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Failure in a composite resin-dentin adhesive bond

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Abstract

Composites are drawing more and more attention as preferred materials for teeth restoration. The success of teeth restoration has been generally limited by the Composite Resin-Dentin bond strength. A testing device has been developed to allow a satisfactory testing method for evaluating bonding strength in tension and shear, which led to reproducible results. A comparison between different bond systems has shown no significant difference in the tensile and the shear strength as well as in the fracture behavior. Moreover, results showed difference between tensile and shear strength, when considering one same bond system. Failure mode examination turned out to be, either cohesive (composite rupture), or adhesive (interface rupture) or both (mixed rupture).

Introduction

The use of composite material in dental restoration is limited by the resin composite-dentine bond strength. In fact, bonding to dentin has led to some problems, such as the shrinkage inherent to polymerisation, leading to a marginal gap in the bonding interface, [1-2].

The success of any resin composite-dentin restorative material relies on physico-chemical properties (adhesion to tooth structure, low polymerisation shrinkage) and mechanical behavior (high wear resistance, high strength to static and cyclic loading), [3]. Furthermore, the effect of an intermediate resin on bonding system and surface preparation has been largely investigated, [5-6]. Finally, some approaches have been proposed for failure prediction of composite resins under specific loading conditions, [7-8].

Because of the non uniform distribution of stress along the bond interface associated with the difficulty of maintaining axiality during testing, pure tensile stress are difficult to achieve. So, one of the principal purposes of our investigation is to elaborate a mechanical device, used to conduct mechanical tests, allowing rigid alignment as well as good control of load on the joint. Some of the aims of this investigation are:

- 1- The development of an experimental device aimed to apply adhesive bonding resins to a reduced section of human teeth dentin, and leading to reproducible results.
- 2- The experimental measurements of tensile and shear strength of composite resin-dentin bond
- 3- The examination of the resulting failure mode using a scanning electron microscope.

Comparison is also made between the resin composite-dentin bond strength of some commercial products under tensile and shear loading conditions.

Materials and Methods

Commercial materials selected for this study are presented in table1, these are designated with capital letters. Different thermoset resin, reinforced with inorganic filler, are used as composite material, and the bonding phase is always different from composite resin.

Table1 Tested Matrials

Material symbol	A	B	C	D	E	F
Commercial designation	All bond	Scotchbond	Syntac	Tenure	Denthesive	XR bond

About fifteen freshly extracted human teeth, previously stored in a formaline solution are used in this study.

The experimental device is constituted of two separate cylindrical parts, assembled coaxially, which allows a precise vertical translation motion during testing. A cylindrical hole was drilled in one of the extremity of the axel aimed to host the prepared tooth, (see Figure 1).

Figure 1 Experimental Device

Specimen used for tensile and shear testing require the preparation of teir respective transversal and longitudinal teeth surfaces. For each specimen the corresponding surface were flattened using a grinding technique followed by polishing with silicon carbide papers. finalt, surfaces are etched with a phosphoric acid solution.

Adhesive ring with a central hole of a 5 mm in diameter is placed on the surface of the tooth, hence limiting the section to be bonded toward the a central circular area. The bonding joint agent is painted with a brush on the exposed surface after which the mixed composite resin is added through a metallic ring mould, which is used as an intermediate part in the device assembly. Composite is deposed by successive layers in order to facilitate ultraviolet light polymerisation. The assembly is monted in a universal tensile testing machine; and the specimens are tested to rupture with a crosshead speed of 5 mm/mn.

Results and Discussion.

The results of tensile and shear bond strenght measurements are shown in table 2.

Table 2 Tensile and Shear Bond Strength of Materials (MPa)

A		A*		B		C		D		E		F	
σ	τ	σ	τ	σ	τ	σ	τ	σ	τ	σ	τ	σ	τ
6,79	14,52	11,66	13,63	6,52	6,00	3,98	3,61	7,83	8,33	6,52	-	4,81	6,06
8,39	13,77	12,23	13,41	-	6,12	4,04	3,78	8,35	8,22	6,32	7,28	4,68	4,85
7,77	13,80	11,88	14,54	6,83	5,39	4,03	4,53	7,44	8,20	6,78	6,88	4,74	5,50
8,36	14,28	12,93	13,27	6,76	5,99	4,06	3,83	7,76	8,49	6,45	6,77	4,93	4,30
7,91	14,38	12,29	-	6,71	5,62	4,08	-	-	8,19	6,38	7,30	4,77	5,90

These results show no significant differences in bonding strength among the materials studied. However, significant differences exist when considering the bond system associated with the first tested material (material A, table 2), which shows a better shear strength " τ " than tensile strength " σ ". Moreover, the same results show an increase in bonding strength of the same material, as a consequence of a wetting followed by a drying pretraitement applied to the dentine surfaces (results A*, table 2), as compared to the only blown drying pretraitement of the same surfaces (results A, table 2).

The fractured surfaces obtained from tensile and shear tests of materials A and E have been analysed using a Scanning Electron Microscope. The analysis has revealed that the failure mode for each material is cohesif as well as adhesif. However, the extension of cohesif and adhesif areas varies from one specimen to another according to the nature of the rupture (tensile or shear), as well as the type of bondind resin.

Conclusions

The best bonding system seems to be the one for which the average mean rupture stress was 14 MPa. in shear.

A significant difference exist between dry and wet pretraitement dentin surfaces when using the " gluma bond resin ", which shows a better dentin adhesion when used in wet condition case.

Fractographic analysis should be continued to understand clearly the mechanisms of failure.

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