Comparison of Shear bond strength using two orthodontic adhesives

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Introduction:
The acid etching and bonding technique introduce by Bunonocore in 1955 has revolutionized the bonding procedure (1, 2) and made orthodontics clinically easier since Newmann introduced it in 1965. Bonding of orthodontic brackets to the etched enamel surface is a standard clinical practice by using chemical or light cure adhesive systems. (3)

The first and most popular bonding resins were chemically cured bonding systems. However, the major drawback of the self-cure adhesive systems is the inability to manipulate the setting time of the composite resin (4) Light curing systems are more widely used for orthodontic bonding after it was first described by Tavas and Watts in vitro. (5)

Majority of the composites used for bonding of orthodontic brackets are made up of synthetic polymers which is primarily bisphenol-A glycol dimethacrylate (Bis- GMA). Other polymers like ethylene glycol di methacrylare (EGDMA) or tri ethylene glycol di methacrylate (TEGDMA) are added to reduce the viscosity of Bis-GMA. Filler particles are incorporated into the resin matrix which improve the mechanical properties like strength, reinforcement, reduction in polymerization shrinkage and thermal expansion. Also, other materials like catalysts and stabilizers are included which modify the opacity and polymerization of the composite resin. (6) Salivary control and maintenance of a dry operating field is thus a prime requisite of orthodontic bonding, because the most commonly used orthodontic primers and adhesives contain hydrophobic functional monomers (Bis-GMA formula). (7)

Newer self-etching adhesive materials have been introduced recently in orthodontics to simplify the bonding process by reducing the bonding steps and eliminating the need for etching and priming, thus lessening the risk of contamination and reducing the bonding time. They generally contain methacrylated phosphoric acid esters which are derived from phosphoric acid and remove calcium ions from the tooth thus resulting in demineralization. These self-etching primers combine the conditioning and priming agents into one acidic solution and have shown advantages such as reduced loss of enamel, prevention of saliva contamination, reducing the chair time and also minimizing the bond failures. However, it has been said that orthodontic bracket bonding performed with adhesive systems with the use of phosphoric acid has a higher value of shear bond strength, but the increased number of clinical steps which prolongs the working time when assembling the orthodontic appliance and can cause iatrogenic damage to the enamel and and a reduction in the mechanical properties due to de mineralizion of the enamel. (8)

Flowable composites have a great advantage when it comes to orthodontic bonding due to their clinical handling properties. They have two distinct characteristics which are fluid injectability and non sticky tendency, along with other properties like adequate bond strength, sufficient working time, short curing time and ease of use. When it comes to the composition of flowable composites, flowable composites have lesser filler content which reduces the viscosity of the composite.

Shear bond strength (SBS) is an important factor which has to be concerned in the properties of bonding materials. The bond strength of the orthodontic brackets must be able to withstand the forces applied during the orthodontic treatment exerted by the arch wires for tooth movement as well as normal masticatory forces. Reynolds stated that 5.9–7.8 MPa resistances are sufficient to withstand masticatory forces. Bishara *et al*. compared bond strengths of an acidic primer and composite resin with a conventional adhesive system and found mean bond strengths of 10.4 and 11.8 MPa, respectively. The SBSs of self-etching primers can vary widely, ranging from 2.8 to 16.6 MPa.

An ideal orthodontic adhesive must possess optimal bond strength to withstand the masticatory and orthodontic forces, patient handling and also de bond with no deleterious effect on the enamel at the end of the treatment. In orthodontics, an adequate bond, which fails at the enamel-composite interface, would be desirable because de bonding and subsequent polishing would become much easier.

Transbond XT is a light cured Bis-GMA based composite resin which is conventionally and popularly used for orthodontic bonding. This product has good test results and is an ideal material for orthodontic bonding. Many factors play a role in determining the success of the bond strength between the tooth and the brackets. The type of adhesive used, composition of the adhesive, etching time, mode of curing, bracket material and design of the base and the surrounding oral environment all play a role in the success of the bond. Also, polymerization shrinkage, degree of conversion of the adhesive and filler particle also play a role in determining the durability of a bond. (9)

Orthodontic bond assessment by learning the associated study of failure patterns can be classified according to the test environment as follows:

1. In vitro studies which are performed with the help of a mechanical testing machine or by stimulation of clinically applied de bonding procedures in a laboratory where microscopic examination studies can be done to assess bond strength.
2. In vivo studies can be done during the course of the orthodontic treatment by recording the following parameters: the type of brackets which de bonded and the site where the bond failure occurrence was increased.
3. Ex vivo studies can be done utilizing finite element analysis modelling of the stress distributions in the components of the enamel- adhesive- bracket system. (10)

Orthofix is a relatively new material introduced in the field of orthodontics for the purpose of bonding brackets. Due to its indigenous make, this material is less expensive when compared with the imported composites. Studies have not been carried out to test the efficiency of bond and properties of this material. This study aims to determine the bond strength of the brackets bonded with Orthofix and compare the bond strength of Orthofix with the traditionally used Transbond XT.

Another characterization of bond strength tests can be made according to the the mode of load application, of it is shear, tension or torsion. Out of these, shear loading is very common due to the relative simplicity of the test and the increased reliability of stimulating the bond de bonding which occurs during treatment.

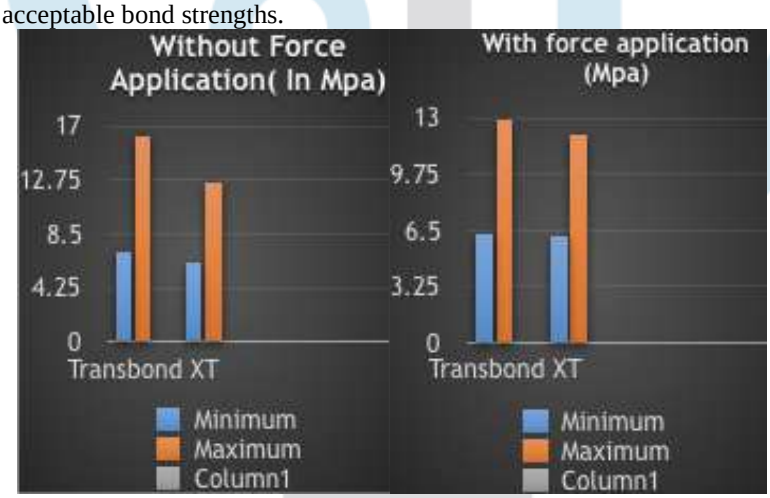
The third classification of bond strength tests is based on the substrate surface namely enamel, composite resin, porcelain etc.

Materials and Methods:

The study was done in Department of Orthodontics, Saveetha Dental College, Chennai. The study was carried out in extracted premolar teeth. 20 Mandibular and maxillary extracted premolars were collected and stored in hydrogen perioxide. Teeth with restorations and other defect like fractures on the crown, attrition and cracks were excluded. The teeth were randomly divided into 2 equal groups, one for Transbond XT and the other for Orthofix. The buccal surface of the teeth were etched with 37% ortho phosphoric acid for 10-15 seconds, followed by placing and curing the bonding agent. The adhesive was then placed on the base of the bracket and pressed firmly on to the tooth. Excess material was removed before setting and cured for 20 seconds from the mesial and distal aspects were cured. The bond strength was then evaluated after mounting on an acrylic bock. The bond strength was measured by using a Universal Testing Machine and the results were derived and statistical analysis was done.

Results and Discussion:

Transbond XT is the gold standard material with superior qualities when compared with Orthofix. Both the groups included in the study showed clinically acceptable bond strengths.



Without force application, the Shear bond strength of Transbond was a maximum of 16.180 Mpa and Orthofix had a maximum of 12.468 Mpa. When the shear bond strength of brackets which were subjected to force after bonding the bracket was measured, Transbond XT had a maximum value of 12.834 Mpa and Orthofix had a maximum value of 12.010 Mpa.

The orthodontist requires an adhesive that in addition to the decrease in chair time, is easy to manipulate, allows sufficient time to position the appliances, that has the needed fluidity to keep the bracket over the tooth surface while it is being light-cured, that penetrates in the retentions created on the tooth as well as in the ones in the bracket, that has minimal water sorption and minimal film thickness to respect the system's prescription; easy identification and removal of resin excess, that does not solubilize in order to avoid microfiltration, decrease the risk of developing lesions under the bracket and the premature de bonding of the appliances; that has dimensional stability, and the sufficient resistance to de bonding to withstand orthodontic biomechanics.

Among the composite resins that could be used in orthodontics as bonding agents today, flowable composite merits great attention because of its clinical handling characteristics. This includes fluid injectability and non- stickiness which enabled the material to be packed or condensed. The development of flowable composites was based upon its flowable viscosity and not any clinical evidence of success for specific applications. These properties were a result of low viscosity of the resin obtained by reducing the filler concentration of traditional hybrid composites but maintaining the same filler size. Depending on the type of

filler used, the majority of flowable composites are filled between 41-53% by volume which translates into 56-70% by weight. Most manufacturers will cite filler content by weight because the number is always higher.

Conventional bonding system uses three different agents on the enamel conditioner, a primer solution and an adhesive resin for the process of bonding orthodontic brackets to enamel. The use of primer was an essential part of the bonding procedure of composite adhesives to allow good wetting and penetration of the sealant into the etched enamel surface. Manufactures have introduced new self-etching primers, which reduce clinical bonding steps and chair time. Self-etching primers, which combine acid and primer, simplify the bonding procedure and avoiding the side-effects of acid-etching. It has been shown that etching with phosphoric acid produces greater loss of enamel.

The most common contaminants of enamel during bonding procedures are saliva and blood. Whereas saliva occurs in all bonding situations, blood is mainly a problem when rebonding brackets if there is gingivitis. When contamination occurs with blood, it seems that high amounts of organic substances impede the binding between primer and adhesive. Therefore, protection of the bonding sites from blood contamination is therefore essential, especially for surgical exposure of retained teeth. Complete repetition of all bonding steps would again lead to optimal adhesion.

Light curing under metallic brackets occurs by trans illumination as the tooth structure transmits light. Still, light curing materials are unable to reach a complete degree of cure which can be potentially diminished by the presence of structures that reduces the intensity of the emission light source. Additionally, incomplete polymerization due to insufficient exposure time may result in reduced bond strengths. The dependence of several external factors on the polymerization kinetics of light-cured resin composites might affect their degree of cure, particularly in the early stages of bonding. (11)

Some studies refer bond strengths of light-cured resins lower than those achieved by self-cured resins. Other studies have shown a reverse trend, with light activated materials giving stronger bond strengths. Most of those studies make specimen testing only after 24h storage. Effectively, at this period we found no differences between adhesive systems tested, which is in accordance with the results obtained by other authors. The 24 h mean shear bond strengths values duplicated from those obtained at 15min for all adhesive systems, which is also in agreement with similar studies. An increase of this magnitude could be explained by the continuous polymerization of the materials beyond the initial 15 min irradiation period which is supported by Greenlaw et al., who suggested that there is an initial production of free radicals at the periphery of the resin, where total light exposure is achieved, and internal diffusion of these free radicals along time. This allows the polymerization of the resin under the bracket base, which results in the increase of bond strengths. (11)

Also, physical properties such as sorption, solubility and film thickness of the adhesive used have a direct effect on the mechanical behavior of orthodontic brackets. Transbond XT presented the lowest sorption, solubility and film thickness, being the most stable adhesive. (12)

One factor which has to be considered in the evaluation of bond strength is the storage media in which the teeth are stored after extraction and prior to the test to evaluate the bond strength. Many reviews by Rueggeberg et. al, in 1990 and Soderholm in 1991 suggest that a storage time of up to 6 months is acceptable prior to the bond strength testing. Also, the highly inorganic enamel has been proposed to remain unaffected (Rueggerberg) (13) However, Silverstone in 1967 suggested to avoid formaldehyde to preserve the teeth because of the strong acidity which is present after the oxidation of formaldehyde to formic acid which may affect the pH of the storage media.

In a Randomized Clinical study conduced by Christine Samantha et. al, Transbond XT and Orthofix showed low bond failure rate, and that the bond failure rate and mean survival time was similar for both these orthodontic adhesives and concluded that Orthofix can be used as an ideal orthodontic adhesive when analysed in terms of bond failure and survival time. (14) Bond failure is often attributed due to moisture contamination. To overcome this problem which is very commonly encountered, newer materials are developed now which are hydrophilic in nature and are believed to offer better bond strength in moisture contaminated environment. (M11) A study was conducted by Rangaswamy Rajagopal et. al. to compare the shear bond strength and de bonding characteristics of three types pf primers, namely conventional, moisture- insensitive and self- etching primers and found out that self- etch primers have a considerably superior performance in dry dry conditions. (15)

Another study was conduced by Andreas Hellak et. al. to determine the Shear Bond strength of three different orthodontic bonding systems and the results show that Transbond XT showed the maximum Shear bond strength on human enamel. (16) Another study was done by Ambesh Kumar Rai to evaluate the bracket failure rate in orthodontic brackets bonded with and without primer. The results of this study did not find any significant difference in de bonding rate between the primer and non primer group and it was concluded that bonding with or without primer is equally successful clinically as far as bracket failure rate is concerned. (17) NIrupama et. al evaluated the Shear Bond Strength of hydrophilic bonding systems like Transbond, Enhance LC, Prime and Bond NT after contamination with artificial saliva and concluded that the non contaminated surfaces have the highest bond strength for both hydrophilic and hydrophobic materials. (18) When the adhesive remnant index(ARI) was done in the same study, it ws found that the teeth bonded in a dry environment has the highest ARI, whereas the tooth which were contaminated with natural saliva and saliva substitute had a lower ARI. This is because the saliva contains some insoluble proteins and minerals which compromise the setting of the resin. (19)

A study was done by Magna Fonseca Protàsio et. al. to study the effect of application mode of self- etching primer on the shear bond strength of orthodontic brackets. They used bovine incisor teeth to conduct the test. The results of this study show that the application mode of self- etching adhesive system used to bond brackets shows no difference in the shear bond strength value. (20)

Results:

The results of this study show that the Shear Bond Strength of Orthofix is comparable to that of the standard Transbond XT and hence can be used effectively in the bonding of Orthodontic brackets.

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