ISSN: 0975-833X

*Available online at http://www.journalcra.com*

**International Journal of Current Research**
**Vol. 16, Issue, 06, pp.28664-28671, June, 2024**
**DOI: https://doi.org/10.24941/ijcr.47307.06.2024**

**INTERNATIONAL JOURNAL OF CURRENT RESEARCH**

# RESEARCH ARTICLE

# COMPARATIVE EVALUATION OF SHEAR BOND STRENGTH OF BRACKETS BONDED WITH SELF-PRIMING, COLOUR CHANGING, AND A CONVENTIONAL ORTHODONTIC ADHESIVE – AN IN VITRO STUDY

***[1]Akshaya Raj, M., [2]Sam Paul, [3]Varun Peter and [4]Prince Chacko**

[1]Mds Post Graduate Student in Orthodontics and Dentofacial Orthopaedics (kuhs), bds (kerala University of Health Sciences, Kuhs), Educare Institute of Dental Sciences, College road Kiliyamannil Campus, Chattiparamba-Kootlangadi Rd, Malappuram, Kerala 676504; [2]MDS IN Orthodontics and Dentofacial Orthopaedics, Phd Scholar (Dy Patil University), Educare Institute Of Dental Sciences, College Road Kiliyamannil Campus, Chattiparamba-Kootlangadi Rd, Malappuram, Kerala 676504; [3]MDS in Orthodontics and Dentofacial Orthopaedics, Phd Scholar (Kerala University of Health Sciences), Educare Institute of Dental Sciences, College Road Kiliyamannil Campus, Chattiparamba-Kootlangadi Rd, Malappuram, Kerala 676504; [4]MDS in Orthodontics and Dentofacial Orthopaedics, Educare Institute of Dental Sciences, College Road Kiliyamannil Campus, Chattiparamba-Kootlangadi Rd, Malappuram, Kerala 676504

**ARTICLE INFO**

*Article History:*
Received 20th March, 2024
Received in revised form
15th April, 2024
Accepted 24th May, 2024
Published online 25th June, 2024

*Key words:*
Orthodontic Adhesives, Shear Bond Strength, Color Changing Adhesive, Debonding.

**Corresponding author:*
*Akshaya Raj, M.*

**ABSTRACT**

**Background:** Enhanced durability and bond strength between the bonding material and the enamel is essential for the clinical success of the orthodontic treatment. Bonding failures are inconvenient, delays treatment, costly and might compromise the outcome of the treatment. Hence this study was undertaken to evaluate and compare the shear bond strength of orthodontic brackets bonded with 3 different composites viz the Transbond-XT, Ormco Grengloo, and EZ-Bond.

**Methods:** 36 freshly extracted maxillary premolars was collected and stored. Then specimen was randomly divided into the following groups and bonded accordingly with the adhesives planned for the study.

1GROUP 1- Transbond XT with Transbond XT primer
2GROUP 2- Grengloo with Ortho solo primer
3GROUP 3- EZ bond adhesive

Appropriately bonded samples were taken for shear bond test done using an Instron testing machine.

**Results:** The mean SBS of Grengloo with Orthosolo primer, Transbond XT and EZ bond were 14.28 MPa, 13.99 MPa and 12.01 MPa respectively. There were no significant differences found in shear bond strength between Grengloo and Transbond XT but significant differences found in shear bond strength between Transbond XT and EZ bond adhesive
as well as Grengloo and EZ bond adhesive.

**Conclusion:** Metal brackets bonded with color changing adhesive Grengloo have shown superior shear bond strength. The color changing adhesives offer a viable alternative in cases demanding robust bond strength. Each presents unique advantages allowing the clinicians to select based on their preferences and specific requirements



**Citation: Akshaya Raj, M., Sam Paul, Varun Peter and Prince Chacko. 2024.** "Comparative evaluation of shear bond strength of brackets bonded with self-priming, colour changing, and a conventional orthodontic adhesive – an in vitro study*". International Journal of Current Research*, 16, (06), 28664-28671.

# INTRODUCTION

Increasing knowledge related to bonding of adhesives to enamel surface in dentistry has caused developments in orthodontics as in other fields. With the advancement of new materials science of orthodontics is rapidly evolving with its research for improvements in its techniques and materials that benefit both the patients as well as the clinicians.

Before 1970s, orthodontic brackets were attached to teeth by stainless steel bands. This technique was painful and time-consuming. In addition, it could harm and damage the periodontal, dental tissue and oral hygiene. The enamel beneath the bands was more caries prone during the period of orthodontic treatment. Later, in 1970s, bonding gained popularity and it became possible to directly bond orthodontic brackets to an etched tooth surface with resinous adhesives.

A review of the long history of orthodontic bonding shows that many evolutional developments have occurred since the first chemically- cured composite resins to the most recently introduced light-cured color- change adhesives (CCAs). There is still a demand for adhesives that have excellent physical qualities, minimal polymerization shrinkage, and ease of bonding attributes. The introduction of new materials that can help clinicians to achieve better results has always been intriguing. Color-changing adhesives are such an addition to orthodontic bonding which is very promising, and evaluation of their bond strength is required to gain knowledge of their clinical success. To directly attach orthodontic brackets with resin adhesive, Newman[1] modified the acid-etch process of Buonocore[2] in 1965 for orthodontics. When compared to the previous method of banding, this direct bonding procedure is better for the patient and the practitioner.

While chemically-cured composite resins have some shortcomings, such as incorporation of air bubbles during mixing and limitation in controlling the curing time accurately,[3,4] light-cured composite resins provide controlled polymerization time, more accurate bracket placement, and easier removal of excess adhesive prior to curing.[3,5] Another drawback of conventional composites is their poor color contrast with enamel, often resulting in the accumulation of resin remnants on the enamel surface after bracket debonding and polishing. Optimal color and shade match of adhesive and teeth makes it difficult to identify the adhesive–tooth interface and complete removal of adhesive remnants may not be easily achieved. An ideal bonding material should have optimal bond strength and minimal enamel loss after debonding.[6] Shear bond strength (SBS) is the key factor, which has to be considered in the evolution of bonding materials. The bond strength of the orthodontic brackets must be able to withstand not only the forces applied during the orthodontic treatment but the masticatory forces as well. According to Reynolds 5.9-7.8 MPa is considered adequate strength that is clinically acceptable for performing orthodontics treatment.[7] The maximum bond strength should be less than the cohesive strength of enamel, which is approximately 14 MPa, to reduce the extent of enamel loss on debonding.[8] The color-changing characteristic of color-change light-cured composites enhances their complete removal after bracket debonding and facilitates easy removal of excess resin after bracket bonding, which is an added advantage.[9, 10, 11]

Grengloo is a color-changing adhesive, which is green in color at temperatures lower than the body temperature. This facilitates easy removal of excess composite during bracket bonding. At body temperature, the green color vanishes and the composite becomes transparent during the treatment period. After bracket debonding, mild air spray or cold water composite changes in color to green again. This enhances adhesive remnant removal[12] EZ Bond is a newly launched single-component light-cure paste system specifically designed for bonding metal and ceramic orthodontic brackets to enamel. It is formulated by a unique chemistry that ensures better adhesion to the tooth surface. It has an excellent workable consistency which gives a hassle-free practice. Since it does not require a separate priming step, it reduces chair-side time for operators. It includes a fluorescent tracer to aid in the removal of excess adhesive material. It is hydrophobic and must be used on teeth that are completely dry, without any contamination from saliva or oil, as these can interfere with its adhesion to the enamel.

# MATERIALS AND METHODS

**SAMPLE SIZE:** Sample size calculated using data obtained from the previous study conducted by S Sharma et al[13]. The calculated effect size is 0.73 with an alpha error probably of 0.05 and power of 0.80. The sample size was calculated using G*Power 3.1.9.4. So, the calculated total sample size is 36.

**INCLUSION CRITERIA**

- Maxillary premolars
- Non-carious
- Intact tooth surfaces
- No visible fracture lines on the enamel surface,
- No pre-treatment with chemical agents (eg: hydrogen peroxide)

**EXCLUSION CRITERIA**

- Extracted premolars with visible distortion
- Fillings
- hypoplastic lesions including Fluorosis,
- with history of orthodontic bonding

**SAMPLING PROCEDURE**

36 samples were divided into three groups such that there are twelve samples in each group. The samples were grouped based on the type of adhesives used; Transbond XT with Transbond XT primer, Grengloo with Ortho Solo primer and EZ bond adhesive

**Classification of samples into three groups**

| Sl No. | Adhesive material | Total number of samples | Color |
|---|---|---|---|
| GROUP 1 | Transbond XT (with Transbond XT primer) | 12 | red |
| GROUP 2 | Gren-gloo (with Ortho Solo primer) | 12 | blue |
| GROUP 3 | EZ bond | 12 | white |

**BONDING PROCEDURE**

Prophylaxis: Each tooth's buccal surface was cleaned and polished with, oil-free pumice paste applied with a rubber cup on a slow speed handpiece for 10 seconds, rinsed with water and dried with an oil and moisture free airstream for 20 seconds

**Etching:** The enamel surface on the buccal aspect of teeth was etched using 37 percent ortho phosphoric acid (Scotchbond – 3M ESPE) for 30 seconds, rinsed with water for 20 seconds and completely air dried for 30 seconds with compressed air.

**Priming:** A thin, uniform film of Transbond XT primer was applied to GROUP 1 and Ortho Solo primer was applied to GROUP 2.

**Applying bonding adhesive:**

**GROUP 1:** Transbond XT with Transbond XT primer was placed onto the metallic bracket base.

**GROUP 2:** Grengloo with Ortho Solo primer was placed onto the metallic bracket base.

**Group 3:** EZ bond adhesive was placed onto the metallic bracket base. And the bracket was firmly pressed on to the prepared enamel; the excess adhesive was then removed with an explorer.

**Curing:** Brackets were light cured for 10 seconds on occlusally and gingivally for a total of 20 seconds per tooth using (3M™ Elipar™ DeepCure-L LED Curing Light(3M ESPE St. Paul,MN, USA) Intensity-1470mW/cm²). The teeth were then stored for 24 hours in distilled water at 37ºC before debonding

**SHEAR BOND TESTING PROCEDURE**

The 20 samples from each group were tested for shear bond strength using Instron machine (AG-X plus,10kN, Shimadzu) series from Department of Mechanical Engineering, centre of biomechanics for strength measurements (NIT calicut). Embedded specimens are secured in a jig to the base plate of an Instron testing machine. The crosshead speed is set to 1mm/min and the maximum load necessary to debond by pushing method is recorded. The shear bond strength tests are measured using an Instron machine and the force values (in Newton) required to debond each bracket is registered. The force values (in Newton) recorded at the point of failure was converted to shear stress by dividing by the bracket surface area ($mm^2$) and was reported in megapascals ($N/ mm^2$) for all 36 samples.

# RESULTS

**STATISTICAL ANALYSIS:** Data was analyzed using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro Wilkinson test.

**Table 1. Shear bond strength**

| GROUP 1 | GROUP 2 | GROUP 3 |
|---|---|---|
| Transbond XT with Transbond XT primer | Grengloo with orthosolo primer | EZ bond adhesive |
| 15.39 | 16.02 | 11.31 |
| 14.34 | 16.2 | 11.83 |
| 14.05 | 12.28 | 12.4 |
| 13.74 | 14.15 | 11 |
| 15.69 | 13.21 | 12.85 |
| 13.07 | 13.68 | 11.7 |
| 13.61 | 14.34 | 11.5 |
| 14.12 | 13.44 | 11.49 |
| 12.85 | 13.79 | 13.1 |
| 14.68 | 14.9 | 12.22 |
| 14.09 | 14.76 | 12.95 |
| 12.35 | 14.62 | 11.88 |

Inferential statistics to find out the difference within the group was done using ONE WAY ANOVA (3 groups) followed by BONFERRONI POSTHOC TEST. CHI SQUARE test will be used for analysis the difference in proportion. Shapiro wilkinson test for normality did not report significant difference ($p>0.05$). Hence Parametric tests are used for the analysis.

Regarding 'SHEAR BOND STRENGTH', Between group analysis by ONE WAY ANOVA reported significant difference ($P<0.05$). POSTHOC Bonferroni test reported statistically significant difference BETWEEN the pair group comparisons($P<0.05$) as given below. Transbond XT with Transbond XT primer vs EZ bond adhesive ($P<0.05$). Grengloo with orthosolo primer vs EZ bond adhesive ($P<0.05$). POSTHOC Bonferroni test did not report statistically significant difference BETWEEN the pair group comparisons($P>0.05$) as given below. Transbond XT with Transbond XT primer vs Grengloo with orthosolo primer ($P>0.05$)

# DISCUSSION

Since the introduction of direct bonding to the enamel, significant advances have been made and different light-cured composites and several generations of bonding systems were introduced to the market.[14] Today, there are various orthodontic bonding materials available like self-cure adhesives, light cure, bonding material with primers, self-etch primers, color change adhesive, etc. These materials are introduced to clinical use after certain quality tests; one of the important tests is shear bond strength to dental enamel. Bond strength of orthodontic adhesives has been the subject of study for many researchers since a long time. Clinical bonding has been demonstrated to be effective for orthodontic operations when shear bond strengths range from 5.9 to7.8 MPa.[7] In order to prevent bracket failure during treatment, the adhesive's shear bond strength must be high enough to prevent bracket failure during treatment and low enough to prevent enamel damage during debonding. Color-changing adhesives are an innovative modality for bracket bonding. They were introduced to the market to enhance facilitate effortless removal of remnant adhesive after bracket debonding because of its color contrast.[9,10,15]

More adhesive material attached to the base of the bracket while debonding, less time required for residual adhesive removal. However, bracket-adhesive interface can be considered, most favorable failure site for safe debonding, leaving most of the adhesive on the enamel surface, since there is less chance of enamel fracture.[16] In orthodontic procedures, the debonding of brackets either by accident or by an orthodontist is a frequent event. The adhesion between orthodontic composite resins and the tooth enamel should be temporary, but it should last enough to withstand masticatory and orthodontic forces at the same time. Iatrogenic damage to enamel on debonding is inevitable, in scenarios where the tensile bond strength was above 14.5 MPa on debonding, enamel damage was reported. When selecting an adhesive for an orthodontic procedure, shear bond strength, the location of bond failure, the amount of enamel loss, cost, and chair time must all be considered. Products have been marketed to improve bond strength, decrease chair time, and reduce unwanted effects to the enamel surface. Orthodontic bonding adhesives with color change capability have been developed to facilitate the removal of excess adhesive during bracket placement and identify remaining adhesive after bracket removal. In the present study the properties of one color-changing adhesive- Grengloo and self-priming adhesive EZ bond were compared with conventional light- cured orthodontic bonding adhesive- Transbond XT. Bond strength and debonding nature of Transbond XT have been

**Table 2. Descriptive Details of The Groups (Shear Bond Strength)**

| Descriptives | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SHEAR BOND STRENGTH | | | | | | | | |
| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
| | | | | | Lower Bound | Upper Bound | | |
| Transbond XT with Transbond XT primer | 12 | 13.998 | .97797 | .2823 | 13.3770 | 14.6197 | 12.35 | 15.69 |
| Grengloo with orthosolo primer | 12 | 14.282 | 1.12474 | .3246 | 13.5679 | 14.9971 | 12.28 | 16.20 |
| EZ bond adhesive | 12 | 12.019 | .68480 | .1976 | 11.5841 | 12.4543 | 11.00 | 13.10 |
| Total | 36 | 13.433 | 1.37401 | .2290 | 12.9684 | 13.8982 | 11.00 | 16.20 |

**Table 3. Descriptive details of the groups (shear bond strength)**

| | | Transbond XT with Transbond XT primer | Grengloo with orthosolo primer | EZ bond adhesive |
|---|---|---|---|---|
| Mean | | 13.9983 | 14.2825 | 12.0192 |
| 95% Confidence Interval for Mean | Lower Bound | 13.3770 | 13.5679 | 11.5841 |
| | Upper Bound | 14.6197 | 14.9971 | 12.4543 |
| 5% Trimmed Mean | | 13.9959 | 14.2872 | 12.0157 |
| Median | | 14.0700 | 14.2450 | 11.8550 |
| Variance | | .956 | 1.265 | .469 |
| Std. Deviation | | .97797 | 1.12474 | .68480 |
| Minimum | | 12.35 | 12.28 | 11.00 |
| Maximum | | 15.69 | 16.20 | 13.10 |
| Range | | 3.34 | 3.92 | 2.10 |
| Interquartile Range | | 1.39 | 1.37 | 1.25 |
| Skewness | | .120 | .190 | .326 |
| Kurtosis | | -.233 | -.002 | -1.089 |

**Table 4. Normality testing**

| Tests of Normality | | | | | | |
|---|---|---|---|---|---|---|
| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Transbond XT with Transbond XT primer | .117 | 12 | .200* | .975 | 12 | .957 |
| Grengloo with orthosolo primer | .125 | 12 | .200* | .972 | 12 | .927 |
| EZ bond adhesive | .164 | 12 | .200* | .944 | 12 | .550 |
| *. This is a lower bound of the true significance. | | | | | | |
| a. Lilliefors Significance Correction | | | | | | |

**Table 5. Comparison Of Shear Bond Strength Using One Way Anova**

| ANOVA | | | | | |
|---|---|---|---|---|---|
| SHEAR BOND STRENGTH | | | | | |
| | Sum of Squares | Df | Mean Square | F | Sig. |
| Between Groups | 36.482 | 2 | 18.241 | 20.340 | **0.0001*** |
| Within Groups | 29.595 | 33 | .897 | | |
| Total | 66.077 | 35 | | | |

*P<0.05 is statistically significant (Shapiro Wilkinson test, p>0.05); Shapiro wilkinson test for normality did not report significant difference (p>0.05), Hence Parametric tests are used for the analysis. Regarding 'SHEAR BOND STRENGTH', Between group analysis by ONE WAY ANOVA reported significant difference (P<0.05).

**Table 6. Post hoc test for multiple comparison**

| Multiple Comparisons | | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variable: SHEAR BOND STRENGTH | | | | | | |
| Bonferroni | | | | | | |
| (I) | (J) | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
| | | | | | Lower Bound | Upper Bound |
| Transbond XT with Transbond XT primer | Grengloo with orthosolo primer | -.28417 | .38661 | 1.000 | -1.2593 | .6909 |
| | EZ bond adhesive | 1.97917* | .38661 | **.0001*** | 1.0041 | 2.9543 |
| Grengloo with orthosolo primer | Transbond XT with Transbond XT primer | .28417 | .38661 | 1.000 | -.6909 | 1.2593 |
| | EZ bond adhesive | 2.26333* | .38661 | **.0001*** | 1.2882 | 3.2384 |
| EZ bond adhesive | Transbond XT with Transbond XT primer | -1.97917* | .38661 | **.0001*** | -2.9543 | -1.0041 |
| | Grengloo with orthosolo primer | -2.26333* | .38661 | **.0001*** | -3.2384 | -1.2882 |
| *. The mean difference is significant at the 0.05 level. | | | | | | |

POSTHOC Bonferroni test reported statistically significant difference BETWEEN the pair group comparisons(P<0.05) as given below
Transbond XT with Transbond XT primer vs EZ bond adhesive (P<0.05)
Grengloo with orthosolo primer vs EZ bond adhesive (P<0.05)
POSTHOC Bonferroni test did not report statistically significant difference BETWEEN the pair group comparisons(P>0.05) as given below
Transbond XT with Transbond XT primer vs Grengloo with orthosolo primer (P>0.05)


1.Transbond XT light cure adhesive
2.Grengloo color change adhesive
3.EZ bond adhesive paste

**Figure 1. Adhesives**

**Figure 2. Armamentarium used Pumice prophylactic paste, rubber cup, micromotor, bracket holder, explorer, applicator brush**

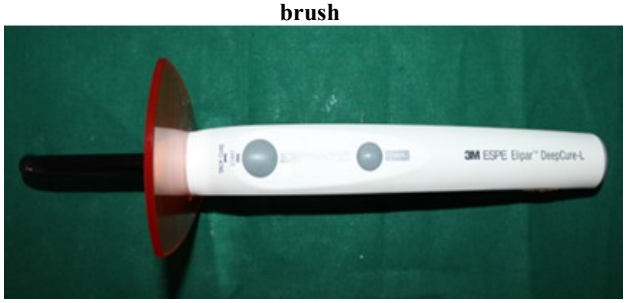



**Figure 3. 3m Elipardeepcure L-LED curing light**

extensively investigated and reported to have optimum bond strength with wide clinical acceptance. Saleh et al[17] conducted an invitro study in which the mean shear bond strength of metal bracket bonded with Transbond XT adhesive was 18.6MPa and similar results were obtained for Sinha et al[18] 18.9 MPa. Arnold et al [19] study, which showed Transbond XT's mean shear bond strength to be 9.7 MPa. Grengloo is a two-way color change adhesive which polymerizes faster than other light-cured orthodontic bonding adhesives providing a higher percent of total bond strength at initial force loading.


**Figure 4. Teeth sample stored in Thymol**

**Figure 5. Prophylaxis with rubber cup and pumice**

**Figure 6. Etching**

It is also designed with patented ingredient which increases impact resistance by 118 percent and has a chemical affinity for metal brackets which can ensure reliable bond strength.

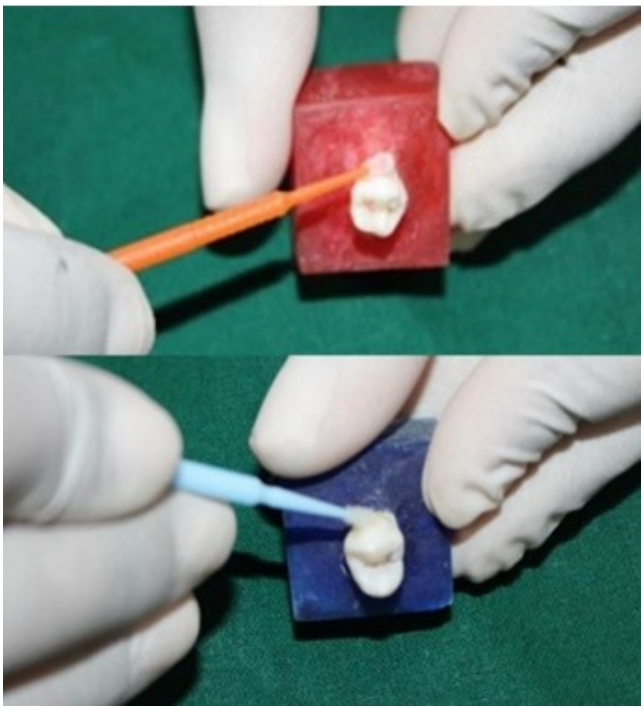


**Figure 7. Primer application**

1.Transbond XT primer application
2.Orthosolo primer application


**Figure 8. Adding Adhesives**

1.Adding Transbond XT adhesive
2.Adding Grengloo adhesive
3.Adding EZ bond adhesive

The green color contrast at lower temperatures during bonding facilitates accurate bracket placement and easy removal of excess adhesive.[12] EZ bond is a self-priming orthodontic bonding adhesive which ensures a better adhesion to the tooth surface. It has an excellent workable consistency which gives a placid practice. It does not require primer after etching. This technology helps dental professional to etch and do the bonding straightway.


**Figure 9. Stainless steel brackets**

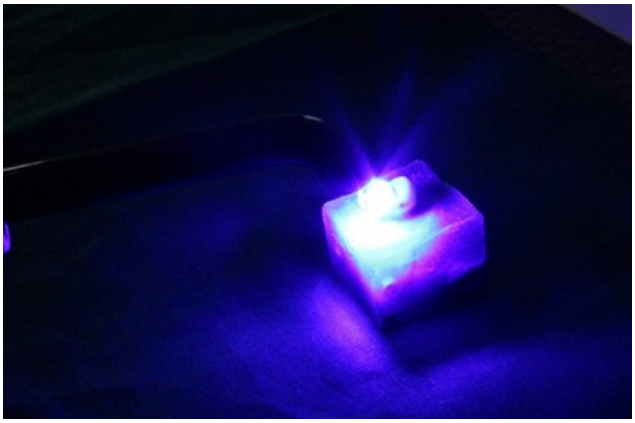
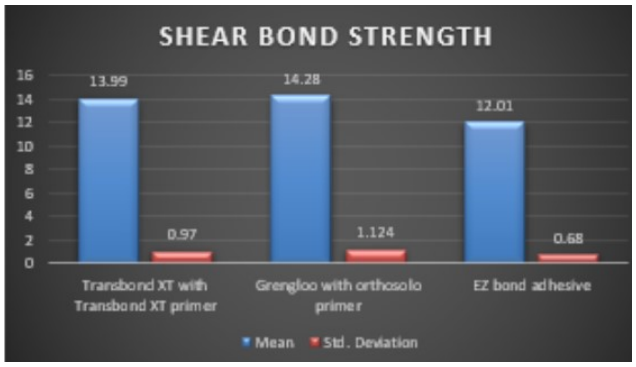


**Figure 10. light curing**

**Figure 11. Bonded samples**

It saves a lot time. It comes with a fluorescent tracer and helps to remove the excess adhesive material. In the present study the mean SBS of Transbond XT with conventional primer and that of Grengloo with Orthosolo primer was 13.99 MPa and 14.28 MPa respectively. GROUP 2 had a higher shear bond strength compared to GROUP 1 which is comparable with the results of Delavarian et al,[16] reported 22.95±5.20 MPa as mean shear bond strength of Grengloo when compared to Transbond XT which had a mean shear

**Figure 12. Instron universal testing machine**




bond strength of 13.71±3.57 MPa. Bayani et al[20] reported that Grengloo provided an SBS higher as 31.25±2.4MPa and 27.55±3.4 MPa after 40s and 20s of curing respectively which is in correlation with our study. The mean Shear bond strength of Grengloo (GROUP 2) and EZ bond (Group 3) according to the current study were 14.28 MPa and 12.01 MPa respectively which was statistically significant. GROUP 2 had higher SBS compared to Group 3 The relatively higher bond strengths of Grengloo may be due to the sealant, Ortho Solo, used in the groups. Ortho Solo is a fluoride-releasing universal sealant and it enhances the bonding ability. It comprises dimethacrylate resins, barium glass, fumed silica, sodium hexafluorosilicate, and ethanol. According to the manufacturers, Ortho Solo has a bond-enhancing property that improves adhesion to the tooth at the adhesive interface, which helps in markedly reducing bond failure rates. Ekhlassi et al[10] reported the shear bond strength of Grengloo to be 11.3 ± 2.8 MPa at 24 hours after bonding, which was lower than the value in the present study, which may be because of the difference in methodology and enamel preparation method. In their study, self-etch primer was applied on the enamel surface, which is believed to significantly reduce the bond strength compared to conventional adhesives. Furthermore, they used bovine teeth instead of human teeth, hence the difference in bond strength values. A similar result was reported by Duer et al[9] who reported a lower shear bond strength value for Grengloo at 24 hr. Lower amounts of shear bond strengths in their study compared to the current study may be attributed to the use of bovine teeth instead of human teeth or the use of ground enamel surface instead of natural intact enamel. They used Transbond primer for all the study groups and chose 20s as curing time for adhesives.

In the present study the mean SBS of Transbond XT and that of EZ bond with conventional primer was 13.99 MPa and 12.01 MPa respectively. The shear bond strength of Group 1 was more than GROUP 3. On evaluation of the results of our study, following observations can be seen. The metal brackets bonded with Grengloo color changing adhesive had the highest shear bond strength. There were no significant differences found between shear bond strength of Grengloo and Transbond XT conventional adhesive. Significant result was found between shear bond strength of EZ bond with Transbond XT conventional adhesive and Grengloo color changing adhesive. The color changing adhesives offer a viable alternative in cases demanding robust bond strength. Grengloo has color contrast that facilitates easy composite removal than Transbond XT and EZ bond which lacks color contrast.

# CONCLUSION

Ever since Buonocore revolutionized clinical orthodontics in 1955 by introduction of the acid etch technique, there has been numerous attempts to further improve the protocol. Products have been marketed to improve bond strength, reduce bonding steps, decrease chair side time, and reduces unwanted effects to the enamel surface. Orthodontic bonding adhesives with color change capability have been developed to facilitate the removal of excess adhesive during bracket placement and identify remaining adhesive after bracket removal. So, there is always a quest for an orthodontic bonding material which has better shear bond strength but minimal enamel loss while debonding. In this study shear bond strength following the use of Grengloo color-changing adhesive, self-priming EZ bond adhesive and Transbond XT conventional adhesive were assessed and compared after debonding of metal brackets.

**From the result of this study, it can be concluded that**

- The metal brackets bonded with Grengloo and conventional Transbond XT adhesive had the highest shear bond strength when compared to the EZ bond adhesive.
- The color changing adhesives offer a viable alternative in cases demanding robust bond strength. Each presents unique advantages allowing the clinicians to select based on their preferences and specific requirements.

# ACKNOWLEDGEMENTS

The authors acknowledge the Department of Orthodontics and Dentofacial Orthopaedics and Department of Oral and Maxillofacial Surgery, Educare Institute of Dental Science, Kerala for helping in the procurement of materials with which this study was conducted. The authors would also like to thank the Centre for Biomechanics, NIT, Calicut for allowing me to work in their department

**Conflicts of interest:** Authors declare no conflicts of interest

**Funding:** No funding.

**Declarations**

Ethics approval and consent to participate. Ethics approval was attained from the Institutional Ethics Committee at the Educare Institute of Dental Sciences, Malappuram, Kerala. EC/2022/07

**Competing interests:** The authors declare no competing interests.

**LIST OF ABBREVIATIONS**

| | |
|---|---|
| ANOVA | Analysis of variance |
| Bis-GMA | Bisphenol A-glycidyl Dimethacrylate |
| SBS | Shear bond strength |
| MPa | Mega Pascal |
| N | Newton |
| P- VALUE | Probability Value |
| SD | Standard deviation |

# REFERENCES


Newman GV 1965. Epoxy adhesives for orthodontic attachments: progress reports.Am J Orthod Dentofacial Orthop, 51: 901-912.

Buonocore, M. G. 1955. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces, J. Dent. Res. 34: 849-853.

Sunna S, Rock WP. 1999. An *ex vivo* investigation into the bond strength of orthodontic brackets and adhesive systems. *Br J Orthod.,* 26:47–50.

Heravi F, Bayani S. 2009. Changes in shear bond strength of ceramic and stainless steel brackets with different visible light curing times and directions. *Aust Orthod J*., 25:153–7.

Mavropoulos A, Staudt CB, Kiliaridis S, Krejci I. 2005. Light curing time reduction: *In vitro* evaluation of new intensive light-emitting diode curing units. *Eur J Orthod.,* 27:408–12.

Rajagopal R, Padmanabhan S, Gnanamani J. 2004. A comparison of shear bond strength and debonding characteristics of conventional, moisture-insensitive, and self-etching primers in vitro. *The Angle Orthodontist*., Apr;74(2):264-8.

Reynolds IR. 1975. A Review of Direct Orthodontic Bonding. *Br J Orthod*., Jul;2(3):171–8.

Neslihan A and Ayca A-Effects of Orthodontic Mechanics on Tooth Enamel. A Review.Semin Orthod 2007;13:281-291.

Duers MW, English JD, Ontiveros JC, Powers JM, Bussa HI, Frey GN, et al. Bond strength comparison of color change adhesives for orthodontic bonding.Tex Dent J.2011;128:267–75.

Ekhlassi S, English JD, Ontiveros JC, Powers JM, Bussa HI, Frey GN, et al., 2011. Bond strength comparison of color-change adhesives for orthodontic bonding using a self-etching primer. *Clin Cosmet Investig Dent.,* 3:39– 44.

Graber,Vanarsdall,Vig. Current principles and techniques-Fifth edition,Elsevier

Ormco Symbron Dental Specialties. [Last accessed on 2018 Oct 10]. Available from: https://ormco.com/ products/ grengloo/

Sharma S, Tandon P, Nagar A, Singh GP, Singh A, Chugh VK. 2014. A comparison of shear bond strength of orthodontic brackets bonded with four different orthodontic adhesives. *Journal of Orthodontic Science*. 1;3(2):29

Delavarian M, Rahimi F, Mohammadi R, Imani MM. 2019. Shear bond strength of ceramic and metal brackets bonded to enamel using color-change adhesive. *Dent Res J.,* 16:233-8.

Türkkahraman H, Adanir N, Gungor AY, Alkis H. 2010. In vitro evaluation of shear bond strengths of color change adhesives. *Eur J Orthod.,* 32:571– 4

Ogaard B: Oral microbiological changes, long-term enamel alterationscdue to decalcification, and caries prophylactic aspects, in Bratley WA, Eliades T(eds): Orthodontic Materials: Scientific and Clinical Aspects. Stutgard, Thieme, 2001, pp 127.

Al-Saleh M, El-Mowafy O. 2010. Bond strength of orthodontic brackets with new self-adhesive resin cements. *Am J Orthod Dentofacial Orthop.,* 137(4): 528-33.

Sinha PK, Nanda RS, Duncanson MG Jr, Hosier MJ. In vitro evaluation of matrix-bound fluoride-releasing orthodontic bonding adhesives. Am J Orthod Dentofacial Orthop. 1997; 111: 276-82.

Arnold RW, Combe EC, Warford JH. Bonding of stainless steel brackets to enamel with a new self-etching primer. Am J Orthod Dentofacial Orthop 2002 Sep;122(3):274-276.

Bayani S, Ghassemi A, Manafi S, Delavarian M. Shear bond strength of orthodontic color-change adhesives with different light-curing times. Dent Res J (Isfahan) 2015;12:265-70.


*******