was used to obtain disks of the tested materials, by placing the mold on the prepared dentin surface Fig. (1B) and each material applied inside the mold. Surefil one composite supplied in the form of capsules, each capsule was activated first by firmly pressing the red activation button until its seated against a hard surface help. Then the capsule mixed in the amalgamator (4500 Rpm, Silamat S6 Amalgamator, Ivoclar, Vivadent, US) for 10 seconds according to manufactures instructions. Then the capsule placed in the extruder and started in material application inside the mold while keeping the nozzle in the material during application till over fill the mold then the excess material was removed) by composite applicator (AMERICAN EAGLE composite SET, U S) and light cured for 20 sec. according to manufactures instructions.

For application of Filtek One Bulk Fill restoration, composite applicator was used to applicate the material inside the mold as one bulk to slightly overfill the mold, excess material was removed then light cured for 20 sec. according to manufactures instructions. The Teflon mold then removed Fig. (1C), addition light curing for 40 sec. was done for each specimen then stored in distilled water at 37°C for 24 hours according to *(**Namith et al., 2017**)*.[10]

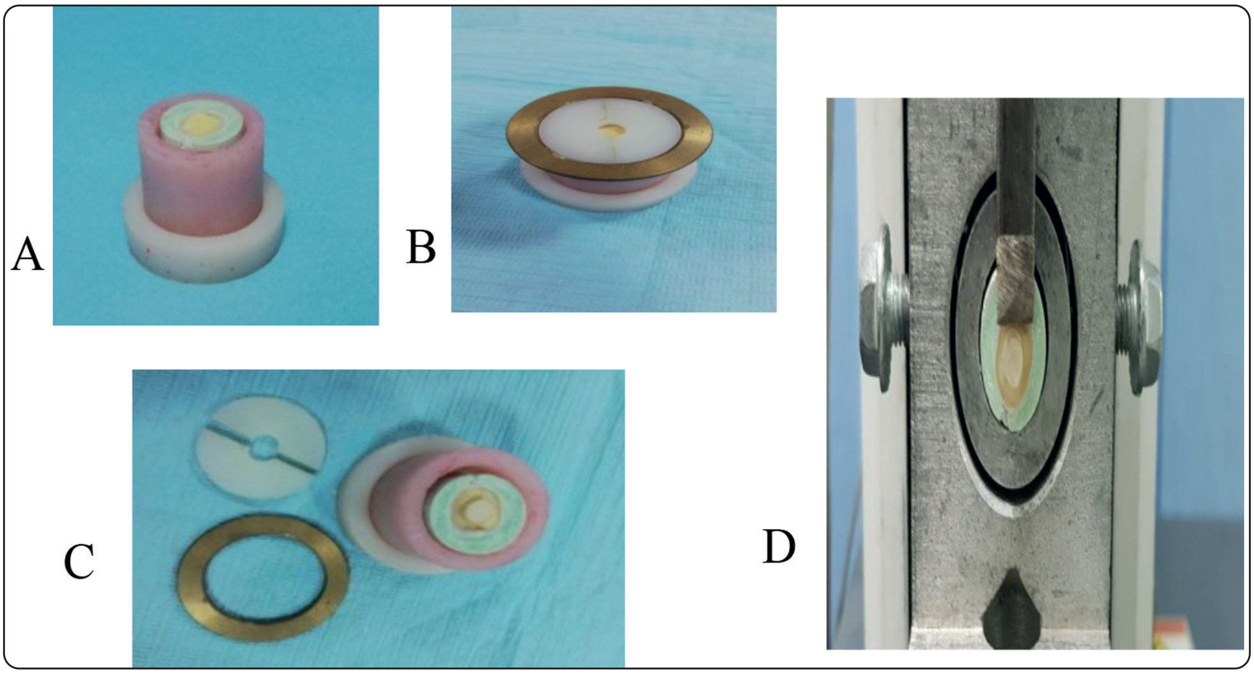

Fig. (1): (A): Occlusal surface of dentin flushed with the surface of acrylic mold. (B): Teflon mold hold against occlusal dentin surface. (C): Prepared restoration disk on the dentin surface. (D): Mono-beveled chisel directed on the interface between the restoration and dentin.

Cyclic Loading fatigue:

The four stations multimodal ROBOTA chewing simulator (ACTA Fatigue tester, Amsterdam, Netherlands) integrated with thermo-cyclic protocol worked on servo-motors under mechanical loads with thermocycling (Model Ach-09075dc-T, Ad-Tech Technology, Berlin, Germany). In the lower sample container, the specimens were housed in Teflon housing. A 5 kg weight was applied, which is equivalent to a 49 N chewing force.

The samples were put through 75,000 cycles, 600 of which were thermal (5 /55 C, dwell period 25 seconds).[11] The following parameters were used for the chewing simulation: 1.6 Hz cycle frequency, 3 mm of rising/vertical movement, 1 mm of horizontal movement, 90 mm/s of rising/forward speed, and 40 mm/s of descending/backward speed.

Measurement of shear bond strength:

The shear test was developed to evaluate the bond strength. Using a computer-controlled Universal testing machine, each sample was positioned separately and horizontally (Instron model 3345; Instron, Norwood, MA, USA). data were recorded using computer software and a load cell of 5 kN. (Bluehill Lite; Instron Instruments). By tightening screws in a specially built metallic housing device with a central hollow into which the substrate fits, samples were mounted to the testing machine's lower fixed compartment.

A mono-beveled metallic rod in the shape of a chisel was attached to the upper moveable compartment of the testing apparatus, and a shearing test was conducted utilising it while travelling at a cross-head speed of 0.5 mm/min. Fig. (1D). The force necessary to cause debonding was measured in Newtons. The following equation was used to estimate the shear bond strength and to express it in MPa as follows:

$$\boldsymbol{\tau = P/ \pi r^2}$$

Where: $\boldsymbol{\tau}$ =shear bond strength (MPa)

P =load at failure (N)

$\boldsymbol{\pi}$ =3.14

r =radius of disc (mm).

Statistical analysis

The one-way ANOVA and Tukey post hoc tests were employed to compare the outcomes of the various groups. The t-test for independent samples was used to compare two groups in unrelated samples. The limit for significance was chosen at P 0.05. With IBM® SPSS® Statistics Version 20 for Windows, a statistical analysis was carried out.

RESULTS

TABLE (2): Mean and standard deviation (SD) of shear bond strength (MPa) for the different groups:

Study groups	n	Mean in (MPa)	SD
SR1	10	4.35	0.876
SR2	10	7.22	0.245
FL	10	8.67	0.378

There was a statistically significant difference between (SR1) and both of (SR2) and (FL) groups, where (($P < .05$). While there was no statistically significant difference between (SR2) and (Fl) groups. The highest mean value recorded in (FL) group, followed by (SR2) group, and the lowest mean value found in (SR1) group.

DISCUSSION

Because to its sufficient mechanical behavior, aesthetically pleasing qualities, and most importantly, their ability to preserve the tooth structure, composites have emerged as the material of choice in restorative dentistry. One of the drawbacks of typical composites with regard to the polymerization reaction, according to Ferracane et al.[12], is that the material's volume shrinks by roughly

3%. [13] This contraction is passed on to the area where dental tissue meets restorative material, where it may result in marginal filtration, secondary caries, loss of the restoration, cuspal deflection [14], and enamel microcracks, which induce postoperative sensitivity, often while chewing.

The most recent strategy has been to develop materials requiring fewer steps in their protocol for use, such as bulk-fill and self-adhesive composites. One of these recent materials is Surfil one, The main ingredient of Surefil One is MOPOS, a modified polyacid with a special structure and set of qualities that open up new possibilities for creating self-adhesive restorative materials. The network development and attachment to tooth structure that MOPOS promotes increase the material's mechanical strength. The hydrolytically stable modification of the polyacid base polymer with polymerizable groups is what distinguishes MOPOS from other technologies. Generally, HEMA is utilised to modify polyacids in resin-containing materials in a hydrolytically unstable way (hydroxyethyl-methacrylate). A surplus of HEMA must be utilised in the formulation to change the equilibrium to the necessary amount of functionalization of the polyacid because this linkage is unstable in an aqueous acidic environment. [16]

Was performed in the current study using ROBOTA chewing simulator integrated with thermo-cyclic protocol operated on servo-motor to stimulate the load cycling and temperature. Bond strength studies are crucial for assessing the effectiveness and longevity of tooth-colored restorations because they show how long the restoration will last inside the patient's mouth.[17] According to (Simarpreet et al., 2012)[18], human teeth were chosen in this study's shear bond strength test because they offer the best model for imitating the clinical setting in lab studies and they determine the clinical effectiveness of tested materials.

Many difficult factors exist in the oral environment that surrounds dental restorations, including humidity, an acidic or basic pH, cyclic loading, and temperature. [19,20] Clinically, mechanical failure of dental restorations results from cyclic interactions between maxillary and mandibular teeth after many years in use, which ultimately reduces the likelihood of survival and lifespan of the restorations. [21] The mouth may experience alterations due to load cycling.

In this study, self etch (universal adhesive bond) was used to test the shear bond strength of the self adhesive composite (Surfil one) with and without adhesive application and comparing the results with that of (Filtek one bulk-fill restorative) resin composite restorative material. The results showed that There was a statistically significant difference between (SR1) and both of (SR2) and (FL) groups, where (($P < .05$). While there was no statistically significant difference between (SR2) and (Fl) groups. The highest mean value recorded in (FL) group, followed by (SR2) group, and the lowest mean value found in (SR1) group.

These results similar to that found by (Francois etal., 2021)[22] bonding values and failure patterns significantly differed in relation to material and adhesive procedure, SBS values were higher for all the materials tested with an adhesive. Perhaps as a result of the strong bonding that universal adhesives have created with dentin[23]; the improved wettability of adhesives, which enables better micromechanical retention; and the chemical interaction between the acidic functional monomer present in SBU and the calcium in dentin. [24]

But the results of (Francois etal., 2021)[22] differ than our results because they found that When adhesive was not applied to (Surfil one) showed high shear bond strength most likely due to the fact that adhesion depends primarily on a functionalized polyacrylic acid with a high molecular weight that can help with smear layer hybridization and on ionic interactions between calcium found in dentin and the carboxyl groups of MOPOS (for the Modified Polyacid System).[25]

Also our finding agreed with (Takamiya et al., 2021)[26] as they found that Because to their inferior chemical and demineralization capabilities when compared to restorative materials employed with adhesive systems, self-adhesive restorative materials have restricted bonding characteristics to tooth substrates. Moreover, the materials' observed bonding strengths to etched enamel were weaker than those previously reported for composites using a different adhesive. [27,28] In comparison to typical one-step, multiple-step, or universal adhesive systems and filling composites, self-adhesive flowable restorative materials still have a limited capacity for chemical bonding, as evidenced by the literature. [27,28]

Abdelrahman etal., 2016,[29] reported that Vertise flow reported a considerably lower shear bond strength than Filtek bulk fill flowable composite with single bond universal when shear bond strength to dentin was assessed. Its weak bond strength may be explained by the non-homogenous adhesive layer in the Vertise flow group. Moreover, Vertise flow's low dentin wettability prevented a close contact between the material and dentin structure, which reduced chemical interaction. In comparison to Vertise flow, which only operates on a surface level, Single Bond Universal, the primary factor in Filtek flowable bulk fill's adhesion, causes deeper penetration and more wetting to the dentine substrate. [30,31]

Moreover, one of the most widely utilised functional monomers is 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP). It can be found in universal single bonds. Due to its resistance to hydrolysis and capacity to establish powerful ionic connections with calcium, it is thought to be the most promising monomer for chemically attaching to the hydroxyapatite found in enamel and dentin. 32 It is a hydrophilic phosphate monomer that, by producing acidic decalcification and attaching to calcium ions or amino groups in tooth structure, improves resin diffusion and adherence. According to reports, it is one of the best materials on the market for chemical bonding.[33]

Therefore according to the results of this study, the null hypothesis was rejected as the shear bond strength of the conventional bulk fill composite (Filtek One Bulk Fill) was higher than the self adhesive composite (Surefil one) without adhesive application.

CONCLUSION

Within the limitation of this study, it can be concluded that:

1- (Surefil one) without adhesive application has limited shear bond strength than other tested groups.

2- Adhesive application improved the shear bond strength of (Surefil one) self adhesive composite.

3- The shear bond strength of (Surefil one) self adhesive composite after adhesive application closed to that of (Filtek One Bulk Fill) resin composite.

RECOMMENDATIONS

Its recommended to use (Surefil one) self-adhesive composite with adhesive application, if it will be used as a final restoration in permanent teeth

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