Original Article

# Effect of C-factor on Micro-tensile Bond Strength of Bulk fill V/S Micro-hybrid Composite in Class II Restorations – An In-Vitro Study

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## Abstract

**Background:** High Configuration factor (C-factor) results into increased polymerization shrinkage causing stress at resin-dentin interface leading to failure of the restoration. The purpose of this study was to evaluate the effect of C-factoron micro-tensile bond strength (μTBS) of bulk fill composites in class-II cavities when restored in 4mm of bulk as compared to conventional composite.

**Methodology:** A total of 90 carious, crack free extracted human mandibular permanent molars were selected and randomly divided into 3 groups (n=30). On all samples, class II cavities (3.5X 3.5cm) were made by single operator and divided as Gp1 (2.5mm), Gp2 (4mm), and Gp3 (6mm) on the basis of depth of cavities. Sampling units of 30 in each group were further randomly subdivided into 3 subgroups (n=10 each subgroup), according to the type of composite resin systems to be used for restoration. Experimental Subgroup includes SubGp1 restored with SDR Surefil (Dentsply, caulk, USA) and SubGp2 restored with Sonic fill (kerr, orange, CA, USA), whereas SubGp3 restored with FILTEK Z250 served as control. After storage in water at 37°C, the teeth were sectioned perpendicular to the restorative tooth interface as 1×1 mm non-trimmed rectangular micro-specimens for micro-tensile bond strength (μTBS) testing. Beams (n=30 max) from each SubGp were fixed to a metal jig and subjected to micro-tensile bond strength testing. The data collected for micro-tensile bond strength (expressed in Mpa) were statistically analysed using one way ANOVA and Tukey's post hoc test.

**Results**: In class II cavities with high C-factor, SDR Surefil showed better μTBS than SonicFill and micro-filled composite when filled in bulk of 4mm, as compared to micro-hybrid composite filled incrementally.

**Conclusion:** There is no effect of high C-factor on μTBS of tooth restored with both SDR Surefil and Sonic Fill in class II cavities as compared to microhybrid composites.

**Keywords:** Micro-Tensile Bond Strength; Bulk Fill Composites; SDR Surefil; Sonicfill.

## Introduction

Patient's inclination towards aesthetically pleasing restoration has lead to the increasing popularity of Resin-based composite (RBC) material as posterior restorative material[1]. Improved resincomposites have been reported over the years, but there are still several drawbacks of using the material for restoring posterior teeth. The most important of which are polymerization shrinkage and questionable adaptability to cavity walls and margins especially in dentin.[2,3]

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Polymerization shrinkage is a significant drawback of composites when used as a posterior restorative material as it can affect marginal integrity that causes marginal leakage, debonding, secondary caries, postoperative sensitivity, development of peri-marginal white lines and even cuspal

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fracture.[4,5,6] It varies by factors such as the total volume of composite used, type of composite, polymerization speed, Configuration factor (C-factor)[7-8]

C-factor is the ratio of bonded to unbonded surface area in cavities restored with composites. The presence of a high C-factor is a risk factor for debonding at the dentin interface and is reported to affect marginal seal and cavity wall adaptation of RBC.[9]C-factor can be reduced by incremental build up techniques of composite restoration, though incorporation of air bubbles, and technique sensitivity are major disadvantage of this technique.[10]

Various new bulk-fill composites (low and high viscosity) have been introduced, as bulk filling material for class I and II restorations to improve the performance of resin composite materials. Recently introduced SDR Surefil [Dentsply, caulk, USA] is a low viscosity bulk fill, which contains a polymerization modulator, to lower polymerization shrinkage,[11]SonicFill [SF, Kerr, CA, USA] is the sonic activated bulk filling material having high viscosity which can be cured up to a depth of 5mm.[12] The Interface between the restoration and the tooth structure should be approximated to reinforce the remaining tooth structure by effectively cross-linking the discontinuity and efficiently transferring and distributing the functional stresses throughout the restorative-tooth complex.[13,14] The effectiveness of bonded interfaces has long been investigated using assessments of microleakage and bond strength.[15,16] Only a few studies are present in the literature where the micro-tensile bond strength of bulk-fill composites and conventional composite have been compared with cavities of high C-factor.
The study aimed to compare the influence of high C-factoron micro tensile bond strength(μTBS) to dentin in class II cavities when bulk fill composites are restored in bulk of 4mm as compared to micro-hybrid composite filled incrementally. The null hypothesis was that the (μTBS) to dentin does not depend on C-factor for class II restorations when restored with bulk-fill or micro-hybrid composites.

## Material and Methods

Overview of the materials used in this study is provided in Table 1.A total of 90 caries-and crack-free extracted human mandibular permanent molars were selected. Collection, storage, sterilization and handling of the extracted teeth used in this study followed the 0ccupational Safety and Health Administration (OSHA) and the Centre for Disease Control and Prevention (CDC) recommendations and guidelines.

The occlusal and one proximal surface of each tooth was wet-grounded using a dental trimmer (Ray foster, M10 model, USA),and flat ended wheel diamond bur (Primadent, Stephenson drive, UK)(s) until a flat dentin surface was obtained. The exposed dentin surface was wet-polished with sandpapers (P1200, YSZZ, China) to produce a standardized smear layer. The roots of each tooth were embedded in self-cure acrylic resin (DPI) inside plastic cylinders 1mm below the cemento-enamel junction. These samples were then randomly divided into 3 specimen groups (Gp1, Gp2, Gp3) of 30 teeth each. In these groups, standard box-type Class-II cavities (3.5 mm×3.5 mm) were prepared on the caries-free proximal aspect with coarse diamond burs (Primadent classic) in a contra-angle handpiecewith profuse water spray and were finished with fine-grained bur (Primadent classic). All cavities were made by the same operator using custom measuring devices to standardize dimensions of cavities. The depth of these cavities was as follows, Group1 (Gp1) - 2.5 mm in depth, Group2 (Gp2) - 4mm in depth, Group3 (Gp 3) - 6mm in depth. The 4mm and 6mm deep cavities were obtained by first building up the molar teeth using the nano-hybrid composite in a contrasting shade using Teflon mold,[17] after which the class II cavities were prepared as above. In this way, the dentin at the cavity bottom in the three groups (including flat surface) was mid coronal, ensuring that the effect of regional variability on micro-tensile bond strength was negligible.[18]

Sampling units of (n=30) in each group were randomly subdivided into 3 subgroups consisting of 10 samples each according to the type of composite resin systems to be used for restoration.

SubGp1 – Low viscosity bulk-fill composite (SDR Surefil (dentsply)

SubGp2 – High viscosity bulk-fill composite (Sonic fill (kerr, orange, CA, USA)

Subgp3 –micro-hybrid composite as control (FILTEK Z250)

Experimental Bulk fill composites were filled in bulk of 2.5mm and 4mm in Gp1 and Gp2 respectively whereas in Gp3 they were filled in an increment of 4mm + 2mm. The micro-hybrid composite was filled in the increment of 2mm in all Gp's to serve as control.

The C-factor was calculated according to the method of dos Santos 2009 as shown in Table 2-(C-factor for different depth of class II cavities)[9]

Adhesive procedures were performed with standard etch and rinse adhesive system (Optibond S, Kerr) following the manufacturer's instructions. The proximal wall was built up by using a metallic matrix of standard diameter. The restoration was light-cured with a high-power VLC curing device (LED Curing Light, Bluephase ,IvoclarVivadent).

**Sectioning of specimen**

After storing the specimen in water at 37ºC for one week, the teeth were sectioned perpendicular to the restoration-tooth interface using an automated water-cooled diamond saw (Isomet saw, Censico international, Agra, India) (Fig-1) to obtain rectangular 1 mm×1 mm, non-trimmed micro-specimens for micro-TBS testing (Fig-2).

**Micro-tensile bond strength evaluation**

The specimens were kept moisturized until tested. From each Subgroups of SDR surefil, Sonicfill and microhybrid composite a maximum of 30 intact beams were analyzed. Beams (n=30 max) from each Subgroups were fixed to metal jig[19] using cyanoacrylate glue (PELCO Pro CA-Gel Glue) (Fig-3). Instron Micro-tensile Tester (Model 5848, Singapore) was used for testing (Fig-4). The dimension of each stick was measured using digital calipers and the bonded area was calculated for subsequent conversion of micro-tensile strength values into units of stress (MPa). (Fig-2). Stress value at which fracture occur is noted (Fig -5).

**Statistical analysis**

The data collected as micro-tensile bond strength (expressed in Mpa) were statistically analyzed using one way ANOVA for intergroup and inter-Subgroup comparison followed by Tukey's post hoc test intragroup and intra-Subgroup comparison individually.

**Results**

µTBS ranged from 15Mpa to 52.6 Mpa in all tested samples as shown in table 4 which also includes the median, minimum, maximum value for µTBS for different tested materials in different cavity depth groups.

Graph (Fig-6) represents the box plot of µTBS results.

Results for One way ANOVA for intergroup comparison (between the different groups for each tested material) are showed in Table- 3. It was found that µTBS for SDR material is statistically significant for 4mm and 6mm cavity depths , with the highest value of mean for Gp2 (4mm) being 37.7 ± 7.27. µTBS for SonicFill and Filtek Z250 is not statistically significant in different groups of class 2 cavities. Post hoc test showed that SDR Surefil resulted in similar micro tensile bond strength when filled in bulk of 4 and 4+2 mm than 2.5mm. Thus it can be concluded that the high C-factor does not affect the micro tensile bond strength of Bulk-fill composites as compared to Filtek Z250.

One way ANOVA for Inter-Subgroup Comparison (between tested materials for each group) showed that - Gp2 showed a significant difference in µTBS for tested materials. Tukeys post hoc test showed that SDR has better µTBS than Sonicfill and Filtek Z250 which is statistically significant in Gp2. (Table - 4) Whereas in Gp1 and Gp3 both Sonicfill and SDR Surefil performed equivalent to micro-hybrid composite filled incrementally.

**Table 1** – Overview of Experimental groups

| Material | Composition | Filler load | Maximum layer thickness | Batch no. |
|---|---|---|---|---|
| **Surefill SDR flow** (dentsply) | Matrix : SDR patented urethane dimethacrylate, dimethacrylate, ethoxylated bisphenol A dimethacrylate, pigment.<br><br>photoinitiator filler: barium and strontium alumino -flouro-silicate glasses | 68%wt 45% vol | 4mm | 04211 |
| **Sonic fill** (kerrorange,CA, USA) | Bis-GMA, Bis-EMA, TEGDMA | 84% 66% NP | 5mm | 4651808 |
| **FILTEK Z250** (Control) | Bis-GMA, UDMA, Bis-EMA | 84.5% wt 71% vol | 2.5mm | T463917 |
| **Optibond S** (kavo, kerr) | 10-30% ethanol, 10 -30% 2hydroxyethyl methacrylate, 1 -5% 2-hydoxy-1,3-propanediyl bismethacrylate, 0.1 -1 alkali flourosilicates (Na) | | | 5257355 |

**Table 2:** The C-factor was calculated according to the method of dos Santos 2009. C-factor for different depth of class II cavities) is as follows.

| S.No | Cross section | Depth | C-factor |
|---|---|---|---|
| 1. | 3.5mm x 3.5 mm | 2.5mm bulk fill | 1.82 |
| 2. | 3.5mm x 3.5 mm | 4mm bulk fill,<br>(4 +2)mm bulk fill | 2.06 |
| 3. | 3.5mm x 3.5 mm | 6mm increment filling | 1.7 |

**Table 3:** Results for One way ANOVA for intergroup comparison (between the different groups for each tested material)

| Group<br>Materials | Group 1 | Group 2 | Group 3 | P value |
|---|---|---|---|---|
| SDR Surefil | 28.3 | 37.1 * A | 34.3 * | .001 |
| SonicFill | 29.4 | 31.5 | 30.3 | >.05 |
| Filtek Z250 | 31.3 | 32.2 | 30.5 | .727 |
| P value | .254 | .002 | .166 | |
| Note- * denotes statistically significant in row<br>A denotes statistically significant in column | | | | |

**Table 4:** One way ANOVA for Inter-Subgroup Comparison (between tested materials for each group)

| Statistics | SDR 2.5mm | SDR 4mm | SDR 6mm | SonicFill 2.5mm | Sonicfill 4mm | SonicFill 6mm | Filtek 2.5mm | Filtek 4mm | Filtek 6mm |
|---|---|---|---|---|---|---|---|---|---|
| median | 28.35 a | 37.7 A | 34 A | 29.3 a | 31.45 a | 30.5 a | 31.6 a | 32.1 a | 30.3 a |
| Q1 | 24.925 | 33.25 | 26.4 | 26.975 | 26.9 | 25.4 | 21.425 | 27.5 | 25.68 |
| min. | 15.6 | 23.6 | 14.3 | 19.8 | 21.6 | 12 | 15 | 18.4 | 16.6 |
| max | 38 | 52.6 | 54.3 | 42.2 | 44 | 48.2 | 47.8 | 46.2 | 45.8 |
| Q3 | 32.225 | 41.075 | 41.85 | 31.425 | 36.1 | 34.7 | 40.25 | 36.73 | 35.43 |
| Groups with the same letter are not statistically significantly different ($p < 0.05$) | | | | | | | | | |

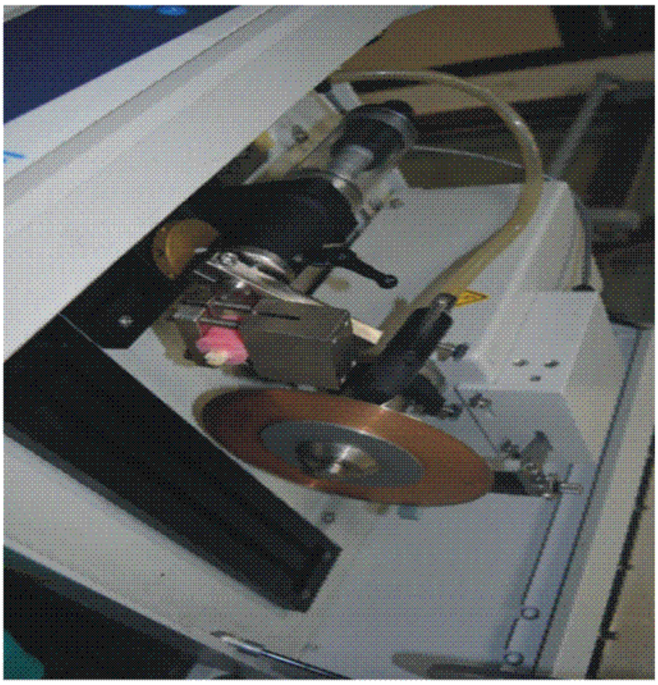

**Fig 1:** Automated water-cooled diamond saw

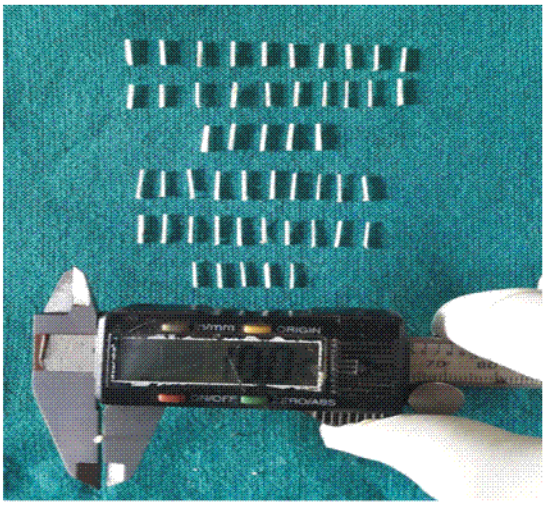

**Fig 2:** Rectangular 1 mm×1 mm, non-trimmed micro-specimens for micro-TBS testing

**Fig 3:** Microspecimen fixed to Jig using cyanoacrylate glue

**Fig 4:** Instron micro-tensile testing machine

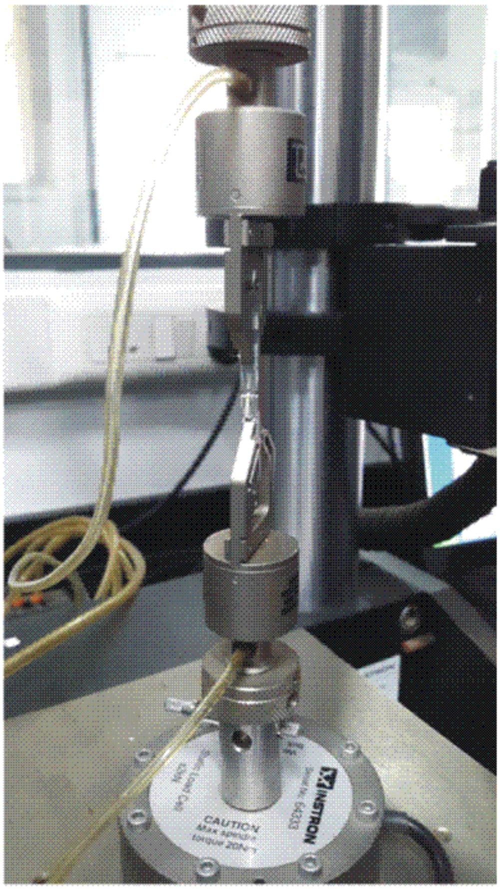


**Fig 5:** Fractured beam on Instron micro-tensile testing machine

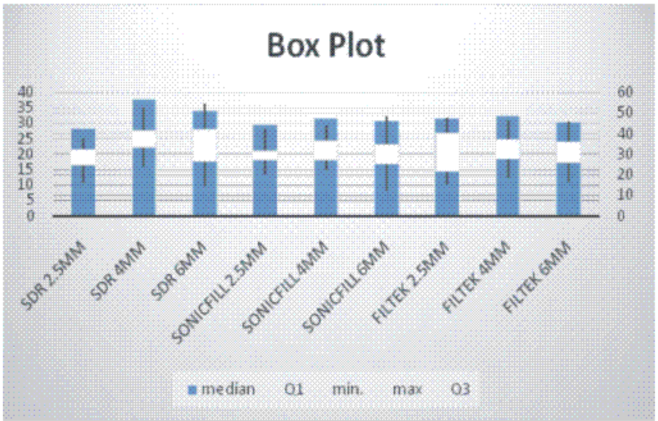


**Fig 6:** Box plot graphical representation of μTBS results

## Discussion

In literature potential negative effects of contraction stress have been reported by examining marginal leakage, gap formation, cuspaldeflection, micro-tensile bond strength, tooth cracking, and mechanical properties of the restorative materials. Usually these studies have involved situations in which polymerization stress was expected to be a significant factor for bond failure. This stress can be attributed to a constraint of free resin shrinking by a confining 3-D cavity preparation, rapid curing protocols, and bulk placement of “non-bulk-fill” materials.[20]

It is very important to understand the effect of polymerization stress on the restoration tooth interface. In some situations, the interface may remain bonded, due to adequate adhesion forces, but continue to exist in a state of stress from the polymerization contraction. This type of scenario would likely be evident in situations where the curing composite is under significant constraint imposed by the adhesion to the walls of a three-dimensional cavity, as described by many authors and characterized by the configuration factor (C-factor).[9]

It has been shown that the C-factor alone cannot be used to predict contraction stresses for a given material, and other factors, such as the volume of the material also may have a significant effect.[21,22] But studies in which composite has been placed within preparations and then either pushed out or sectioned to test adhesion have shown reduced bond strength under conditions of greater constraint, suggesting that the higher stresses negatively affected the bonds.[23-24]

Thus in this study we have evaluated the effect of high C-factor on mico-tensile bond strength of bulk-fill composites in Class II cavities when filled in bulk as compared to micro-hybrid composite filled incrementally.

Bulkfill RBC materials are highly desired in routine restorative practice to help dentists reduce placement time and work more efficiently. The first flowable bulk-fill concept was introduced with 'SDR Surefil' (Dentsply). It consists of a two-staged procedure, involving the placement and curing of a 4-mm thick flowable composite base that subsequently is covered by a conventional composite.[11] Bulk-filling is possible due to its stress-relieving flowability which is potentially enhanced by a so-termed 'polymerization modulator' chemically embedded in the polymerizable resin backbone of 'SDR' resin monomer (Dentsply).[25] SonicFill also shows improved flowability at the time of placement after sonic activation which will turn to highly viscous after some time.[12] In the present study, SDR SureFil and SonicFill were tested against conventional micro-hybrid composite which served as a positive control as it was placed incrementally up to a maximum of 2mm thickness in class II cavities with different C-Factor and evaluated for micro-tensile bond strength to cavity bottom dentin.

In this study, micro-tensile bond strength protocol was employed to evaluate the potential impact of bulk-filling materials on the bond strength to dentin in Class II Cavities with high C-factor as used in previous studies.[17] The tensile stress generated due to polymerization shrinkage at the dentin restoration interface of the cavity floor affects the bond integrity. The latter effect was measured in terms of μTBS.

In this study when the 2.5-mm deep cavities were restored in bulk with SDR Surefil and SonicFill, they showed μTBS comparable to standard composite filled incrementally. The configuration of the 4-mm deep cavities was the less favourable, because it has a higher C-factor and restoration volume. In this study, 6mm depth cavity was also filled in increments of 4mm + 2mm for bulk-fill composites. Thus C-factor is similar to 4mm but curing distance is increased simulating different clinical conditions. High C-factor induces polymerization stress[9] hence control group was filled incrementally to a maximum depth of 2mm.

In this study, high bond strength was maintained for 'SDR Surefil filled in 4mm bulk and 6mm (4 + 2) increments and appeared significantly different from that recorded for 2.5mm bulk restoration. SonicFill showed bond strength similar to conventional composite placed incrementally in all depth cavities and lower than SDR Surefil as 4mm and 6mm cavities. Thus, it is observed that the high C-factor of class II cavities does not affect bond strength to cavity bottom dentin of bulk-fill composites. Thus, the null hypothesis is accepted.

In this study, it is also observed that in 2.5mm depth of the cavity subgroup both SDR Surefil and SonicFill showed comparable micro-tensile bond strength to conventional composite filled incrementally in 2.5mm depth of the cavity, whereas in 4mm bulk and 6mm incremental subgroup SDR Surefil showed statistically significant better results for μTBS than SonicFill and conventional composite. This data implies that these bulk-fill composites SDR Surefil (Dentsply) and SonicFill can be cured in bulk for a maximum of 4mm, without harming the bond to cavity-bottom dentin. Better performance of SDR than SonicFill might be attributed to low polymerization shrinkage stress, better flowability, low elastic modulus and greater depth of cure due to translucency.[26]

Previous research, have shown that the mechanical properties of SDR Surefil and SonicFill are maintained at 4mm depth after bulk curing, and SDR Surefil showed low polymerization contraction and smaller marginal gap than Sonicfill and conventional composite.[27-] This is in accordance with literature where lower polymerization shrinkage and better marginal integrity was seen with bulk fill composites.[28,29,30] Though in literature, it is unclear whether the tests related to shrinkage stress induced by bulk-filling have any clinical relevance as they seem inconsistent in providing any clarity.[31]

In literature, it is reported that high C-factor in Class I cavities does not affect adhesion of bulkfill composites to cavity wall when filled in bulk of 4mm and can be used for posterior tooth restorations. Similar findings were confirmed by our study in Class II cavities. [32,33]It is also reported that bulk-fill composites present similar fracture strength in molars with mesio-occlusal-distal restorations.[34]

More studies should be done to compare the different mechanical and physical properties of the bulk fill RBC's compared to the conventional RBC materials placed in the layering technique.

## Conclusion

Results of this In-Vitro study showed that SDR Surefil and SonicFill can be used to restore class II cavities in bulk of 4mm and bulk increment of 4+2 even though SDR Surefil significantly performed better.Their comparable micro-tensile bond strength as compared to micro-hybrid composite which is filled incrementally shows its good adaptability and adhesion to dentin.

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## Conflict of Interest:

Authors deny any conflict of interest.

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