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ORIGINAL: Evaluation of the Effects of Different Composite Types on the Shear Bond Strength: An in vitro Study

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ABSTRACT

Introduction: The aim of this in vitro study was to determine and compare the shear bond strength (SBS) of two types of composites.

Material and Methods: Twenty cylindrical samples were prepared and divided into two control and case groups. The case group consisted of 10 cylindrical samples of two types of composites (3M and Vivadent), and the control group, which was divided into two subgroups of 5, included only one type of composite (3M or Vivadent). After preparation, the samples were transferred to the Instron device for testing the SBS. The data were analyzed by SPSS version 15 software using Smirnov-Kolmogorov test for studying the normal distribution of data and t-student test for independent populations.

Results: Heliomolar (Ivoclar-Vivadent) composite (microfill) showed the lowest SBS, but the difference was not significant (P>0.05). The highest SBS was for Filtek Z100 (3M ESPE) composite. There were no fracture lines in the interface of the two composites.

Conclusion: This confirms that proper use of adhesives can prevent fracture in the interface of different composites. So, using two different composite brands on each other does not reduce the bond strength between them.

Introduction

The composite resins were first developed in the early 1960s. These materials have higher mechanical properties than acrylics and silicates, lower thermal expansion coefficient, less dimensional variations during setting, higher wear resistance, and hereby better clinical performance (1). The composite resins are currently the preferred restorations for the anterior and posterior teeth (2).

Recent advances in the technology of adhesive systems and composite resins have improved the longevity of composite restorations. However, a significant amount of fracture still occurs (3). The annual fracture rate of these restorations in the anterior and posterior teeth varies from 1 to 4 percent. In the cases of composite restoration

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fractures, the dentist has three ways to deal with a defective restoration: refurbish, repair or replacing the composite. Refurbishing includes refinishing and repolishing to improve surface anatomical properties without removing or adding material. Repair is a method to remove partially the defective part of the restoration, which is then repaired with new materials. Unlike refurbishing and repairing that are conservative, replacing a restoration is a complete harvest and then replacement with new materials. In fact, in this method, it is impossible to prevent damaging the sound tooth structure during the preparation of the cavity and the risk of damage to the pulp increases (2).

According to some studies, repair has a good clinical success and is considered a reliable and promising method for defective restorations (3). Moreover, in comparison to the replacement technique, it reduces the risk of iatrogenic damage and the need for local anesthesia, and saves time and materials in managing the defective restoration (4). Many studies have stated that the repair of restoration is a simple and fast method that results in improved clinical properties of defective composite resins. In addition, it is effective as much as a complete replacement technique is and increases the longevity of restoration. The disadvantages of restoration replacement include being time-consuming, the risk of greater restoration, and the risk of damage to the dentin-pulp complex (5).

Repair can be applied to localized defects, such as superficial marginal staining, shade correction, marginal defects, fracture of the resection, fracture of the tooth, and even in the presence of secondary caries lesions (3).

The bond strength between new and old materials is reportedly considered as a successful parameter in the repair. Although in vitro tests do not correctly represent the complexity of the oral environment, it is possible to compare the effects of different repair protocols under controlled conditions (6).

Sometimes we have to use a composite material with any brand at repair time for various reasons, for example because of not having the desired brand. Since there are different views on the applicability of two different composites, the aim of the present in vitro study was to determine the shear bond strength (SBS) of two types of 3M and Vivadent composites.

Methods

The current in vitro study examined two types of light-cure restorative materials. After a pilot study, 20 cylindrical samples were prepared and divided into two groups of case and control. The case group consisted of 10 cylindrical samples of two types of composites, and the control group, which was divided into two subgroups of 5, included only one type of composite.

The materials tested were Filtek Z100 (3M ESPE, Minnesota, US) composite (micro-hybrid), Heliomolar (Ivoclar-vivadent, Liechtenstein, Germany) composite (microfill) and single bond adhesive (3M ESPE, Minnesota, US).

A plastic mould with dimensions of 4 mm in diameter, 5 mm in height and 1 mm in thickness was used to prepare the samples. The mould was placed on a flat surface and the composite was packed on it and was light-cured from four directions each for 40 seconds. Two different composite hues were used to create a contrast staining and ease of detection of the fracture pattern. At this stage, 15 cylinders were prepared from Heliomolar composite (Shade A1) and 5 cylinders made from 100 Z composite (Shade A4).

The samples were then placed in distilled water at room temperature for 2 weeks to fulfill the polymerization shrinkage. Subsequently, the samples were kept using hemostat, and the desired surface was freshened by bur 012 (Tizkavan, Tehran, Iran). After etching with 37% phosphoric acid (Ultradent, Minnesota, US), two single bond layers (3M ESPE, Minnesota, US) were applied and cured for 10 seconds. The Z100 composite was then packed and cured inside the mould. Thus, 20 samples were prepared from inter-bonded cylinders, of which 10 bonded cylinders were from non-namesake

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composites with different colors (3M-Viva) and consisted the case group, and two groups of five samples were prepared from namesake inter-bonded composites (Viva-Viva and 3M-3M), which formed two control groups to compare the fracture pattern. Then the inter-bonded cylinders were mounted in green acrylic (Pars dandan, Tabriz, Iran) so that the blade edge of the machine could exert the force on the bonded surface.

The samples were placed in distilled water at room temperature and transferred to the thermocycling device (Nemov, Tehran, Iran) in accordance with ISO 11405 with 500 thermocycles. After thermocycling, the samples were transferred to the Instron device for SBS testing. The Instron device was calibrated and the blade velocity was adjusted to 0.5 mm/min. The samples were horizontally mounted on the device and the blade edge of the device was set perpendicular to the interface of the two composites; the force was applied and the fracture points were plotted by the device for each sample in Newton.

Given that the numbers obtained from the Instron device represent the force required to break the bond in Newton, the SBS was determined via the resulting numbers divided by the cross sections of the bonded samples (12.56 mm^2), and the data were recorded in MPa (***Table 1***).

The fracture pattern was also macroscopically studied and recorded according to the contrast straining of the two composites.

The data were analyzed by SPSS version 15 software using Smirnov-Kolmogorov test for studying normal distribution of data and t-student test for independent populations.

Results

According to ***Table 2***, the SBS level of the composites in the Viva-Viva, Viva-3M, and 3M-3M group was normal in the samples. The highest SBS was achieved in the 3M-3M group and the lowest in the Viva-Viva group. According to the results of student t-test in ***Table 3***, there was no significant difference between the mean SBSs at α=0.05 in each of the above binary groups, and also the scattering of the SBS values is the same in each of the above binary groups at α=0.05. It should be noted that the mean difference in SBS in the Viva-3M/Viva-Viva group with 95% confidence interval was less than the other two groups.

Discussion

In addition to advances in dental materials, one of the greatest advances in the dental practice in recent years is the shift in mechanical views towards biologic perspectives, which emphasizes minimally invasive treatments (7).

Table 1. SBS (Mpa) and fracture patterns

Number	Case groups	SBS (Mpa)	Fracture pattern
1	Viva-3M	19	Viva
2	Viva-3M	20	Viva
3	Viva-3M	26	Viva
4	Viva-3M	24.6	Viva
5	Viva-3M	14.3	Viva
6	Viva-3M	23	Viva
7	Viva-3M	25	Viva
8	Viva-3M	20	Viva
9	Viva-3M	18	Viva
10	Viva-3M	23	Viva
Number	**Control Groups**	**SBS (Mpa)**	**Fracture pattern**
11	Viva-Viva	17.5	Viva
12	Viva-Viva	19	Viva
13	Viva-Viva	20	Viva
14	Viva-Viva	23	Viva
15	Viva-Viva	19	Viva
16	3M-3M	23	3M
17	3M-3M	27	3M
18	3M-3M	39	3M
19	3M-3M	27.8	3M
20	3M-3M	23	3M

Table 2. Smirnov-Kolmogorov test results for study variables

Statistical profile	Viva-Viva	Viva-3M	3M-3M
Z-value	0.595	0.568	0.541
P-value	0.871	0.904	0.932
Mean	19.7	21.29	27.16
Median	19	21.5	27
SD	2.05	3.67	7.49
Minimum	17.5	14.3	19
Maximum	23	26	39

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Table 3. Student t-test results in independent populations for comparing mean SBSs in study groups

Binary groups	Mean difference	Standard deviation difference	Leven's test	t statistic	degree of freedom	Binary groups	Mean difference
3M-3M/ Viva-3M	5.87	2.823	0.276	2.079	13	0.058	11.97-0.23
3M-3M/ Viva-Viva	7.46	3.473	0.162	2.148	8	0.064	15.47-0.55
Viva-3M/ Viva-Viva	1.59	1.783	0.103	0.892	13	0.389	5.44-2.26

Replacing the fractured restorations is one of the most common issues in dental care, which may happen to about half of the dental restorations. Removing composite restorations is time consuming. In a study, it was shown that the loss of dental structure when removing a composite from the tooth is more than doubled compared to removing an amalgam. Therefore, the composite repair is recommended instead of the replacement of the whole restoration. Some clinical evidence suggests that the composite repair increases the longevity of restoration (8).

Although the restoration replacement is commonly preferred by dentists, its repair is more conservative treatment. The fractured restoration repair is part of the minimally invasive dentistry, which maintains the healthy tissue of the teeth (5).

Replacing a defective restoration can lead to loss and weakening of the sound teeth. Compared to the full replacement of the restoration, the repair technique reduces pulpal damage, maintains mechanical strength of the tooth and reduces the clinical time (3). Some repair indications are local defects such as marginal fracture, marginal discoloration and secondary caries. Being controversial, some believe that the teeth should be restored due to les available bonding surface and also the difference in the brands of composites that were previously used (9).

Dental materials are under different stress in clinical conditions, including tensile, compressive and shearing stresses. Currently, the most common in vitro method for evaluating bond strength is the SBS test (10). The present study was conducted to investigate the possibility of using two different composites on each other. The reasons for choosing these two types of composites are due to the fact they are widely used both for anterior and posterior teeth.

The results demonstrated that the SBS in the 3M-3M, Viva-3M, Viva-Viva composites was normal, meaning that the SBS curve is symmetrical in these three groups.

By comparing different groups, the lowest SBS was assigned to the Viva-Viva group and the highest SBS belonged to the 3M-3M group. The lower SBS in the Viva-Viva group could be the result of the microfill entity of composite material, which has a weaker strength due to its structure. In fact, these types of composites have small and low-volume fillers that reduce their mechanical properties. However, in recent years, most of the companies have produced microfill composites that have appropriate wear resistance and mechanical properties (11).

In addition, the mean SBS of the 3M-Viva group was closer to the Viva-Viva group, and fracture in the 3M-Viva group occurred in the Viva region. The 3M-3M group had the highest SBS, which could be due to the composite structure, which is a microhybrid type. This type of composite is a mixture of hybrid and microfill composites with fine and microfine particles, which have excellent mechanical properties (12). Investigations carried out at the fracture site showed that in all cases fractures occurred inside the composites, and none of the samples had the fracture in the interface of the two composites. This confirms that proper use of adhesive can prevent the fracture in the interface of different composites, verifying the hypothesis that the use of two different composite brands on each other does not reduce the bond strength between the two composites.

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Conclusion

By examining the SBS of the tested materials in this study, the following results were obtained:

- Heliomolar (Ivoclar-vivadent) composite (microfill) showed the lowest SBS, but it was not significant (P>0.05).
- The highest SBS was for Filtek Z100 (3M ESPE) composite (microhybrid).
- None of the samples tested for fracture occurred in the interface of the two composites. This confirms that proper use of adhesive can prevent the fracture in the interface of different composites. So, the use of two different composite brands on each other does not reduce the bond strength between the two composites.

Conflicts of interest

The authors declare no conflict of interest regarding publication of this article.

Authors' contributions

All authors have intellectually committed to the study design and process. The final manuscript was revised and accepted by all authors.

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