

Bond Strength Tests in Dentistry

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ABSTRACT: Numerous bond strength tests have been performed in dentistry for decades to test the cohesive and adhesive strength of bonding agents to dental tissues. Not all tests can be clinically acceptable because simulating clinical conditions extraorally is not

always possible. These tests will give us a picture about the bond strength and which agent is more successful. This article reviews about various bond strength tests conducted and its clinical significance.

Key words: cohesive strength, tensile strength, Push out bond strength

Introduction:

Adhesives join materials together to resist separation and transmit loads across the bonds. In dentistry, the adherend is the substrate to which the adhesive—enamel and dentin, rarely cementum—is applied. The success of a bonding agent lies in its capacity to adhere to dental tissues viz enamel and dentin so that there is no microleakage, staining and secondary caries. The bond strength to enamel is always more than that to dentin. The histology of dentin is more complicated than enamel because of the presence of dentinal tubules. The dentinal fluid severely affects the bond strength. Research has been done and is going on to this day to improve the bond strength to dentin. Several bond strength tests are designed to study the bonding efficiency of these agents.

Tensile bond strength

Shear bond strength

Push out/pull out bond strength

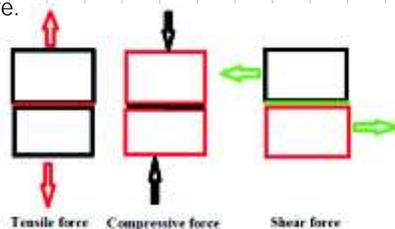
Few basic definitions we have to know before knowing about bond strength tests:

Shear stress—Ratio of shear force to the actual cross-sectional area that is parallel to the same direction in which the applied force.

Shear strength—Shear stress at which fracture occurs.

Tensile stress—Ratio of tensile force to the actual cross-sectional area perpendicular to the direction in which force is applied.

Tensile strength (ultimate tensile strength)—Tensile stress at the point of fracture.



The flexural or bending strength is a measure of the fracture resistance of a material. For restorative materials in occlusion bearing areas, the ISO standard demands a flexural strength of at least 80 MPa

Shear Test :

Methods to evaluate resin enamel or resin dentin adhesion³². In macroshear strength tests, composite cylinders with a diameter of about 3 or 4 mm are adhered to flat ground tooth tissue (dentin or enamel) surfaces after application of the adhesive systems.

Tensile test: composite cylinders are adhered flat dentin or enamel surfaces and tensile force may be exerted on composite cylinders using chucks or conical composite plugs employed instead of

cylinders

Smaller surface areas are associated with higher tensile bond strengths, and conversely, larger surface areas are associated with lower tensile bond strengths. The reasons for this phenomenon may be due to the effect of the presence of defects and/or stress raisers at the interface or in the substrate. The smaller diameters give researchers the ability to test several bonded specimens on one flat dentin or enamel surface, thus allowing both for the regional mapping of the mineralized surface and the conservation of extracted teeth needed to provide the necessary substrates.

Microtensile test:

The microtensile test was introduced in Dentistry by Sano et al.²⁹. Microshear bond strength test is applied on bonded cross-sectional areas of 1 mm² or less.²² The force (in Newtons) required to break the bond of composite cylinder from the substrate is measure of the shear strength.

The microtensile bond strength test is the tensile load at failure divided by the cross-sectional area of the interface that is bonded. In a micro-tensile strength test, the load is applied at a right angle to the bonding surface.^{23, 24, 25}

Teeth and composite resin bonds are very rarely subjected to only acute tensile/shear stresses, but in clinical situation they are subjected to cyclic sub-critical loads during function.¹

Advantages:

Non uniform distribution of stresses on large surface area can be eliminated.³³

Strength measurement at relatively small clinical sites.³⁴

1. Quicker to detect with artificial aging than other tests, example tests for fracture toughness, microleakage and nanoleakage¹⁰
- (2) Several TBS specimens can be recorded per tooth, hence allowing balanced study designs to avoid error due to 'tooth' variability;¹
- (3) The TBS test is most commonly used and accepted.¹

Push out bond strength: less sensitive to small changes amongst specimens and to changes in distribution of stress when load is applied, and also it is easy to align samples during testing.¹³

Factors affecting push out test¹⁴⁻²¹:

1. Pin size-smaller than 0.85 times the filler diameter
2. Specimen's thickness
3. Material type

Types 2, 3

1. Static: in this case the bond strength is measured under static

conditions, that are the tooth is fixed to an instron machine and subjected to acute tensile or shear forces.

2. Dynamic: seldom are the restorations in the mouth are subjected to acute forces as in static test conducted in the laboratory. The tooth structure is subjected to dynamic forces, and all forces might not lead to failure of the bond but the tooth when subjected to such forces repeatedly can lead to failure of the bond. In this case the tooth samples prepared are clamped to a pin-chuck and connected to a stepping motor, free end loaded with a definite amount of weight.

Methods of aging:

1. Mechanical loading, thermo-cycling
2. Water storage
3. Thermocycling
4. In vivo

Variables that can affect the results

1. Aging duration
2. Thermo cycling temperature, dwell time and cycles
3. Water storage temperature
4. Aging by occlusal loading

Thermocycling: Repeated cyclic exposures to hot and cold temperatures, in a water baths to simulate thermal changes that occurs in the oral cavity. 7, 8

Effects of thermocycling:

1. Stress formation between resin and tooth
2. Depending on the adhesive system, it may affect bond strength
3. It can affect the marginal integrity of the restoration, causing the microleakage phenomenon that can cause marginal breakdown leading to stain formation in the gap formed, hypersensitivity and pulpal pathology. hot water accelerates hydrolysis.11

Temperatures for thermocycling: 35 1C for 28 s., 15 1C for 2 s., 35 1C for 28 s., 45 1C for 2 s.9

A note on laboratory tests:

- a. It measures the strength with only one variable while all other variables are constant but in reality there are many variables that act simultaneously in the oral cavity
- b. Its simple, cheap and fast
- c. Its useful in determining the effectiveness of bonding agent under a particular laboratory set up which doesn't resemble the oral cavity in any capacity

DISCUSSION:

The force per unit of area required to break the bond with failure taking place with in or close to the adhesive surface is the measure of bond strength.31 the various force that will be acting at the bonding interface include force due to polymerization shrinkage of the composite which will pull the composite away form the tooth structure, mechanical stressed during chewing, and temperature changes causing thermal and chemical stresses.

Tensile bond test is mainly a measure of adhesive and shear bond test is a measure of bond between adhesive and tooth structure. Shear strength is more important in a clinical situation as shear forces are more common within the oral cavity during mastication12. The bond strength for self etching systems is less than total etching system in which there is a separate etching step with phosphoric acid. This is mainly because the smear layer is completely eliminated in case of total etch adhesives.26

Shear and tensile bond strength tests are frequently used to assess the integrity of the adhesion of dental adhesive materials to tooth structure. In fact, the bonding testing methods are highly influenced by the specimen geometry. The science behind the microtensile technique is to exert a tensile load between a dentin-adhesive-restorative material beam to break the bond at the interface in the interest of measuring the adhesive bond strength. In case of shear technique, shear forces are employed through the bond interface to break the bond of the materials (dentin-adhesive-restorative material) as an indication of the adhesive bond strength.35

The results of micro- and macroshear bond tests are usually same but micro tensile bond test is usually 4 times more than macro tensile bond test results.

Aging of tissues due to various reasons occurs simultaneously and tensile strength test is more affected by aging process. Micro tests whether its shear or tensile are highly useful because very small area is taken for testing and we can record the values in multiple places on the same surface so that we can better understand the bonding process and variables affecting the bond strength. Factor like regional mapping, the measure of depth also can be observed. 27 the substrate also plays a vital role. Substrate related variables include enamel or dentin, crown or root dentin, hypermineralization, sclerosis, tubular density, and collagen orientation. The bond to dentin is always a challenge compare to enamel. The results of these tests do not reflect the material properties but only the nature of the bonding system under a given set of conditions and variables. Hence, the results must be carefully extrapolated to clinical set up as changing even one parameter might change the results totally. 1, 28, 30 there are studies where microtensile test could differentiate the bond strength of the adhesives but shear bond test could not differentiate. This is where the significance of measuring both micro tensile and shear bond test lies. 30

Conclusion: The greater the bond strength the more the success rate. The tests performed in the laboratory may not be directly correlated to the clinical set up but it's a good indication of the longevity and the properties of the bonding agent with regard to the bonding capability of any given agent. With the advancements in technology more in vivo studies can be performed to better test the bond strength of these agents.

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