

Original Article**Shear Bond Strength of resin composite materials to dentin: the effect of the direction of application of the adhesive system : A comparison between maxillary and mandibular teeth .**

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Abstract

In this study a comparison was set between the mean shear bond strength of resin composites to dentin related to maxillary teeth and that related to mandibular ones .Therefore the direction of application of an adhesive was being investigated .80 non – carious extracted human first molar (maxillary and mandibular) were included in this study . They were divided into two groups of 40 to represent either the maxillary teeth or the mandibular ones. Each group was further subdivided into two subgroups of 20 to represent an immediate investigation or an investigation after one month. A universal bond adhesive (BISCO – USA), and the resin composite (3M FILTEK Z 250 XT) were used in this study. The results showed that the mean shear bond strength of resin composite to dentin related to mandibular teeth was statistically significantly higher than that related to maxillary teeth. Also, the results showed that the incubation time (one month) had no significant effect on the mean shear bond strengths of all samples.

KEY WORDS : Shear Bond Strengths , adhesive application , maxillary and mandibular teeth.

Introduction

Dental adhesive systems produce appropriate retention (while conserving the sound tooth structure) ; appropriate marginal sealing and favorable distribution of forces across the restoration – tooth interface (1,2). Bond strength measurement is one of the most reliable methods for evaluating the adhesives clinical performance (2,8). This has ,even, been made easier due to the vast advances in dental adhesive technology. The strength and durability of adhesive bonds depend on multiple intersecting factors among which are ; the quality of the hybrid layer in terms

of : the qualitative distribution of adhesive monomers [tubule – wall hybridization, lateral tubule hybridization, direction of tubules and radial diffusion, and depth of demineralization and monomer diffusion] ; mechanical properties of the hybrid layer [ultimate tensile strength, modulus of elasticity and bond strength] ; as well as microleakage , nanoleakage and deterioration of bond strength over time. (2-7 , 9 , 10 – 12) Additional factors include ; the compositional and structural aspects of enamel and dentin, the intended clinical method of dealing with the smear layer, polymerization shrinkage,

transmission of functional stresses across the bonding interface, the clinical variables related to the case management and the skill of the operator (2 – 9 , 13 – 16). Several studies reported that the different dentinal regions, the orientation of the dentinal tubules, and the microstructural features of the dentinal substrate ; were among the important variables determining the bond strength to dentin . It was further reported that the bond strength to dentin areas where the dentinal tubules ran parallel to the bonded surface was , significantly, higher than that of dentin areas where the dentinal tubules were perpendicular or at an angle to the bonded interface (3, 17 – 22). In the end, it has to be mentioned that several studies have investigated the different variables related to the methodology of application of adhesives, but none of them has investigated the effect of the direction of application of an adhesive on the bond strength to dentin. Thus the demanding question is : does the bond strength to dentin of maxillary teeth differ from that of mandibular ones .

Materials and methods

A total of 80 non- carious extracted human maxillary and mandibular first molars (equal in number), were selected for this study. The teeth were extracted for periodontal reasons. The teeth belonged to male patients of the age range (30 – 45) years old. All the selected teeth were stored in deionized water. Before usage, the teeth were cleaned, scrubbed and ,meticulously rinsed. The teeth were divided into two groups of 40. Group A represented the 40 maxillary teeth while group B represented the 40 mandibular teeth. Each group was , further , subdivided into two subgroups of 20 to represent immediate investigation or investigation after incubation for one month ; (one month incubation is equivalent to several years of clinical service) (23). The incubation was

performed by placing the samples in a 100% humid environment. For each molar the occlusal surface was ground to the level of the dentino-enamel junction and perpendicular to the long axis of the tooth in order to expose a flat dentin surface. The dentin surface was rinsed for 20 seconds with an air / water spray, then, gently, air dried for 5 seconds. After that the flat dentin surface was polished with a # 600 silicon carbide paper under running water. Both maxillary and mandibular teeth were mounted on their respective casts by the aid of a compound impression material. The casts of maxillary teeth were mounted on the upper jaws of phantom heads, while the casts of mandibular teeth were mounted on the lower jaws of the phantom heads. For standardization, the occlusal plane was adjusted for the casts of both maxillary and mandibular teeth. Regarding the maxillary teeth the casts were adjusted in such a way that the occlusal plane of the upper jaw of the phantom head made a forty five degree angle to the floor. Meanwhile, for the mandibular teeth, the occlusal plane of the lower jaw of the phantom head, was set parallel to the floor. In order to, exactly, determine the occlusal plane angulation to the floor ; a right angled triangle, a ruler and a protractor were used. During adjustment of the occlusal plane of the upper jaw of each phantom head ; the long axis of the phantom head was set perpendicular to the floor. The ruler was , then , placed perpendicular to the long axis of the phantom head representing the horizontal axis (x). Afterwards, the right angled triangle was placed along side the ruler to represent the vertical axis (y). Consequently, having both conjugate axes perpendicular with a vertex (o) ; it was made easy determining a forty five degree angle to the floor (represented by the x-axis) ; by the aid of the protractor. Similarly, the occlusal plane of the lower jaw of each phantom head was adjusted parallel to the floor. For all teeth (maxillary

and mandibular) ; the adhesive (All – Bond Universal – BISCO – USA), table (1) ; was applied to the flat dentin surfaces with a self – etch adhesion protocol and according to the manufacturers instructions. Then polytetrafluoroethylene molds (each measuring 3 x 2 mm) ; were placed onto the adhesive area of the teeth and light curing performed for 20 seconds, using an LED curing device (Eighteenth – China) with an intensity 1500 mw / cm². A resin composite restorative material (Filtek Z 250 XT – USA) (table 1) was , then , applied and inserted within each mold according to the manufacturers instructions. Light curing was performed using the LED curing device at an intensity 1500 mw / cm². The samples that were not assigned for immediate investigation, were incubated for one month in a 100% humid environment. All samples were subjected to shear stress testing using a computer controlled materials testing machine (Model LRX – plus – Lloyd instruments Ltd. – Fareham , UK) at a load cell of 5 KN. The data were recorded using the computer software (Nexygen – 41 – Lloyd Instruments).

Results

The results were analyzed using the graph Pad InStat (Graph Pad, Inc.) software for windows. Values of $P \leq 0.05$ were considered statistically significant. All continuous variables were expressed as means and standard deviations. Following the confirmation of the homogeneity of variance and normal performed to assess the presence of statistically significant differences in the mean shear bond strengths between maxillary and mandibular teeth. The Student – Newman-Keuls test was used for pairwise comparison between means to reveal which means were , significantly different. The above mentioned tests were , separately, performed for the groups of samples that

were immediately investigated as well as those that were investigated after incubation for one month. Also, the ANOVA test was performed to study the effect of incubation time on the mean shear bond strengths of all samples. The mean shear bond strengths of maxillary and mandibular teeth at immediate investigation :

The results showed statistically significant differences between the mean shear bond strengths of the maxillary and mandibular teeth ($P < 0.001$) (table 2). The mean shear bond strengths of mandibular teeth were, significantly, higher than the mean shear bond strengths of maxillary teeth. Using the Student – Neuman – Keuls test for pairwise comparison between means to reveal which means were, significantly, different ; it was found that the mean shear bond strengths of samples belonging to the groups (A and B) ; were statistically significantly different ($P < 0.05$).

The mean shear bond strengths of maxillary and mandibular teeth after one month incubation: The results were similar to those obtained at immediate investigation. (Table 2) The effect of incubation time on the mean shear bond strengths of maxillary and mandibular teeth :

The results were not statistically significant ($P > 0.05$), (table 2).

The columns indicate statistical significant differences in the mean shear bond strengths of maxillary and mandibular teeth. The rows indicate that the effect of incubation time was non significant (NS) for all samples.

Table 1 Materials used in this study

Materials	Components	Batch number	Manufacturer
Filtek Z 250 XT Nanohybrid Composite	The resin matrix AUDMA, UDMA dodecane DMA The fillers : non agglomerated, non aggregated 20 nm silica fillers ; non agglomerated, non aggregated (4 – 11) nm zirconia fillers ; aggregated zirconia / silica cluster fillers (20 nm silica fillers size and 4-11 nm zirconia fillers size) and ytterium trifluoride fillers (100 nm)	NF40669	3M ESPE St. Paul, MN, USA
All – Bond Universal (BISCO)	Ethanol / water based dental adhesive	2200003937	BISCO , Inc 1100 W. Irving Park Rd.Schaumburg , IL 60193 USA

Table 2 Mean shear bond strengths of maxillary and mandibular teeth and effect of time.

Variable	Shear Bond Strength (MPA) (means + standard deviation)		p value
Maxillary teeth	Immediate investigation	After one month	P > 0.05 NS
Mandibular teeth	22.9 +1.6	21.1+2.9	P > 0.05 NS
	29.4 +2	27.3+4	
p value	S P < 0.001	S P < 0.001	

Discussion

In this study it was assessed whether the direction of application of an adhesive would influence the value of the shear bond strength of resin composite restorative materials to dentin. Hence it was investigated whether the mean shear bond strength of resin composite to dentin of the maxillary teeth would differ from that of mandibular teeth. For standardization, only one type of adhesive was used for both maxillary and mandibular teeth (table 1). The same operator performed the whole procedure for all samples. The two groups of patients matched as regards the age and sex of the patient donors. All the samples were first molar teeth. A ruler, a right angled triangle and a protractor were used to adjust the upper jaw of each phantom head , exactly, making a forty five degree angle to the floor and to ensure complete parallelism of the lower jaws of the phantom heads to the floor. The universal bond adhesive was used in a self – etch adhesion protocol in order to eliminate the problem of discrepancy between the depth of demineralization and the depth of monomer diffusion ; as the self – etch adhesion protocol produces simultaneous demineralization and infiltration into dentin.(2 – 7 ; 9) Also, the self – etch adhesion protocol rules out the problems related to the amount of water that should be left post conditionally. (9) The results showed statistically significant differences between the mean shear bond strengths of maxillary and mandibular teeth ; where the mandibular teeth demonstrated, significantly, higher mean shear bond strengths. That meant that the direction of application of the adhesive had a pronounced effect on the mean shear bond strength of resin composite to dentin. It has to be emphasized that for the maxillary teeth, the direction of application of the adhesive was against the general direction of the earth gravity i.e. with the material

having to overcome the pull of gravity. Meanwhile, regarding the mandibular teeth ; the direction of application of the adhesive was aligned in the general direction of the earth gravity. The quality of the hybrid layer has a strong influence on the resultant mean shear bond strength of resin composites to dentin. Several factors are included in the quality of the hybrid layer. One of them is the qualitative distribution of monomers , in terms of, tubule wall hybridization ; lateral tubule hybridization ; direction of tubules and radial diffusion. (3 – 9). That pattern and quality of distribution of adhesive monomer could have been affected by the direction of application of the adhesive in this study. Other factors related to the quality of the hybrid layer include ; the mechanical properties of the hybrid layer ; in terms of ; the tensile strength, modulus of elasticity, and bond strength. In addition to that, there are the compositional and structural aspects of dentin. (2 – 7 , 9). The orientation and anastomosis of the dentinal tubules differ in different dentinal regions and it was reported as having a pronounced effect on bond strength. Several previous studies had reported that the bond strength of resin composite materials to dentin in areas where the dentinal tubules were parallel to the bonded interface ; was , significantly, higher than that in areas where the dentinal tubules were perpendicular or at an angle to the bonded interface (3 ; 17 – 22). Universal adhesives are the most recent adhesive systems. They possess a multimodal usage i.e. can be used in an etch and rinse mode ; a self – etch bonding mode or , even , a selective etch mode ; as the clinical situation demands. These adhesives , also , save time due to their rather simplified method of application. Moreover, these adhesives have the ability to adhere to indirect tooth restorations as glass – rich and glass – poor zirconia ceramics. (3 , 24 , 25). The rapid turnover in adhesive technology necessitates

continuous studies investigating the recent types of adhesives and the different variables related to the methodology of their application.

Conclusion
- The maxillary and mandibular teeth demonstrated statistically significant differences regarding the mean shear bond strength of resin composites to dentin.
- The mandibular teeth showed, significantly, higher mean shear bond strengths.

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