EVALUATION OF THE SHEAR BOND STRENGTH OF THE ORTHODONTIC BRACKETS BONDED WITH ALL SURFACE PRIMER-ASSURE PLUS

Author 1 Dr. Farhan Hussain, Post Graduate Student (3rd year), Department of Orthodontics and Dentofacial Orthopedics, Kalka Dental College, Meerut
farhanhussain661@gmail.com,

Author 2 Dr. Shipra Nagar, Professor and HOD, Department of Orthodontics and Dentofacial Orthopedics, Kalka Dental College, Meerut
shipray@yahoo.com,

Author 3 Dr Ashutosh Wadhwan, Professor, Department of Orthodontics and Dentofacial Orthopedics, Kalka Dental College, Meerut
dtashutosh798@gmail.com,

Author 4 Dr Ashish Kumar, Senior lecturer, Department of Orthodontics and Dentofacial Orthopedics, Kalka Dental College, Meerut
ashish.idst@gmail.com,

Author 5 Dr. Mansi Singh, Senior lecturer, Department of Orthodontics and Dentofacial Orthopedics, Kalka Dental College, Meerut
manshi.singh1996@gmail.com,

Author 6 Dr. Kumar Gaurav, MDS, Senior Resident, Dept of Orthodontics and Dentofacial orthopaedics, Dental college, Rajendra institute of medical sciences, RIMS, Ranchi.

Eur. Chem. Bull. **2023**, *12(Special Issue 5), 4451 – 4459*

4451

Introduction:

Bonding brackets and other orthodontic attachments is one of the most critical stages of treatment. Bonding's ease of use can be deceiving. The technique can, without a doubt ,be abused, not only by inexperienced clinicians but also by more experienced orthodontist who do not perform procedures with care. Bond failure is one of the frustrating occurence in orthodontic practise. Knowing the location of bond failure allows the orthodontist to modify his technique to bond brackets and attachments.

Adhesive bonding is important for orthodontics especially in terms of the fixation of the brackets to the teeth. It involves joining of two solid substances or adherents by an intervening layer of adhesive. Biomechanical principles required a relatively inelastic interface that would transfer a load applied to the bracket, due to engagement of an activated archwire, to the tooth without exceeding its bond strength. The introduction of bonding to orthodontics added a new dimension to fixed appliance therapy.

The success of fixed orthodontic treatment is highly dependent on maintaining the connection between the braces and teeth during treatment. Bracket/tube removal can significantly increase chair time, operator time material costs, and patient discomfort. At the first bonding appointment, the orthodontist should be able to achieve good adhesion to the enamel. The acid etching bonding technique is used to attach brackets to the tooth surface. An intact and clean enamel surface after abrasion is the primary concern of dentists. In contrast to bond failures at the adhesive/enamel interface, bond failure at the bracket/adhesive interface or within the adhesive are therefore tolerated. Can other enamel conditioners, including maleic acid and acidic primers, lessen the amount of enamel breakdown and the number of bonding processes while still producing clinically useful orthodontic bracket strengths as a result?

Material and Method:

Among the patient who came to the department for orthodontic treatment, teeth were collected 80 teeth were sorted into 4 groups of 20 teeth each.

Total Etch (37% phosphoric acid) with Transbond™ XT Primer and Transbond™ XT light cure adhesive, **Group 1**(Control group).

Transbond Plus self-etching primer along with Transbond XT light cure adhesive, **Group 2**(Study group).

Total Etch (37% phosphoric acid) with Assure™ Plus all surface primer and Transbond™ XT light cure adhesive, **Group 3**(Study group).

Transbond™ Plus self-etching primer with Assure™ Plus all surface primer and Transbond™ XT light cure adhesive, **Group 4**(Study group).

Each sample was embedded in a 2cm diameter cylindrical block of dental stone(Type III),exposing only the coronal portion of the specimen ,and crowns were oriented along the long axis of the blocks.

Group 1:-The surface to be bonded was prepared with oil free pumice slurry and was rinsed and dried. **Total Etch™ (37% Phosphoric Acid)** was applied on the teeth surface for 30 seconds before being rinsed with an air water spray and dried until a chalky white appearance was observed.A layer of Transbond™ XT light cure primer was applied. Brackets were kept in the manufacturer's packaging until just prior to bonding and was always handled with bonding tweezers to avoid any contamination of the bonding base. The bracket was coated with **Transbond™XT light cure adhesive** and the bracket was pressed to the tooth surface with the end of the bracket tweezer. The samples were light cured for 30 seconds.

Group 2:- The surface to be bonded was prepared with oil free pumice slurry,rinsed and dried. Applying **Transbond™ Plus** self-etching primer on the surface**.** The bracket base was coated with **Transbond™ XT Light Cure Adhesive**, and the bracket was firmly pressed against the tooth surface with the end of the bracket tweezer. Samples were cured for 30 seconds.

Group 3:- The bonding surface was prepared with an oil free pumice slurry, rinsed and dried . **Total Etch™ (37% Phosphoric Acid)** was applied and left to etch for 30 seconds before being rinsed with an air water spray and air dried until a chalky white appearance was obtained.All prepared teeth will be treated with Assure Plus all surface primer and lightly dried with air. Coating the bracket base with Transbond XT light cure adhesive the bracket base was firmly pressed against the tooth surface with the end bracket tweezer. For 30 seconds, the samples were allowed to cure.

*Eur. Chem. Bull. **2023**, 12(Special Issue 5), 4451 – 4459*

4452

Group 4:- The bonding surface was prepared with an oil free pumice slurry and was rinsed and dried. **Transbond™ Plus** Self-etching primer was applied first, followed by **Assure™ Plus** all surface primer and air dried lightly. The bracket base was coated with **Transbond™ XT Light Cure Adhesive** and the bracket was firmly pressed against the tooth surface with the end of the bracket tweezer. All the samples were cured for 30 seconds.

Shear bond strength was measured using a universal testing machine with a load cell capacity of up to 500N of all the groups. Each specimen was loaded into the Universal Testing Machine with its long axis parallel to the applied force direction. The block was attached to the metal framework with a central circular opening for shear testing which was then secured in the lower jaw with the long axis of the tooth and the bracket base in a parallel to the direction of the shear force applied. Samples were loaded in the occlusal-gingival direction with a uniform crosshead speed of 0.5mm/min. The maximum force necessary to debond or initiate bond failure was recorded in Newton (N) on the computer that was electronically connected with the universal testing machine. The shear bond strengths in mega pascals (MPa) was computed as a ratio of force in Newton (N) to the surface area of bracket ($9.63mm^2$).

Results:
The shear bond strength values obtained from testing the samples in all four groups were recorded in MICROSOFT EXCEL; VERSION 2010. The values which were recorded in Newton were converted into MPa (Mega Pascal) (MPa $=N/mm^2$). The shear bond strength were

calculated and tabulated and the observations are contained in Table 1 & Graph 1.

These analysis were carried out by applying the One –Way Analysis Of Variance (ANOVA) and post-hoc Tukey's test at the level of <0.05. The values obtained for One –Way ANOVA test and their statistical significance are tabulated in Table 3. One way ANOVA test values revealed a statistically significant difference in shear bond strength between the four groups at the level of 0.05

The values obtained for Post-hoc Tukey's test and their statistical significance were Group 1 versus Group 4=$p<0.01$, Group 2 versus Group 4 =$p<0.01$, $p<0.01$ was showed calculating Group 3 versus Group 4

Post-hoc Tukey's test showed that Group 4 (Transbond™ Plus Self-Etching Primer with Assure™ Plus all surface primer and Transbond™ XT Light Cure Adhesive) produced statistically significant higher values at the level of <0.05, for the shear bond strength, than all other groups- Group 1, Group 2 and Group 3.

The Group 1, Group 2 and Group 3 did not show any significant difference ($p<0.05$) between them for the shear bond strength.

Group 4 has the highest bond strength.
The base of the bracket and surface of the enamel were examined two times, to evaluate the fracture site and tabulated for adhesive remnant index (ARI) scores along with the graphical representation of frequency distribution among all the four group (Graph 4 and Table 7). Table 6 displays the number of samples in each group as well as their ARI scores. The ARI scores were recorded using a scale, by Artun and Bergland:

If there is no adhesive on the tooth, the score is 0
Less than half of the adhesive on the tooth has been removed, the Score is 1
If there is more than half of the adhesive on the tooth, the Score is 2
If there is complete adhesive on the tooth and make a clear bracket impression, the Score is 3

The Chi-Square test (Graph 2) of independence was used to investigate the relationship between four different study groups and their frequency of debonding from the tooth surface.

In Group 1, 25% of the samples gave a rating of 0, 20% samples gave a rating of 1, 25% samples gave a rating of 2, 30% gave a rating of 3.

In Group 2, 20% of the samples gave a rating of 0, 25% gave a rating of 1, 30% gave a rating of 2, 25% gave a rating of 3.

In Group 3, 25% of the samples gave a rating of 0, 15% gave a rating of 1, 20% gave a rating of 2, 40% gave a rating of 3.

Eur. Chem. Bull. **2023**, *12(Special Issue 5), 4451 – 4459*

4453

In Group 4, 25% of the samples gave a rating of 0, 5% gave a rating of 1, 25% gave a rating of 2, 45% gave a rating of 3.

The ARI score of 3 (i.e all adhesive left on the tooth) of group 4 was found to be most prevalent (45%), followed by Group 3 (40%), Group 1(30%) and Group 2 (25%) presented with the least.

DISCUSSION
In Group 1, 25% of the samples had a score of 0, 20 % of the samples had a score of 1, 25% of the samples had a score of 2, 30% of the samples had a score of 3

In Group 2, 20% of the samples had a score of 0, 25% of the samples had a score of 1, 30% of the samples had a score of 2, 25% of the samples had a score of 3

In Group 3, 25% of the samples had a score of 0, 15% of the samples had a score of 1, 20% of the samples had a score of 2, 40% of the samples had a score of 3

In Group 4, 25% of the samples had a score of 0, 5% of the samples had a score of 1, 25% of the samples had a score of 2, 45% of the samples had a score of 3.

Low percentage distribution of samples for ARI scores of 3 in group 1 and group 2 indicated that the failure occurred at enamel-adhesive interface which in turn means less adhesive remains and tooth clean up is liable to be easier and faster.

Bonds are subjected to stresses that are torsion, tensile or shear or a combination of all of these, and it is difficult to precisely measure and quantify these forces.

Jou et al stated that for light cure adhesive, 70% of the failures occurred at the adhesive-bracket interface. The most probable reason could be the poor polymerization of the resin below the metal base of the bracket as the curing light cannot reach the adhesive behind the bracket mesh (Legler et al., 1989)

Most debonding procedures with clean up rarely removes up and carries a risk of persistence of resin tags in enamel after debonding. These residual resin tags might discolour with time, leading to an esthetic problem Henceforth, adhesives with adequate bond strength and less

resin penetration are more acceptable. Analysis of the mode of bond failure is helpful to characterize the adhesive bond and to determine at which interface the weak link may be found. Also the use of colour changing adhesives can help in better removal of the remnant in and around the brackets.

At the conclusion it can be assessed that if there is fluoride releasing anticariogenic property in the adhesive or primer system we may conquer over many problems like discolouration or enamel loss or spot lesions during and after the treatment duration. More research can be done to determine the effect of fluoride on tooth enamel demineralization caued by adhesives under and around brackets.

Conclusion
The shear bond strength of four different groups was compared. The 80 premolars were divided into four groups of 15 each and mounted on four different stone blocks. The teeth were bonded with stainless steel premolar brackets. Servo controlled Instron machine with cross head speed of 1mm/min was used to de - bond the brackets.

The shear bond strengths of the four adhesives were obtained. Within the limitations of this present study it can be concluded that;

- As there is more F-value (F value=17.720) compared to critical value $\phi = 4.56$
- On calculating p-value with chi-square test (value=4.67) and degree of freedom (value=79) for the ARI (adhesive remnant index) score which gives the p-value of 0.001
- Tukey's HSD test showed a p-value of 0.899 while comparing group 1 and group 2, 0.364 for group 1 vs group 3 and Tukey's HSD p-value of 0.001 for group 1 vs group 4(significant result).Tukey HSD between groups 2 and 3 has a p-value of 0.330,Tukey HSD between groups 2 and 4 has ap-value of 0.001(significant result), and Tukey HSD between groups 3 and 4 has a p-value of 0.001(significant result).
- Group 4 showed highest SBS of the four groups, followed by group 3. Both had high SBS and ARI ratings. It was concluded that Group 4 (**Transbond™ Plus Self-Etching Primer with Assure™ Plus all surface primer and Transbond™ XT Light Cure Adhesive**) can be used as a regular method instead to dual conventional system.
- Group 1(**Transbond™ XT Primer and Transbond™ XT Adhesive**) and Group 2 (**Transbond™Plus Self-Etching Primer and**

Eur. Chem. Bull. **2023**, *12(Special Issue 5), 4451 – 4459*

4454

Transbond™XT Adhesive) had almost similar SBS (Shear Bond Strength) and mild variation in ARI (Adhesive Remnant Index) scores. Even though comparatively their SBS is low (12.355 ± 4.235 MPa, 12.257 ± 3.327 MPa), the two adhesives mentioned above can also be used in a clinical setting.
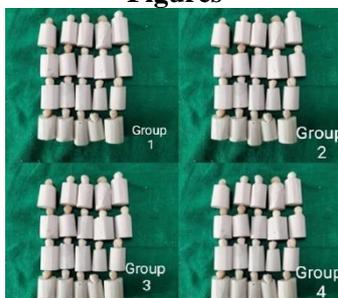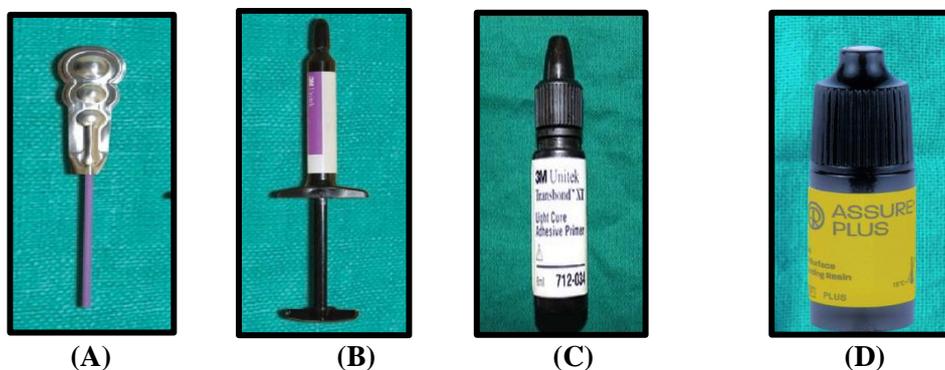
Figures

Fig-Collected sample

| **(A)** | **(B)** | **(C)** | **(D)** |

Fig:A-Transbond XT Adhesive B-Transbond plus primer C-Transbond plus self-etching D-Assure plus primer

Fig-Working on Universal Testing Machine and steremicroscope

Table-1 Shear Bond Strength (MPa) of samples in the four groups

Sample No.	Group 1	Group 2	Group 3	Group 4
1.	18.40	18.63	18.40	23.61
2.	13.93	11.54	13.93	29.45
3.	12.36	10.25	12.36	28.64
4.	10.52	14.22	10.52	24.03
5.	16.42	15.21	16.42	25.29
6.	7.50	6.52	7.50	25.75
7.	5.5	7.51	8.5	8.65
8.	23.30	20.21	23.30	21.37
9.	9.35	11.64	9.35	25.61
10.	18.51	15.37	18.51	7.82
11.	9.21	11.43	9.21	13.83

Eur. Chem. Bull. **2023**, *12(Special Issue 5), 4451 – 4459*

4455

12.	9.30	11.34	18.30	24.89
13.	9.87	10.55	19.87	26.54
14.	10.71	13.12	10.71	19.76
15.	10.25	11.34	10.25	32.10
16.	11.32	13.64	11.20	12.21
17.	10.25	11.33	20.17	23.14
18.	13.58	12.22	21.61	22.36
19.	12.22	9.22	17.54	21.22
20.	14.61	9.85	21.23	27.54

Table-2 Mean Shear Bond Strength values (MPa) and descriptive statistics

Groups	N	Mean	SD	SE	Minimum	Maximum
Group1 (Transbond™ XT Primer and Transbond™ XT Adhesive)	20	12.355	4.235	0.947	5.5	23.30
Group 2(Transbond™Plus Self-Etching Primer and Transbond™XT Adhesive)	20	12.257	3.327	0.743	6.52	20.21
Group 3(Assure™Plus all surface primer and Transbond™XT Adhesive)	20	14.944	5.091	1.122	7.5	23.31
Group 4(Transbond™ Plus Self-Etching Primer with Assure™ Plus all surface primer and Transbond™ XT Light Cure Adhesive)	20	22.190	6.706	1.620	7.82	29.45

The mean value of shear bond strength was 12.355 ± 4.235 MPa., 12.257 ± 3.327 MPa, 14.944 ± 5.091 MPa & 22.190 ± 6.706 MPa for the Group 1,2 3& 4 respectively (Graph 3).

TABLE-3 One way ANOVA test of significance between Mean of Shear Bond Strength (SBS) of all the groups

Source of Variation	Sum of Squares SS	Degrees of freedom υ	Mean Squares MS	F Statistics	p-value
Between the groups	1,309.2171	3	436.4057		
Within the groups	1,898.1977	76	24.9763		
Total	3207.4148	79		17.4728	0.0001

One way ANOVA showed a significant difference in mean values of SBS among the groups was p<0.0001

The p-value corresponding to the F-statistic of one-way ANOVA is lower than 0.05, suggesting that the one or more groups are significantly different. So, the Post hoc Tukey test would likely identify which of the pairs are significantly different from each other.

Table-4 Post hoc Tukey HSD Results

Comparative Groups	Tuckey HSD Q statistic	Tuckey HSD p-value	Tuckey HSD Inference
Group 1 vs Group 2	0.0881	0.899	Insignificant
Group 1 vs Group 3	2.3163	0.364	Insignificant
Group 1 vs Group 4	8.8009	0.001	P<0.01
Group 2 vs Group 3	2.4045	0.330	Insignificant
Group 2 vs Group 4	8.8890	0.001	P<0.01
Group 3 vs Group 4	6.4845	0.001	P<0.01

where,
k=4 groups
Degrees of freedom for the error term υ=79
Critical values of the studentized Range Q ststistic:

$Q^{\alpha=0.01, k-4,\ \upsilon=76}=4.5531$ $Q^{\alpha=0.05, k=4,\ \upsilon=76}=3.7150$

Table-5 Post hoc Tukey Kramer test of Significance between the Means of Shear Bond Strength of all the groups

Groups	Post-hoc test
Group 1 (Transbond™ XT Primer and Transbond™ XT Adhesive)	A
Group 2 (Transbond™Plus Self-Etching Primer and Transbond™XT Adhesive)	A
Group 3 (Assure™Plus all surface primer and Transbond™XT Adhesive)	B
Group 4 (Transbond™ Plus Self-Etching Primer with Assure™ Plus all surface primer and Transbond™ XT Light Cure Adhesive)	B

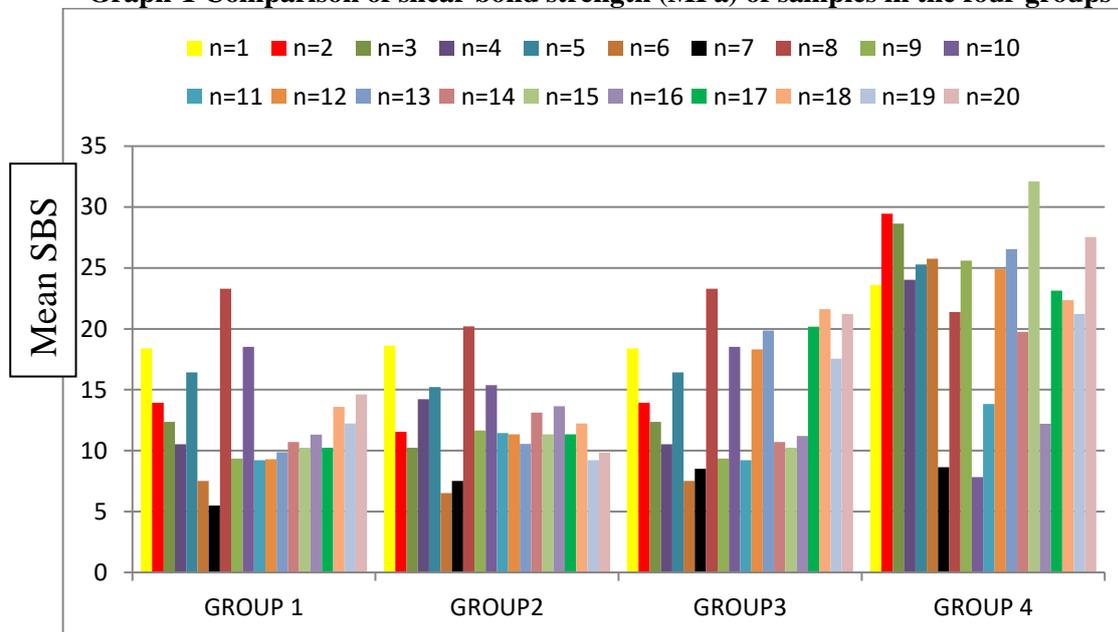The Tukey test showed that mean with the same letter were not significantly different.

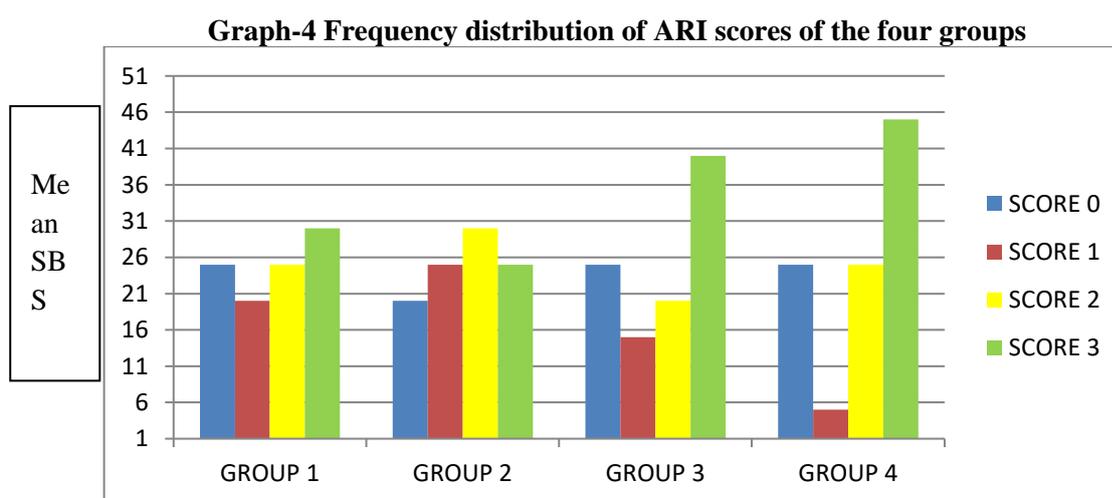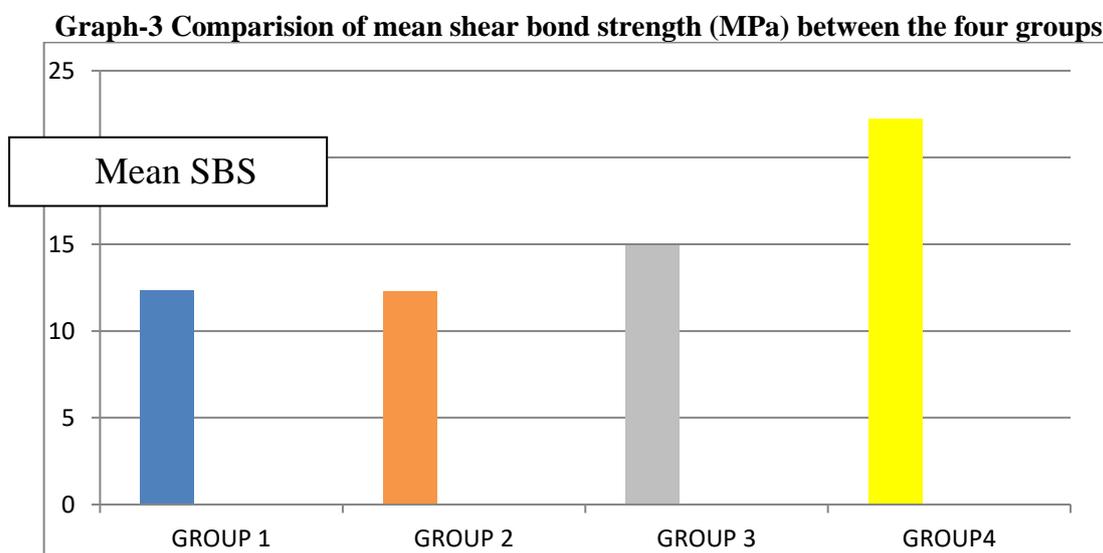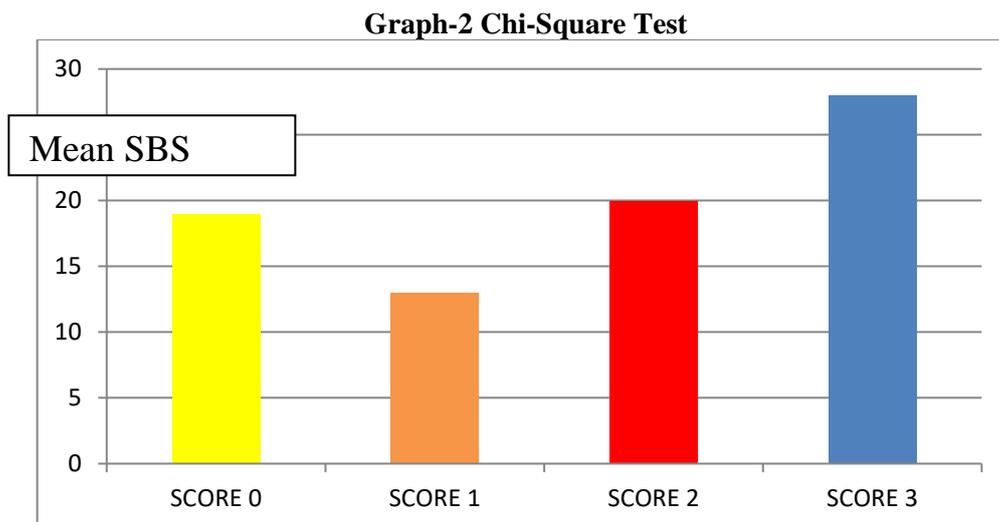**Table-6 Number of samples (N=20) and their distribution according to ARI**

ARI SCORE			
GROUPS	0	1	2	3
Group 1	5	4	5	6
Group 2	4	5	6	5
Group 3	5	3	4	8
Group 4	5	1	5	9

TABLE-7 Distribution frequency and percentages of ARI scores

Groups	0	1	2	3	N
Group 1	25%	20%	25%	30%	20
Group 2	20%	25%	30%	25%	20
Group 3	25%	15%	20%	40%	20
Group4	25%	5%	25%	45%	20

Graph-1 Comparison of shear bond strength (MPa) of samples in the four groups

Graph-2 Chi-Square Test

Graph-3 Comparision of mean shear bond strength (MPa) between the four groups

Graph-4 Frequency distribution of ARI scores of the four groups

REFERENCES

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. 34: 849-53, J Dent Res 1955.

2. Buonocore MG et al A report on a resin composition capable of bonding to human dentin surfaces. 35:846-51, J Dent Res 1956.

3. Newman GV. Epoxy adhesives for orthodontic attachments: progress report. 51:901–912, Am J Orthod. 1965.

4. Buonocore MG et al "Penetration of resin dental materials into enamel surfaces with reference to bonding." 73: 61-70, Arch Oral Biol. 1968.

5. Newman. "Concept and commentary of current status of bonding attachments." 425 -428, J.Clin.orthod. 1973; July.

6. Silverstone LM et al "variation in the pattern of acid etching of human dental enamel examined by scanning electron microscopy. 1: 373 -387, Caries Res 1974.

7. Reynolds IR. "A review of direct orthodontic bonding." 2:171-178, BrJOrthod1975.

8. Retief DH. "Clinical experience with the acid-etch technique in orthodontics." 68:645 -54, Am J Orthod 1975.

9. Zachrisson BU .Cause and prevention of injuries to the teeth and supporting structures during orthodontic treatment. 69:285-300, Am J Orthod 1976.

10. Zachrisson BJ. A post treatment evaluation of direct bonding in orthodontics. 71:173 -189, Am J Orthod 1977.

11. Artun J,and Bergland S. "clinical trials with crystal growth conditioning as an alternative to acid-etch enamel pretreatment." 85:333 - 340,Am J Orthod.1984.

*Eur. Chem. Bull. **2023**, 12(Special Issue 5), 4451 – 4459*

4459