Journal of Orofacial and Health Sciences 2024;11(3):126–132

Content available at: https://www.ipinnovative.com/open-access-journals

DJ COLLEGE OF DENTAL SCIENCES & RESEARCH

Journal of Orofacial and Health Sciences

Journal homepage: https://www.johs.in/

INNOVATIVE PUBLICATION

Original Research Article

Evaluation of shear bond strength of brackets bonded using different hydrophobic and hydrophilic adhesives: An invitro study

Megha Vilas Markand[1]*, Tushar Patil[2], Abhijit Misal[2], Avinash Mahamuni[2], Rajshree Gudadhe[2], Samkit Sakhariya[3]

[1]*Dept. of Orthodontics, M.A Rangoonwala Dental College, Pune, Maharashtra, India*
[2]*Dept. of Orthodontics, Y.C.M.M and RDF Dental College, Ahmadnagar, Maharashtra, India*
[3]*Dept. of Oral and Maxillofacial Surgery, DY Patil Dental College, Pune, Maharashtra, India*

ARTICLE INFO

Article history:
Received 26-06-2024
Accepted 26-08-2420
Available online 24-09-2024

Keywords:
TransbondXT
Aqualine LC
Greengloo

ABSTRACT

Introduction: A review of the long history of orthodontic bonding adhesives shows that many evolutional developments have occurred from the first chemically-cured composite resins to the most recently introduced light-cured color-change adhesives. An ideal orthodontic adhesive should have adequate bond strength while maintaining unblemished enamel after debonding. Therefore, researchers have been working hard to achieve the best quality and gentlest materials for bonding orthodontic brackets.
Aim and Objectives: To evaluate the shear bond strength of brackets bonded using four different adhesives in both dry and in moist environment.
Materials and Methods: A total of 80 orthodontically extracted premolars will be selected. They are divided into 4 equal groups of different adhesives which are further sub-divided into 2 group each (dry and in presence of moisture). All the selected teeth will be cleaned and store in saline until it use. All teeth will be mounted on acrylic block. The shear bond strength will be measured by Lloyd's Universal testing machine. The obtained data will be statistically evaluated using SPSS22 for Windows using ANOVA test at statistical significance.
Result: The shear bond strength of the four groups were tested with Instron universal testing machine; breaking load at which bond failure occurred was recorded and bond strength was calculated. Data obtained was compiled on MS Office Excel Sheet (2007, Microsoft Redmond Campus, Redmond. Washington, United States.)Data was subjected to statistical package for social sciences (SPSS v 21).
Statistically significant difference seen between the hydrophobic and hydrophilic adhesives. In the present study we did Tukey's post hoc test for pairwise comparison of different hydrophobic and hydrophilic adhesives. It show highly significant values.
Conclusion: The greatest bond strength values were achieved with TransbondXT in both dry and saliva contamination condition. These values were significantly greater than those achieved with Greengloo, RMGIC and Aqualine LC. The overall study conclude that TransbondXT was considered the feasible adhesive material for orthodontic bonding followed by Aqualine LC.

1. Introduction

Bonding is an important orthodontic milestone that replaced the hardest task of banding. The ability to bond orthodontic attachment has reduced patient chair side

* *Corresponding author*.
E-mail address: megha.markand1996@gmail.com (M. V. Markand).

https://doi.org/10.18231/j.johs.2024.026

time and appointment, improved the esthetics and aided in improvement of oral hygiene. Direct bonding became popular after the contributions of the pioneers such as Buonocore (1955) suggested a surface acid treatment of enamel.[1]

Newman (1965)[2] introduced direct bonding as a viable clinical technique and then orthodontic bonding developed as an excellent over banding.

A review of the long history of orthodontic bonding adhesives shows that many evolutional developments have occurred from the first chemically-cured composite resins to the most recently introduced light-cured color-change adhesives.[3]

Recently, Color-change light-cured composites were introduced to the orthodontic market to enhance differentiation of adhesive and enamel. Due to their different colors and contrasts, they can be easily detected on the tooth enamel during bonding and debonding procedures. This characteristic enhances their complete removal after bracket debonding. Furthermore, after bracket bonding, excess resin can be easily removed, which is an advantage of Color-change adhesives. Greengloo (ormco), a colour changing adhesive is also develop in the world of orthodontic adhesives, with the purpose of facilitating the discrimination between the adhesive material and enamel. CCAs are becoming popular among clinicians due to promising characteristics reported.[4]

Over the years a great deal of attention has also been paid to improve the acid-etching technique, primers and adhesives. Traditional bonding materials like Transbond XT present hydrophobic properties and require dry surfaces to obtain clinically acceptable bond strength. Thus, contamination during orthodontic bonding process is undesirable because it interferes on the adhesive and resin properties and causes failure on the adhesive interface because when etched enamel get wet, most of the pores get plugged, and resin penetration get impaired resulting in insufficient resin tags. For this reason, manufacturer introduced hydrophilic primers that promised successful bonding to contaminant enamel surface.[5]

Buonocore in 1955 demonstrated a simple method to increase adhesion of material to enamel surface by acid pre-treatment with 85% phosphoric acid.

Saliva contamination of etched enamel seems to cause a significant decrease in bond strength between the resin and the enamel surface Klocke et al 2003[6] stated that contamination during bonding procedure reduces the bond strength. So, hydrophilic resin system like Resin modified GIC (Fuji ortho) are introduced to provide adequate bond strength in presence of moisture.[7]

They are fluoride-releasing adhesives which inhibit caries lesion development during fixed orthodontic treatment. The use of these cements for direct bonding of orthodontic brackets has been proposed because of their ability to adhere to base metal alloys.[8]

Recently, new adhesive material like Aqualine L.C(Tomy japan) has been introduced for bonding metal brackets which form strong bond to etched enamel surface without priming. The ability of combining conditioning and priming into single step has reduced patient chairside time, improved the esthetics and aided in the improvement of oral hygiene.[9]

An ideal orthodontic adhesive should have adequate bond strength while maintaining unblemished enamel after debonding. Bond strength of 90orthodontic brackets to the enamel should be high enough to maintain the brackets in place during the treatment period. It must be high enough to resist occlusal loads as well. On the other hand, very high bond strength is not favorable since it increases the risk of enamel fracture and subsequent pulp injury during debonding. According to Reynolds, bond strength as high as 5.9–7.8 MPa can resist masticatory forces. It is clinically favorable and minimizes enamel fracture. Bond strength higher than 14 MPa can cause enamel cracks on the tooth surface. Therefore, researchers have been working hard to achieve the best quality and gentlest materials for bonding orthodontic brackets.

2. Aim

The aim of the invitro study is to evaluate the shear bond strength of brackets bonded using different hydrophobic and hydrophilic adhesives.

3. Materials and Methods

Bonding materials:

1. Transbond XT (3M UNITEK)
2. Resin modified GIC (FUJI ORTHO LC, JAPAN)
3. Aqualine LC (TOMY JAPAN)
4. Greengloo (ORMCO)

Brackets: Metal Brackets – Stainless steel brackets [Maxillary and mandibular first and second premolar brackets of both side] were selected.

Teeth Samples: - 80 extracted human maxillary and mandibular premolar teeth of both side were used.

3.1. Exclusion criteria

1. Absence of caries
2. Absence of cracks
3. Absence of any developmental defects or restorations.
4. Absence of Fluorosis and any anamolies.

Storage: The samples were stored in distilled water at room temperature in airtight container to prevent dehydration.

Table 1: Descriptive statistics of shear bond strength of brackets bonded using different adhesives (without saliva contamination)

(in Mpa)	Mean	SD	SE	Minimum	Maximum
Group I (Transbond XT)	8.19	0.83	0.26	6.9	9.38
Group II (Greengloo)	4.51	0.6	0.19	3.42	5.42
Group III (RMGIC)	3.0	0.4	0.12	2.38	3.71
Group IV (Aqualine LC)	6.93	0.72	0.22	5.8	8.04

Table 2: Inter group comparison of shear bond strength of brackets bonded using different adhesives (without saliva contamination)

	Mean	SD	One-way Anova F test	P value, Significance
Group I (Transbond XT)	8.19	0.83		
Group II (Greengloo)	4.51	0.6	**F = 125.78**	**p < 0.001****
Group III (RMGIC)	3.0	0.4		
Group IV (Aqualine LC)	6.93	0.72		
Tukey's post hoc test for pairwise comparison				
Group	**Comparison Group**		**Mean Difference**	**P value, Significance**
Group I (Transbond XT) Vs	Group II (Greengloo)		3.68	p<0.001**
	Group III (RMGIC)		5.18	p<0.001**
	Group IV (Aqualine LC)		1.26	p=0.001*
Group II (Greengloo) Vs	Group III (RMGIC)		1.5	p<0.001**
	Group IV (Aqualine LC)		2.42	p<0.001**
Group III (RMGIC) Vs	Group IV (Aqualine LC)		3.92	p<0.001**

p>0.05 – no significant difference*p<0.05 – significant**p<0.001 – highly significant

Table 3: Descriptive statistics of shear bond strength of brackets bonded using different adhesives (with saliva contamination)

(in Mpa)	Mean	SD	SE	Minimum	Maximum
Group I (Transbond XT)	6.78	0.53	0.17	5.82	7.6
Group II (Greengloo)	3.91	0.57	0.18	3.04	4.85
Group III (RMGIC)	2.09	0.39	0.12	1.52	2.57
Group IV (Aqualine LC)	5.48	0.65	0.2	4.61	6.42

Table 4: Inter group comparison of shear bond strength of brackets bonded using different adhesives (with saliva contamination)

	Mean	SD	One-way Anova F test	P value, Significance
Group I (Transbond XT)	6.78	0.53		
Group II (Greengloo)	3.91	0.57	F = 135.916	p < 0.001**
Group III (RMGIC)	2.09	0.39		
Group IV (Aqualine LC)	5.48	0.65		
Tukey's post hoc test for pairwise comparison				
Group	**Comparison Group**		**Mean Difference**	**P value, Significance**
Group I (Transbond XT) Vs	Group II (Greengloo)		2.86	p<0.001**
	Group III (RMGIC)		4.68	p<0.001**
	Group IV (Aqualine LC)		1.29	p<0.001**

p>0.05 – no significant difference*p<0.05 – significant**p<0.001 – highly significant

4. Results

The study was to evaluate the shear bond strength of brackets bonded with hydrophilic and hydrophobic adhesives in presence and in absence of saliva.

In this study 80 specimens were taken which were divided into four groups which were further sub-divided into 2 groups each i.e., with saliva contamination and without contamination.

The shear bond strength of the four groups were tested with Instron universal testing machine; breaking load at which bond failure occurred was recorded and bond strength was calculated.

Data obtained was compiled on MS Office Excel Sheet (2007, Microsoft Redmond Campus, Redmond. Washington, United States.)

Data was subjected to statistical package for social sciences (SPSS vs 21) For all tables:

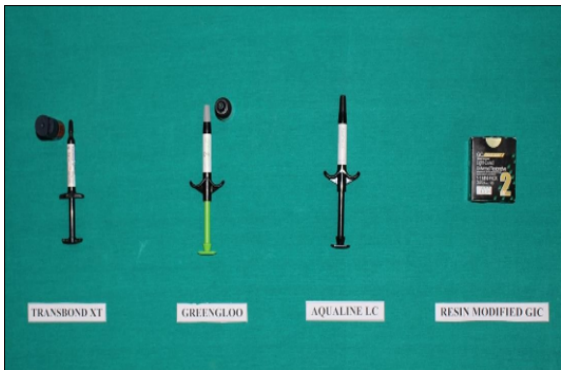

Figure 1: Bonding materials

Figure 2: Premolar brackets

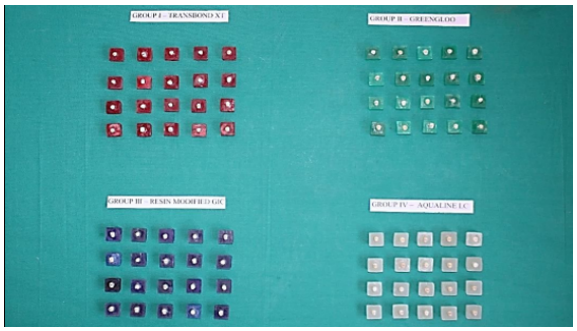

Figure 3: Teeth sample mounted in acrylic block

Figure 4: Light curing procedure

Figure 5: Curing light

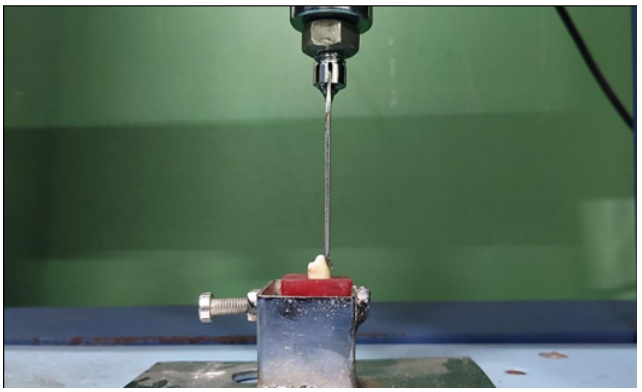

Figure 6: Shear bond strengthdone in universal testing machine.

Figure 7: Universal testing machine

Figure 8: Artificial saliva used

Table 1 Descriptive statistics of shear bond strength of brackets bonded using different adhesives (without saliva contamination).

Table 2 Intergroup comparison of shear bond strength of brackets bonded using different adhesives (without saliva contamination)

Table 3 Descrpitive statistics of shear bond strength of brackets bonded using different adhesives (with saliva contamination).

Table 4 Intergroup comparison of shear bond strength of brackets bonded using different adhesives (with saliva contamination).

Descriptive statistics of shear bond strength values (in MPa) obtained in the study without saliva contamination are shown in Table 1 and with saliva contamination are shown in Table 3.

One way ANOVA test was used to compare the differences in the bond strength among the four different groups and when significant differences were found, Tukey's post hoc

test for pairwise comparison was used to verify specific group in which such differences had occurred. They are specified in Table 2 and Table 4.

The study data was analysed using SPSS software version 21. The frequency distribution for shear bond strength is expressed in terms of means and standard deviations.

Includes the Mean, Standard Deviation, Standard error, minimum and maximum bond strength values of all the four adhesives in dry condition.

Includes the pairwise intergroup comparison of shear bond strength of brackets bonded using different adhesives in dry condition.

Includes the Mean, Standard Deviation, Standard error, minimum and maximum bond strength values of all the four adhesives in saliva contamination condition.

Includes the pairwise intergroup comparison of shear bond strength of brackets bonded using different adhesives in saliva contamination condition.

The Transbond XT (Group 1) which is a hydrophobic adhesive was used as a control group.

The mean shear bond strength value of Group I and Group IV were significantly higher than those with Group II and Group III.

In dry conditions, statistically highly significant difference was found in mean SBS among Transbond XT, Greengloo(Group II), RMGIC(Group III) given in (Table 1) However there was slight less significant difference in mean SBS of Transbond XT and Aqualine LC (Group IV) (p=0.001).In Wet conditions (saliva contamination condition) the mean SBS was found to have highly significant difference among the Transbond XT, Greengloo, RMGIC and Aqualine LC.

5. Discussion

Ever since the introduction of direct bonding of orthodontic brackets in fixed appliance mechanotherapy, enormous improvements have occurred in the range of the orthodontic direct bonding adhesives and materials available. Enamel bonding for orthodontic appliances was introduced in 1965 and is considered a significant milestone in orthodontic treatment. As reported by Owens and Miller,[10]direct bonding of orthodontic brackets to enamel was made a reality by Buonocore, Bowen, and Tavas and Watts. These researchers were instrumental in developing procedures and materials that have led to present-day standards in orthodontic adhesives. Traditionally, the use of acid etchants followed by primer has been an essential part of the bonding procedure for composite adhesives to allow good wetting and penetration of the sealants into the enamel surface. Acid-etching, self-cure composite resins, glass ionomer cements, and visible light curing adhesives have evolved from these early efforts. New technologies using novel materials are constantly evolving to improve the quality of the bond between the brackets and tooth. Initially, hydrophilic primers were used for dentin bonding in restorative dentistry. However now, hydrophilic enamel primers have also been introduced in orthodontic bonding to displace moisture from enamel surface. Manufacturer has introduced new self-etching primers, which reduce clinical bonding steps and chair time. Self-etching primers, which combine acid etchant and primer, simplify the bonding procedure avoiding the side-effects of acid-etching. Salivary control and maintenance of a dry operating field is a

prime requisite of orthodontic bonding, because the most commonly used orthodontic primers and adhesives contain hydrophobic functional monomers (bis-GMA formula). A reduction in bond strength of composite resins to etched enamel after moisture and saliva contamination has been reported by several authors. An area for clinical improvement is the tolerance to moisture contamination during bonding to reduce the incidence of bond failures.

Every orthodontist and orthodontic patient prefer best treatment in shorter duration of time but orthodontic treatment time can be greatly influenced by the frequency of debonding occurring during treatment that can lead to lack of progress in the treatment and in some cases even relapse. Therefore bond strength between the bracket and enamel has become an important issue in research. It has been suggested that bond strength values between 5.9 and 7.8 MPa are sufficient for a clinically effective orthodontic bonding. These bond strength are considered to be able to withstand various tensile loads. However, the clinical acceptable SBS for orthodontic brackets to enamel is still unknown. There is a wide variation in the bond strength values in the literature.

In the present study we did Tukey's post hoc test for pairwise comparison of different hydrophobic and hydrophilic adhesives. It show highly significant values.

5.1. Group 1 (Transbond XT)

In present study, the use of Transbond XT is probably the most selected protocol for the control group. Our finding that the control group had the highest SBS value was expected because phosphoric acid increase the bond strength.

Our result showed that Transbond XT (Group 1) produced greater shear bond strength for brackets bonded in dry condition than in saliva contamination condition .

Bond strength value when Transbond XT (Group 1) were compared with Greengloo (Group 2) and RMGIC (Group 3) show highly significant difference in dry condition. whereas bond strength of Transbond XT when compare with Aqualine L.C (Group 4) in dry condition show less significant difference but show highly significant difference when compared in saliva contamination condition. Ascension vicente et al(2006)[11] observed in his study that the Transbond XT show the best result for shear bond strength of orthodontic brackets. Bond strength of orthodontic brackets with new self – adhesive resin cements given by Mohammed AL – Saleh et al (2010)[12] observed that Transbond XT show highly significant bond strength to metallic and ceramic brackets.

5.2. Group 2 (Greengloo)

The mean shear bond strength value for Greengloo range from (3.42 – 5.42MPa) with mean value of (4.51Mpa) in dry condition and mean SBS range from (3.04-4.47 MPa) with mean value of (3.92Mpa)in presence of saliva .The bond strength of TransbondXT was found to be much more higher than Greengloo in the present study.It was also observed that Greengloo when compared with RMGIC and Aqualine L.C show significantly high difference in bond strength in both dry and in saliva contamination condition.

5.3. Group 3 (RMGIC)

In the present study when the RMGIC (Group 3) where compared with other groups they show highly significant difference in bond strength in both dry and saliva contamination condition which is also similar to the finding of Voss et al, Komori et al, Fajen et al, and Haydar et al.[13]

The SBS of ceramic brackets was found to be higher than that of stainless steel brackets; which is in accordance with the results of Uysal et al[14] and Haydar et al.

Andrew Summers et al(2004)[15] in his article compared the shear bond strength of conventional resin adhesive and resin modified glass ionomer adhesive and he concluded that SBS of Bond resin is significantly greater than RMGIC. These finding agree with those of the present study Group 4 (Aqualine LC)

The new adhesive i.e Aqualine L.C (Group IV) reduced the number of steps during bonding so that it will save the time and reduce the potential for error and contamination during bonding procedure as it is a self- priming adhesive.

Bond strength value observed in the present study range from (5.80-8.04MPa) with mean value of 6.94 MPa in dry condition and it range from (4.61- 6.42MPa) with mean value of 5.49 MPa in saliva contamination condition.

Even though Aqualine LC is hydrophilic adhesive it show significant difference in bond strength with Transbond XT(in saliva contamination condition) which is hydrophobic in nature.It can be concluded by that Aqualine LC would be expected to give somewhat similar result to those obtained with TransbondXT in Dry condition. However this does not apply to the saliva contamination condition. Among the remaning adhesives the bond strength of Greengloo would be higher than RMGIC but lesser than Aqualine LC and TransbondXT in both dry and saliva contamination condition.

6. Conclusion

In this In -Vitro Study, we found that the bond failure mode differed among the adhesives.

The greatest bond strength values were achieved with TransbondXT in both dry and saliva contamination condition. These values were significantly greater than those achieved with Greengloo , RMGIC and Aqualine LC.

The 2 adhesives (TransbondXT and Aqualine LC) had a

favorable mean values of SBS and thus orthodontic brackets can be successfully bonded with any of these adhesives.

It was also found that though Aqualine LC was hydrophilic in nature it show lower bond strength that Transbons XT which was hydrophobic in nature in saliva contamination condition.

The RMGIC was found to have the least SBS in both dry and saliva contamination condition.

The overall study conclude that TransbondXT was considered the feasible adhesive material for orthodontic bonding followed by Aqualine LC.

7. Ethical Approval

Study is approved by ethical committee of institute and MUHS committee.

8. Source of Funding

None.

9. Acknowledgement

I would like to express my sincere gratitude to my mentor and guide Dr.Tushar Patil (HOD and Professor, Department of orthodontics,YCMM & RDF Dental College and Hospital , Ahmednagar) who provided inspiration and guidance behind the idea of the study.

References

1. Rossouw PE. A Historical Overview of the Development of the Acid-Etch Bonding System in Orthodontics. *Semin Orthod*. 2010;16(1):2–23.
2. Blakey R, Mah J. Effects of surface conditioning on the shear bond strength of orthodontic brackets bonded to temporary polycarbonate crowns. *Am J Orthod Dentofac Orthop*. 2010;138(1):72–80.
3. Bayani S, Ghassemi A, Manafi S, Delavarian M. Shear bond strength of orthodontic color-change adhesives with different light-curing times. 2021;12(3):265–70.
4. Bayani S, Ghassemi A, Manafi S, Delavarian M. Shear bond strength of orthodontic color-change adhesives with different light-curing times. *Dent Res J*. 2015;12(3):265–70.
5. Behrens BA, Retamoso LB, Tanaka O, Filho OG. Blood contamination effect on shear bond strength of an orthodontic hydrophilic resin. *J App Oral Sci*. 2021;20(1):1–7.
6. Klocke A, Shi J, Nieke BK, Bismayer U. In vitro investigation of indirect bonding with a hydrophilic primer. *Angle Orthod*. 2003;73(4):445–50.
7. Rix D, Foley TF, Mamandras A. Comparison of bond strength of three adhesives: Composite resin, hybrid GIC, and glass-filled GIC. *Am J Orthod Dentofac Orthop*. 2001;119(1):36–42.
8. Toledano M, Osorio R, Osorio E, Romeo A, Higuera BDL, Godoy FG, et al. Bond strength of orthodontic brackets using different light and self-curing cements. *Angle Orthod*. 2003;73(1):56–63.
9. Sharma S, Singh G, Singh A, Tandon P, Nagar A. A comparison of shear bond strength of orthodontic brackets bonded with four different orthodontic adhesives. *J Orthod Sci*. 2014;3(2):29–33.
10. Owens SE, Miller BH. A Comparison of Shear Bond Strengths of Three Visible Light-Cured Orthodontic Adhesives. *Angle Orthod*. 2000;70(5):352–8.
11. Vicente A, Bravo LA, Romero M, Ortíz AJ, Canteras M. Effects of 3 adhesion promoters on the shear bond strength of orthodontic brackets: An in-vitro study. *Am J Orthod Dentofac Orthop*. 2006;129(3):390–5.
12. Al-Saleh M, El-Mowafy O. Bond strength of orthodontic brackets with new self-adhesive resin cements. *Am J Orthod Dentofac Orthop*. 2010;137(4):528–61.
13. Voss A, Hickel R, Mölkner S. In vivo bonding of orthodontic brackets with glass ionomer cement. *Angle Orthod* . 1993;63(2):149–53.
14. Uysal T, Ustdal A, Kurt G. Evaluation of shear bond strength of metallic and ceramic brackets bonded to enamel prepared with self-etching primer. *Eur J Orthod*. 2009;32(2):214–22.
15. Summers A, Kao E, Gilmore J, Gunel E, Ngan P. Comparison of bond strength between a conventional resin adhesive and a resin-modified glass ionomer adhesive: An in vitro and in vivo study. *Am J Orthod Dentofac Orthop*. 2004;126(2):200–6.

Author's biography

Megha Vilas Markand, Assistant Professor

Tushar Patil, HOD and Professor

Abhijit Misal, Associate Professor

Avinash Mahamuni, Associate Professor

Rajshree Gudadhe, Post Graduate Student

Samkit Sakhariya, Assistant Professor

Cite this article: Markand MV, Patil T, Misal A, Mahamuni A, Gudadhe R, Sakhariya S. Evaluation of shear bond strength of brackets bonded using different hydrophobic and hydrophilic adhesives: An invitro study. *J Orofac Health Sci* 2024;11(3):126-132.