

**Comparative evaluation of the effect of different salivary pH on Shear Bond Strength of Orthodontic Brackets – An Invitro study.**

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**Introduction**

Orthodontics is a dental specialty which aids in correction of the alignment of teeth, with relation to the skeletal type,

and soft-tissue relationship of the patient endeavouring the treatment. This field is related to numerous varieties of fixed appliances which comprises of brackets which are

attached to the teeth by adhesive, and arch wires which are attached to the brackets. To ensure the prosperity of the fine-tuned orthodontic treatment, there is a demand for coherent adhesion of the bracket on the surface of the tooth till the treatment completes. For this purpose of bonding the brackets to the enamel surface of tooth, orthodontic adhesives are used. The adhesive ought to have high shear bond strength to keep the bracket bonded to the tooth surface. This will obviate in preventing the debonding and shift in its actual position of the brackets while the force is applied.

Acid etching is an important aspect within the field of bonding which was introduced by Buonocore for increasing the adhesion of acrylic filling materials to the tooth surface which will create the bonding procedure more successful.<sup>(1)</sup>

Shear bond strength (SBS) is one of the important considerations in the era of advancements in bonding materials. Shear bond strength in terms of orthodontic adhesive alleged to be the strength of adhesive to resist the force applied on the enamel surface which might debond the bracket.<sup>(2)</sup> During the orthodontic treatment, the bracket's bond strength ought to be able to resist the forces enforced at some point. Reynolds acclaimed that a resistance of 5.9-7.8 MPa is required to withstand the masticatory forces.<sup>(3)</sup> Bond strengths of an acidic primer and composite resin with a conventional adhesive system was compared by Bishara *et al*<sup>(4)</sup> and ascertained that the bond strengths were 10.4 and 11.8 MPa, respectively. The commonly encountered problem within the field of orthodontic treatment is that the bond failure with the frequency varied between 0.5 and 17.6 per cent which was declared by the authors Zachrisson *et al*,<sup>(5)</sup> Sunna and Rock *et al*.<sup>(6)</sup>

Type of etching, bracket design and size, adhesives, fluorosis, salivary pH, anatomical changes within the teeth

surface, masticatory forces, properties of the brackets, technique of the operator, behaviour of the patient and miscellaneous alternative factors have an effect on the shear bond strength of the orthodontic brackets. There are also few studies showing the bond failure of the orthodontic brackets as a result of the inclusion of acidic and alcoholic food and drinks within the patient's diet.<sup>(7,8)</sup>

Even the oral hygiene of an orthodontic patient hampers as a result of the fixed appliances employed in orthodontic treatment. Because the pH decreases, there is abundance increase in the biofilm around the bracket-adhesive-teeth junction. Therefore, the common issue encountered in these orthodontic patients is white spot lesions.

*Streptococcus Mutans* is removed in 50%–80% of orthodontic patients as a not unusual motive of decalcification as a result of the build-up of cariogenic plaque across the brackets progressing into carious lesions in such patients which further degrades with decrease in the salivary pH. Demineralization of the enamel is additionally the leading cause behind the drop in the salivary pH and the surge in bacterial growth.<sup>(9)</sup>

Failure of the bond strength of the brackets during the orthodontic treatment will cause ample of issues giving rise to long span of treatment duration, inapt expenses, inconvenience of the patient, destruction of the enamel layer on debonding at the cessation of the treatment.<sup>(10)</sup>

There are very few studies showing the effect of salivary pH on orthodontic brackets.

Therefore the aim of the present study is to evaluate the effect of different salivary pH on Shear Bond Strength of Orthodontic Brackets. And the objective of this study is to evaluate the shear bond strength of orthodontic brackets at 4.5, 5.5, 6.5 salivary pH.

## Materials And Method

The present study was undertaken in Department of Orthodontics And Dentofacial Orthopaedics, SDS, after approval of ethical committee of KIMSUDU, Karad, Maharashtra.

This was an in vitro study carried out on 60 extracted maxillary first/ second bicuspid teeth for orthodontic purpose. The sample size was selected by randomized sampling technique.

### Inclusion Criteria

- Healthy extracted maxillary first/ second bicuspid teeth freed from caries/ restorations.
- Bicuspid teeth that are non-hypoplastic.

### Exclusion Criteria

- Teeth with attrition and with intrinsic stains.
- Fractured teeth and teeth with dental anomaly.
- Iatrogenic damaged teeth during extraction.
- Teeth previously undergone endodontic, orthodontic, or chemical treatment.

The enamel surfaces of sixty extracted bicuspid teeth were cleansed and envisioned under dental light to ensure the absence of caries and cracks on the labial surface. The chosen teeth were stored in distilled water at room temperature.

Preparation of the sample was done by mounting the teeth in acrylic moulds. They were cleaned and pumiced before the bonding procedure. All the teeth samples were etched on the buccal surface with 37% Phosphoric acid (Etching gel-Prime Dental Products) for 15-30 seconds then rinsed with water and air dried with oil- and moisture-free air spray. On the etched buccal surface appearance of white chalky appearance verified that the tooth was efficiently etched. Once this etching procedure was complete, the etched buccal surface was applied with a layer of Bonding agent 3M Unitek Transbond™ XT Light Cure Adhesive Primer and then light cured for 15-20 seconds. This

procedure was followed by bracket placement (Unitek™ Gemini Metal Brackets) in the desired position with a Boon's Guage using 3M Unitek Transbond™ XT Light Cure Adhesive Paste. Then we removed the extra adhesive paste with a Hollenback carver and Light cured (Ivoclar vivadent BLUEPHASE N Light cure unit) it for thirty seconds.

Following the bonding procedure, these teeth were randomly segregated equally into 3 groups. For a period of 3 months, each group was incubated in artificial saliva with a ph of 4.5, 5.5, 6.5 respectively and maintaining the similar conditions. This artificial saliva with the specific ph was refreshed in an equal interval of time.

The test to ascertain the shear bond strength was conducted in the material testing laboratory at Shivaji University, Kolhapur. In the shear mode temperature of 25°C, an Instron universal testing machine was used to record the bond strength. The prepared acrylic blocks were placed on the metal jig and positioned on the Instron universal testing machine in such a way that the long axis of the crown was parallel to the direction of the load application at a crosshead speed of 2 mm/ min. debonded from the tooth surface. Until the bracket debonded from the tooth surface, an occluso-gingival load was progressively applied. The load at which the bracket were debonded was recorded in Newton's and subsequently calculated in Mega Pascal's using the formula:

$$\text{Bond strength in Mpa} = (\text{force in newton}) / (\text{surface area of the bracket in mm}^2)$$

The bracket base area for metal brackets (Gemini Series, 3M Unitek) is 9.61 mm<sup>2</sup> as per the data provided by the manufacturer.

Following the debonding procedure, every tooth was examined beneath ×40 magnification with a stereo microscope (XTL 3400E, Wuzhou New Found Instrument

Co.Ltd) and also the residual adhesive remaining on the teeth was scored using the adhesive remnant index (ARI), which was delineated by Oliver (1984).The scores of this index were obtained by the percentage of adhesive remained on the surface. The scores are: one, 100%; two, more than 90%; three, between 10-90%; four, less than 10%; and five, 0% .Obtained data of initial pH, SBS, and ARI scores was subjected to statistical analysis.

**Statistical Analysis**

Descriptive statistics which included mean and standard deviation of SBS values calculated by means of statistical package for social science SPSS version 21.Shapiro wilk test suggested normal distribution of data. Anova and Turkes post hoc test were used for multiple comparisons of SBS between groups. To evaluate difference in ARI score, Chi square test was supplied. P less than 0.05 was considered significant for all statistical tests.

**Results**

**Table 1:** shows the mean of shear bond strength values in the three groups.

Group 3 (pH = 6.5) showed the highest mean value of shear bond strength (11.17 ± 1.28) and Group 1 (pH = 4.5) showed the lowest mean value of shear bond strength (8.02 ± 0.99).

**Figure 1:** shows the Mean shear bond strength in Group 1, Group 2, Group 3 was found to be 8.02 (0.99), 9.97 (0.73) and 11.17 (1.28) .Greater shear bond strength was found in higher pH group.

On using Anova F test (**Table 2**) for overall comparison , there was high statistical significant difference (p<0.001) among groups.

On individual pairwise comparison , Group 2 & Group 3 have high statistically significant (p<0.001) greater bond strength as compared to Group 1

Group 3 have statistically significant (p<0.05) greater bond strength as compared to Group 1.

The obtained ARI scores are shown in **Table 3**. Score 1 was not observed in Group 2 & 3 , while 20% was prevalent in Group 1.

Score 2 was seen in 35% of Group 1 samples, 10% of Group 2 samples, and 20% of Group 3 samples

Score 3 was seen in in 15% of Group 1 samples, 20% of Group 2 samples, and 15% of Group 3 samples

Score 4 was seen in in 20% of Group 1 samples, 45% of Group 2 samples, and 50% of Group 3 samples

Score 5 was seen in in 10% of Group 1 samples, 25% of Group 2 samples, and 15% of Group 3 samples

Highly statistical significant association is observed between ARI score and Ph.

Table 1: Descriptive statistics of effect of salivary pH on shear bond strength of orthodontic brackets

	Mean	S.D	Std. Error	Minimum	Maximum
Group 1 (4.5 pH)	8.02	0.99	0.22	6.09	9.09
Group 2 (5.5 pH)	9.97	0.73	0.16	8.54	11.12
Group 3 (6.5 pH)	11.17	1.28	0.28	8.6	12.90

Figure 1: Graph showing the Mean shear bond strength in Group 1, Group 2, Group 3

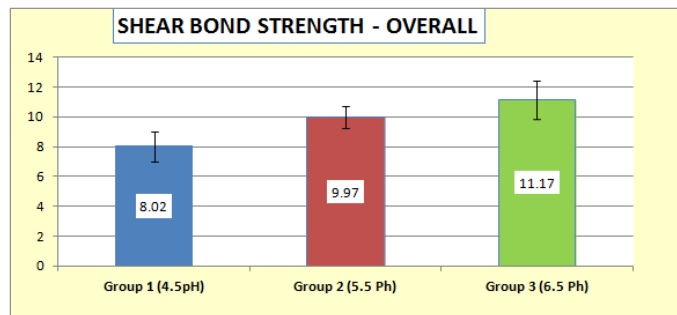


Table 2: Comparative statistics of statistics of effect of salivary pH on shear bond strength of orthodontic brackets using one way Anova F test respectively

	MEAN	S.D	ANOVA F TEST	p value, Significance
Group 1 (4.5 pH)	8.02	0.99	F = 47.864	p <0.001**
Group 2 (5.5 pH)	9.97	0.73		
Group 3 (6.5 pH)	11.17	1.28		
Tukey's post hoc test to find pairwise comparison				
Group	Comparison Group	Mean Difference	p value, Significance	
Group 1 (4.5 pH)	Group 2 (5.5 pH)	1.95	p <0.001**	
	Group 3 (6.5 pH)	3.15	p <0.001**	
Group 2 (5.5 pH)	Group 3 (6.5 pH)	1.20	p = 0.001*	

p >0.05 – not significant      \*p<0.05 – significant  
 \*\*p<0.001 – highly significant

Table 3: Comparison of Adhesive Remnant Index (ARI) scores in different study groups

	Group 1 (4.5 pH)	Group 2 (5.5 pH)	Group 3 (6.5 pH)
Score 1	4 (20%)	0 (0%)	0 (0%)
Score 2	7 (35%)	2 (10%)	4 (20%)
Score 3	3 (15%)	4 (20%)	3 (15%)
Score 4	4 (20%)	9 (45%)	10 (50%)
Score 5	2 (10%)	5 (25%)	3 (15%)
Chi square test = 29.84 , p <0.001**			

p >0.05 – not significant      \*p<0.05 – significant  
 \*\*p<0.001 – highly significant

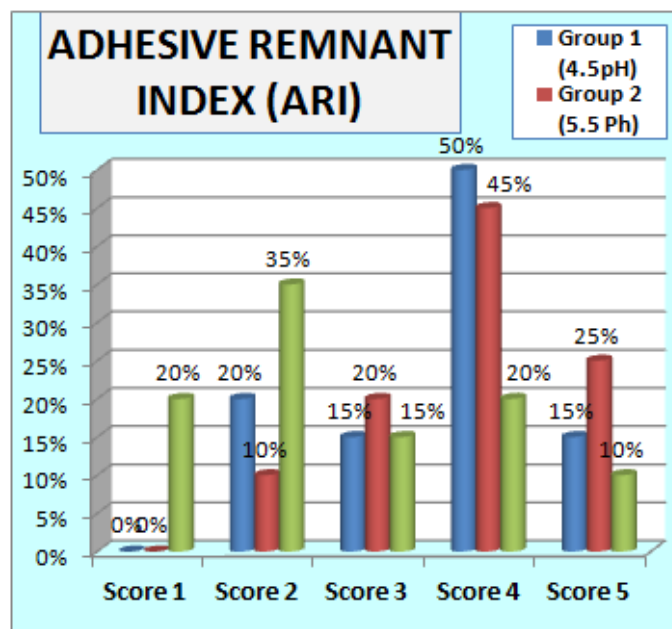


Figure 2: Graph showing the Comparison of Adhesive Remnant Index (ARI) scores in different study groups

**Discussion**

To create a better facial esthetics, there is a requirement of efficient orthodontic treatment. The orthodontists skills, to properly control the tooth movement during the treatment phase is of utmost importance to successfully bring about the desired result. For the effective movement of the teeth, the interface between the bracket and therefore the wire is taken into consideration.<sup>(11)</sup>

Therefore, the orthodontic brackets ought to have strong bond to face up the masticatory forces throughout the orthodontic treatment phase and should remain bonded to the tooth surface.<sup>(12)</sup>

There will be no control over the movement of the tooth once the bracket is debonded. This will increase the treatment duration along with that will cause patients inconvenience which is not acceptable to the dentist.<sup>(13,14)</sup>

In Orthodontics, direct bonding of orthodontic brackets to enamel is taken into account as ‘state of art’. There is a requirement to bond the brackets to different restorative materials like composite resin, porcelain, amalgam etc.as well as to the enamel surface of the tooth. So, recently

there has been an increase in the research fields on the subject matter of increasing the shear bond strength to the surfaces of the composite.<sup>(15,16)</sup>

The acid etching technique utilized in dentistry was introduced by Buonocore<sup>(8)</sup> in 1955 stating that there is a thin layer of enamel that is removed during the etching technique and therefore the surface becomes porous that is in turn filled by the rein matrix. Newmann<sup>(17)</sup> was the one who bonded the brackets with the acid etch technique over the enamel surface of the tooth. There should be proper isolation protocol maintained during the etching as well as the priming procedure. Any contamination throughout this procedure will cause failure of the bond strength of the brackets. Saliva, blood and alternative factors will act as contaminants. Thus utmost care ought to be taken in gingivitis, hyper salivating patients.<sup>(18)</sup>

In our study, Etching gel-Prime Dental Products was used as an etchant, 3M Unitek Transbond<sup>TM</sup> XT Light Cure Adhesive Primer was the primer, and 3M Unitek Transbond<sup>TM</sup> XT Light Cure Adhesive Paste was the composite resin used.

A study was undertaken by Lai *et al.*,<sup>(19)</sup> where he compared different variety of brackets and its effects over the bond strength of the brackets to the composite resin and explicated that type of adhesive was less imperative than type of brackets in this reverence. Another author Odegaard *et al.*<sup>(20)</sup> concluded that the ceramic brackets have considerably higher shear bond strength than that of the metal types. In the present study, stainless steel brackets were used as they are the commonly used brackets by the orthodontists in their clinical setup in respect to other different types of brackets which will help in deriving more generalized results to the clinical settings.

As soon as there is an introduction of the orthodontic fixed appliance in the oral cavity, a swift rise is seen in the

microbial flora of plaque. Mostly commonly Streptococcus mutans and Lactobacillus are seen amongst the higher levels of microorganism. As the microorganisms increases, there is a decrease in the salivary pH levels at a quicker rate and wide extent. Therefore there is an increased decay rate encountered amongst the orthodontic patients.<sup>(21)</sup>

Ulusoy and co workers<sup>(22)</sup> in their study on 90 intact premolars that were immersed in different kinds of tea (black tea, green tea, tea with lime flavour and fruit tea) showed that there was an association among the SBS of orthodontic brackets and the pH of the various tea.

In our study, the least shear bond strength value was determined in group 1 with the pH of 4.5.

This shows that in acidic conditions, that may be due to frequent consumption of acidic drinks, increase in bacterial flora, or poor dental attention can lead to the tendency of bond failure in the patients undergoing orthodontic treatment.

Methods such as ARI have gained importance in assessing the quality of adhesion between the composite and tooth as well as between the composite and bracket base. In this study, the ARI score of 1 (i.e., all adhesive left on the tooth) was found to be the foremost prevailing in group 1 (20%). This shows that the brackets fail at the bracket adhesive interface in an acidic environment.

### Conclusion

A comparative evaluation of the shear bond strength was undertaken with three different pH of 4.5, 5.5 and 6.5 and the following conclusions were drawn:

1. There was a direct relationship between the shear bond strength of the orthodontic brackets and the pH.
2. There was high statistically significant difference ( $p < 0.001$ ) among group 1 (pH = 4.5), group 2 (pH = 5.5) and group 3 (pH = 6.5).



3. Group 1 showed statistically significant ( $p < 0.001$ ) lower bond strength as compared to Group 2 and group 3.
4. Group 3 showed the highest bond strength among the three groups.
5. This study reveals that increase in pH increases the shear bond strength of the orthodontic brackets.

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