Effects of composite thickness on shear bond strength to dentin

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Abstract:

Sixty non-carious extracted human molars were used in this study. The enamel on the occlusal surface of the crown of the tooth was removed by a diamond bur then the surfaces of the teeth were ground flat. The teeth were randomly divided into six groups each of ten and stored in distilled water at 37^0 C. Two types of composite were used in this study, Definite and Tetric. The bonding agents Etch and Prime were prepared according to manufacturers directions and applied to the dentin surface on the first three groups and light cured for 20 seconds. The composite Definite was packed into either 2, 3, and 4mm thick using split metal mould in the first, second and third groups respectively and bulk-cured from top of the composite for 40 seconds, the same procedure was repeated in the remaining three groups but the composite used was Tetric which its corssponding bonding agent was Excite. The bond strength was measured with universal compression machine.The results showed that there was no significant difference between the two types of composite Tetric and Definite used in this study. The shear bond strength was affected by the composite thickness, the 2 mm increment showed higher bond strength than the 3mm and 4mm increment in both composites.

Key Words:

Composite resin; Dental Bonding; Dentin-Bonding System

Introduction:

The use of visible light to cure dental materials has expanded over recent years. Successful use of composite resins depends directly on correct functioning of the visible light curing unit. The essential components required for adequate polymerization of composite resin are sufficient radiant intensity, correct wave length of the visible light and ample curing time.[1,2] Other factors also influence the depth, and therefore the adequacy of polymerization. These include the type of composite resin,[3,4] shade[1] translucency,[5] temperature of composite material,[6] thickness of the increment,[7] distance of light tip from the surface of the material,[8] curing time[9] and post irradiation time[10-13].

When the light passes through composite, the light is absorbed or scattered and the light intensity is reduced as the composite thickness increases. It has been reported that the composite dentin bond strength decreases as the amount of light energy decreases.[14,15] Consequently, if insufficient light passes through a five millimeter increment of composite the composite dentin bond may be reduced. The hardness at the bottom of four millimeter of composite has been reported to be less than the hardness at

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the top [16-17] and at three millimeter the degree of conversion at the bottom of the composite is about 50% of that at the top of the composite,[18] inadequate curing of composite not only adversely affects its physical properties,[19] but also increases its cytotoxicity.[20]

Diminished light intensity due to increase composite thickness can result in restorations which are incompletely polymerized. Possible consequences include a reduction in mechanical properties resulting in marginal breakdown, increased wear, decreased strength, questionable colour stability and increased water sorption. [12, 21] These problems can subsequently be responsible for secondary caries, pulpal irritation and decreased longevity of the restoration. The purpose of this study was to determine the shear bond strength of two commercially available composite resins to dentin in a two, three and four millimeter thick increment.

Material and methods:

Sixty non-carious extracted human molars were used in this study. After extraction, the teeth were cleaned with rubber cup and non fluoridated flour of pumice and stored in distilled water. The enamel on the occlusal surface of the crown of the tooth was removed by a diamond bur (Black Diamond Inc USA) and the roots were embedded in a ring with a cold-cure acrylic resin so that the occlusal surface projects above the lips of the ring. The surface of the teeth were ground flat using 240 and 400 grit silicon carbide papers under water. The teeth were then stored in distilled water at 37^0 C.

Final finishing of the test specimen with 600- grit silicon carbide paper was done. The ground dentin surfaces were washed well in running tap water and dried with air. The teeth were inspected to ensure that there was no enamel or pulpal exposure at the bonding site. The teeth were randomly divided into six groups of ten each and stored in distilled water at 37^0 C.

Two types of composite were used in this study, Definite (Degussa Hulls Hanau, Germany) and Tetric (Vivadent, Schaan Licechtenstien). The bonding agents with definite (Etch and Prime) were prepared according to manufacturers directions and applied to the dentin surface in the first group and light cured for 20 seconds using Degulux curing light (Degussa Hulls Hanau, Germany) and the same procedure repeated for the second and third groups. Also the bonding agent (Excite) for Tetric were applied on the dentin surfaces in the remaining three groups and light cured for 20 seconds using the same curing unit.

The composite Definite was packed into 2, 3 and 4 mm thick with a central hole of 4 mm in diameter using split metal mould in the first, second and third groups respectively and bulk-cured from top of the composite for 40 seconds, the same procedure was repeated in the remaining three groups but the composite used in these group was Tetric. All the specimens stored in distilled water at 37^0C until testing.

The bond strength was measured with universal compression machine (Electronic Compression Apparatus, Soil test Co. Inc., USA). The specimen was tested at across-head speed of 0.5 mm / min. After calculating the area of the bonding in mm^2 and the magnitude of the loading from the dial gauge in Kgm, the force was divided over the surface area, the results were recorded in mega Pascal (Mpa) and the data were statistically analyzed.

The debonded specimens were examined with reflecting microscope (Colzesis Germany) at X40

magnification to determine the type of failure.

Results:

The mean and standard deviation, maximum and minimum shear bond strength expressed in Mpa obtained with each of the procedures are listed in Table (1).

Table (1): Mean and standard deviation, maximum and minimum shear bond strength (Mpa) for the tested groups.

	Composite	Mean	Standard Deviation	Standard Error	Minimum	Maximum
1-	Tetric 2mm	18.070	1.999	.6323	16.10	21.70
2-	Definite 2mm	15.970	2.306	.7294	12.30	19.10
3-	Tetric 3mm	9.050	1.5834	.5007	7.20	11.50
4-	Definite 3mm	7.700	1.495	.4731	5.10	9.60
5-	Tetric 4mm	7.350	1.4339	.4534	5.10	9.40
6-	Definite 4mm	4.800	1.472	.4655	2.30	7.30

The effects of the composite thickness on shear bond strength were tested statistically using analysis of variance and Duncan multiple range test Table (2).There was statistical difference in bond strength among the tested groups ($p<0.05$). The 2mm thick Tetric had the greatest bond strength. The 4mm thick Definite had the lowest bond strength. There was also a significant ($p<0.05$) difference between the 2mm thick Definite and the other tested groups. There was no significant difference between the 3mm thick Tetric and the 3mm thick Definite and between the 3mm thick Definite and the 4mm thick Tetric.

Table (2): Analysis of variance for the tested groups.

Source	Sum of quares	df	Mean square	F	P
Between groups	1399.6	5	279.9	91.17	0.000*
Within groups	165.8	54	3.07		
Total	1565.4	59			

Duncan Multiple Range Test for the tested groups.

	Composite	Mean	N	Grouping **
1-	Tetric 2mm	18.070	10	A
2-	Definite 2mm	15.970	10	B
3-	Tetric 3mm	9.050	10	C
4-	Definite 3mm	7.700	10	CD
5-	Tetric 4mm	7.350	10	D
6-	Definite 4mm	4.800	10	E

* Source of significant

** Means with the same letters are not significantly different.

The mean bond strength and standard deviations for the 2, 3 and 4 mm thick of the two types of composite are shown in Table (3).

Table (3): Mean and standard deviation, maximum and minimum shear bond strength (Mpa) for 2, 3 and 4 mm thick of both composites.

	Composite	Thickness	Mean	Standard Deviation	Standard Error	Minimum	Maximum
1-	Tetric and Definite	2 mm	17.020	2.361	.5279	12.30	21.70
2-	Tetric and Definite	3 mm	8.375	1.651	.3693	5.10	11.50
3-	Tetric and Definite	4 mm	6.075	1.926433	.4308	2.30	9.40

Analysis of variance and Duncan multiple range test Table (4) showed a significant ($p<0.05$) difference between the shear bond strength of the 2mm thick (Tetric and Definite) with other groups. Also there was a significant ($p<0.05$) difference in shear bond strength between the 3mm thick (Tetric and Definite) and the 4mm thick (Tetric and Definite).

Table (4): Analysis of variance for the 2, 3 and 4 mm thick of both composites.

Source	Sum of squares	df	Mean square	F	P
Between groups	1332.127	2	666.564	166.336	0.000*
Within groups	228.247	57	4.004		
Total	156	59			

Duncan Multiple Range Test for 2,3, and 4mm thick for both composites.

	Composite	Thickness	N	Standard Error	Grouping**
1-	Tetric and Definite	2 mm	20	.5279	A
2-	Tetric and Definite	3 mm	20	.3693	B
3-	Tetric and Definite	4 mm	20	.4308	C

* Source of significant

** Means with the same letters are not significantly different.

Table (5a) shows the mean bond strength and standard deviations for the two composites Definite and Tetric. Analysis of variance Table (5b) for the two composites showed no significant differences between them.

Table (5a): Means and standard deviation for shear bond strength (Mpa) of the two composites.

	Composite	Number	Mean	Standard Deviation	Standard Error
1-	Tetric	30	11.4700	5.0758	.9267
2-	Definite	30	9.4900	5.1173	.9342

Table (5b): Analysis of variance for the two composites.

Source	Sum of squares	df	Mean square	F	P
Between groups	58.806	1	58.806	2.264	.138
Within groups	1506.590	58	25.976		
Total	1565.396	59			

The mode of failure are shown in Table (6), seven dentinal fractures occured with the 2mm thick increment of Tetric and six dentinal fractures occured with the 2mm thick Definite. The number of mixed type of fractures is higher than the number of adhesive type of fractures.

Table (6) Modes of failure

	Composite thickness	Number of failures		
		Adhesive	Mixed	Cohesive
1-	Tetric / 2-mm	0	3	7
2-	Definite / 2-mm	0	4	6
3-	Tetric / 3-mm	2	9	0
4-	Definite / 3-mm	2	8	0
5-	Tetric / 4-mm	2	8	0
6-	Definite / 4-mm	6	4	0

Discussion:

In pervious studies [7, 22-24] the entire dentin surface was treated with the dental bonding system (DBS) and light cured before the composite was bonded to the dentin. This technique has been reported to increase the bond strength values. [25, 26] Therefore, in this study, the DBS on the dentin surface was light cured only within the metal mould positioned on the dentin surface to which the composite was subsequently boned. When a composite in a tooth is being polymerized some additional light may be transmitted throw the tooth to polymerize the composite. But the amount of light will vary according to the tooth thickness, tooth colour, the presence or absence of a metal matrix band. The 2, 3, and 4 mm metal moulds used in this study did not allow light to penetrate the composite from the sides and allow light to enter the specimen only from the top. The shear bond strength of 3 and 4mm thick composite were lower than the two millimeter thick composite using exactly the same material and bonding procedures. This finding supports previous reports that there is a marked decrease in the hardness and degree of conversion when the composite is more than 3mm thick. [27-29]

When DBS fail mainly because of dentin fracture or cohesive composite fractures this may indicate good adhesion between the dentin and the composite. [26] The 4mm thick specimens exhibit only adhesive failures and their bond strengths were significantly lower than the 2mm thick. There were more dentin fractures and mixed failures for the systems with higher bond strength (Table 5). This result supports the view that bond strength and mode of failure may be related. [22,23] because the shear bond strength of the of 3, 4 mm thick

specimen were significantly lower than those of 2 mm specimens clinicians should not try to bond increments more than 2mm thick of composite to dentin.

Conclusion:

Two conclusions were drawn, under the condition of this study first, the shear bond strength of Tetric and Definite tested were much lower when cured in 4 mm thick increment of composite compared to two millimeter thick increment. Second, Tetric composite have the same bond strength as Definite regardless of composite thickness.

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