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COMPARISON OF SHEAR BOND STRENGTH BETWEEN CONVENTIONAL ORTHODONTIC COMPOSITE, RESIN MODIFIED GIC AND NANO-CERAMIC RESTORATIVE COMPOSITE

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ABSTRACT: Context: Bowen developed Bis-GMA monomer in an attempt to improve physical properties of acrylic resins. Urge for change in properties and filler size has led to development of a new composite resin characterized by nano particles. Improvements in composite resin were accomplished by altering filler levels which helped in reducing polymerization shrinkage. In view of developments in bonding this in vitro study was aimed. **Aims:** To evaluate and compare three adhesive resins, Transbond XT†, Fuji-Ortho-LC • and Filtek Z 350 ♦ for their comparative strengths before and after subjecting these materials to a caries producing solution for 2 hours / day for a period of 30 days. **Settings and Design:** 180 sound premolars were divided into 2 broad groups of 90 teeth each, control group were exposed to artificial saliva solution for a period of 30 days, whereas, experimental group were exposed to artificial saliva and two hours of exposure to caries producing solution. These groups were subdivided into six subgroups of 30 teeth each. After a period of 30 days, shear bond strength tests were carried out using Universal Testing Machine. Bond failure was assessed by Adhesive Remnant Index and bracket base were examined under stereomicroscope using 10 X magnification. Results: Nano ceramic restorative material (Filtek Z 350 TM♦3M) had lower bond strength when compared to Conventional orthodontic composite (Transbond XTTM† 3M) and Resin Modified glass ionomer Cement (Fuji-Ortho-LC TM•). Analysis of variance (two way ANOVA) ($p < 0.05$) and Tukey's HSD Post-hoc test ($p < 0.05$) indicated significant differences between these materials. When Adhesive Remnant Index was evaluated it was seen that majority of groups showed score of 0 and 1. **Conclusions**: Subjecting teeth to demineralization solution did not alter bond strength to statistically significant values. No specimens tested showed failure site at adhesive-bracket interface.

KEYWORDS: Shear bond strength, Adhesive Remnant Index, Transbond XT† , Filtek Z 350 ♦, Fuji-Ortho-LC

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1.INTRODUCTION

Bonding of orthodontic brackets is a contemporary procedure that has come to stay. Bond strength should be sufficient to withstand forces of mastication and stresses exerted by archwires. Buonocore (1955)[1] used orthophosphoric acid to improve adhesion of acrylic resin to surface of enamel. In 1962, Bowen developed Bis-GMA monomer in an attempt to improve physical properties of acrylic resins .The procedure introduced by Bunocore (1963)[2] was adopted by Newman (1973)[3], ten years later to enhance mechanical adhesion of orthodontic brackets to the teeth. Research in Composite continues to be unceasing, making it necessary to keep one abreast continually.[4] Nano technology, also known as molecular technology or molecular engineering, is production of functional materials and structures in range of 0.1 to 100 nm .[5] Urge for change in properties and filler size has led to development of a new composite resin characterized by nano particles measuring approximately 25nm and nano aggregates of approximately 75nm, and are made up of zirconium/silica or nanosilica particles. [4] Addition of inorganic inert fillers to conventional polymethylmetacrylate resin improved mechanical properties and reduced thermal expansion. Further improvements in composite resin were accomplished by altering filler levels which helped in reducing polymerization shrinkage. Since shrinkage occurs in resin matrix, reduction of a resin can be effective in controlling shrinkage. This led to introduction of nano hybrid restorative materials using nanotechnology.[6] In view of developments in bonding this *in vitro* study was aimed to assess shear bond strength of newer restorative composites (nanofilled restorative composite; Filtek Z 350♦), Resin Modified Glass Ionomer cement (Fuji-Ortho- LC *) with conventional one used in Orthodontics (Transbond XT†). Subjecting teeth to demineralizing solution, affects substrate upon which brackets are bonded. Hence, it was felt, that this could affect the kind of bond failure. Besides materials by virtue of their properties could affect bond strength per se which led to aims and objectives of this study.

AIMS AND OBJECTIVES OF THE STUDY:

1. To compare shear bond strengths of a conventional orthodontic composite (Transbond XT†), Nano ceramic restorative composite (Filtek Z 350♦), and resin modified GIC (Fuji-Ortho-LC*) before and after subjecting teeth to demineralizing solution.
2. To ascertain the site of bond failure with aforementioned adhesive material.

2. MATERIALS AND METHODS

Freshly extracted, caries free, 180 human premolars were collected and stored in saline solution. Premolars were scaled and dried thoroughly before bonding. Bonding was carried out using a Conventional Orthodontic Composite (Transbond XT†), Nano ceramic restorative material (Filtek Z 350♦) and Resin Modified GIC (Fuji-Ortho-LC•) according to manufacturer’s instructions. Prior to acid etching and bonding, masking tape was used to cover occlusal area adjacent to brackets to isolate areas from acid etching procedure. An acid resistant varnish (Nail polish) was used to paint rest of tooth surfaces. 180 teeth were randomly assigned to 2 groups of 90 each; these groups were subdivided into 3 subgroups (Schematic diagram -1)

Group - 1 (Control group) – Artificial saliva solution group; 30 teeth in each subgroup

Subgroup (a): Conventional orthodontic composite (Transbond XT†),

Subgroup (b): Nano ceramic restorative material (Filtek Z 350 ♦)

Subgroup (c): Resin Modified Glass Ionomer Cement (Fuji-Ortho-LC•).

Group - 2 (Experimental group) – Caries producing solution group; 30 teeth in each subgroup

Subgroup (a): Transbond XT†

Subgroup (b): Filtek Z 350♦

Subgroup (c): Fuji-Ortho-LC•

Teeth in group - 1 and group - 2 were mounted on standardized acrylic block bonded with appropriate material according to Protocol – 1 described below. Teeth of Group-1 were immersed in artificial saliva and Group -2 teeth were alternately cycled in artificial saliva and cariogenic solution as per Protocol-2 described below. Teeth were subjected to evaluation of shear bond strength according to Protocol-3 described below. Bond failure was assessed by Adhesive Remnant Index (ARI) using protocol- 4 described below.

Protocol 1: Bonding Procedure (Fig – 1a- 1g) and (Fig 2-a,b, c)

(a) Bonding materials used for our study

Fig 1 a


(b) Bonding materials

Fig 1 b


(c) 3M UNITEK Orthodontic premolar brackets

Fig 1 c

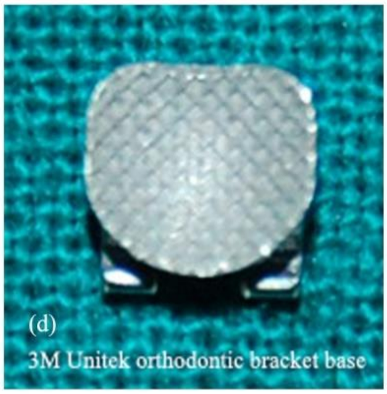

(d) 3M Unitek orthodontic bracket base

Fig 1 d

(e) Transbond XT™ light cure composite

(f) Filtek Z350 Nano filled restorative material

Fig 1 e & f

(g) Resin modified glass ionomer cement Fuji ORTHO LC™

Fig 1 g

Buccal crown surface of each tooth was rinsed and dried after a 15-second polish with fluoride-free pumice slurry. Stainless steel premolar brackets (0.022” x 0.028” slot, MBT prescription, 3M Unitek) were bonded onto teeth utilizing procedure outlined for each group. Bracket bases had an average surface area of 9.00 mm2.

Sub Group ‘a’ (1a and 2a):

Buccal enamel surface was etched with 37% phosphoric acid for 30 seconds, rinsed for 15 seconds, and dried with oil and moisture-free air until enamel had a faint white appearance. Transbond XT† primer was applied as a thin film to etched surface and light cured for 10 seconds. Transbond XT† adhesive paste was applied to bracket base and bracket was positioned on tooth and pressed firmly with an instrument to expel excess adhesive after which excess bonding resin was removed using a sharp scaler. Material was light cured as per manufacturer’s protocol that is, 20 seconds from incisal and 20 seconds from gingival end.

Sub Group ‘b’ (1b and 2b):

Buccal enamel surface was etched with 37% phosphoric acid for 30 seconds, rinsed for 15 seconds, and dried with oil and moisture-free air until enamel had a faint white appearance. Transbond XT† primer was applied as a thin film to etched surface and light cured for 10 seconds. Filtek Z 350 ♦ adhesive paste was applied to bracket base and bracket was positioned on tooth and pressed firmly with an instrument to expel excess adhesive after which excess bonding resin was removed using a sharp scaler. Then, adhesive was light cured for 40 seconds.

Subgroup ‘c’ (1c and 2c):

Buccal enamel surface was etched with 37% phosphoric acid for 30 seconds, rinsed for 15 seconds, and dried with oil and moisture-free air until enamel had a faint white appearance. Fuji-Ortho-LC• paste was applied to bracket base and bracket was positioned on tooth and pressed firmly with an instrument to expel excess adhesive after which excess bonding resin was removed using a sharp scaler. Then, adhesive was light cured for 40 seconds.

Protocol 2: Immersion in artificial saliva and cariogenic solution

(a) (b) (c)

Fig 2. a, b, c

Small hole was drilled near apex of each tooth and dental floss was fed through the hole to facilitate suspension of teeth in different solutions. Group -1 was immersed in artificial saliva solution of neutral pH 20mmol/L $NaHCo_3$, 3mmol/L NaH_2PO_4 and 1 mmol/L $CaCl_2$ at room temperature.

Teeth in Group -2 were stored in artificial saliva solution for 12hrs before subjecting them to artificial caries producing solution which consisted of 2.2mmol/L of Ca^{2+}, 2.2mmol/L of PO_4^{-}, 50mmol/L Acetic acid at pH of 4.4. Teeth in group 2 were cycled between saliva and caries solution twice daily for 30 days. After every 11 hours in artificial saliva, these teeth were removed & placed in Caries producing solution for 1 hour & after that they were put back into artificial saliva. Artificial saliva solution was changed twice weekly.

Placement of teeth from Group 1 and Group 2 in Artificial saliva
(P^H -7 ; neutral)

(d)

Placement of teeth from Group 2 in Artificial caries solution for
1hour twice daily (P^H - 4.4 ; acidic)

Total Period of exposure of teeth to solution- 30 days (e)

Fig 2 d, e

Protocol 3: Shear Bond Strength Test: (Fig 3a– 3e)

Shear bond strength were measured using Universal Testing Machine (HOUNSFIELD H5KS-0195) at a cross head speed of 1 mm/minute. A custom made rod was locally fabricated for debonding of brackets. Teeth were set at base of the machine so that sharp end of rod incised in area between base and wings of bracket, exerting a force parallel to tooth surface in an occlusal-apical direction. Force applied at failure was recorded in Kilograms and converted to Newtons (N), and stress was calculated in Mega Pascals by dividing force in N by bracket base area of 9 mm2. (1 MPa = 1 N/mm2).

Fig 3 a

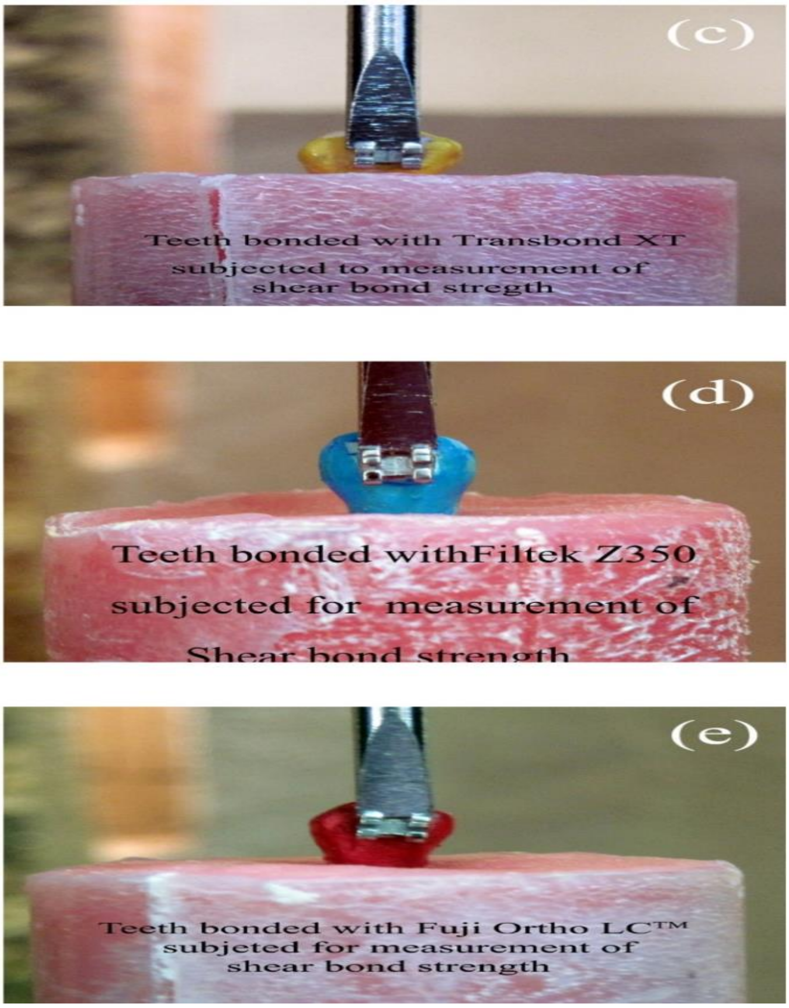


Fig 3 b **Fig 3 c, d, e**

Protocol 4: Bond Failure Assessment (Fig- 4a – 4e)

Debonded enamel surfaces were examined under stereomicroscope (Lawrence and Mayo) using 10 X magnification. Percentage of area still occupied by adhesive remaining on tooth after debonding was obtained by subtracting area of adhesive covering the bracket base from 100%. Later each tooth was assigned an Adhesive Remnant Index (ARI) value according to Artun J and Bergland S (1984)7

Score 0: No adhesive remained on the tooth;

Score 1: Less than 50% of adhesive remained on tooth;

Score 2: More than 50% of adhesive remained on tooth; and

Score 3: All adhesive remained on tooth.

ARI scores were used to assess sites of bond failure on enamel-adhesive interface and adhesive-bracket interface.

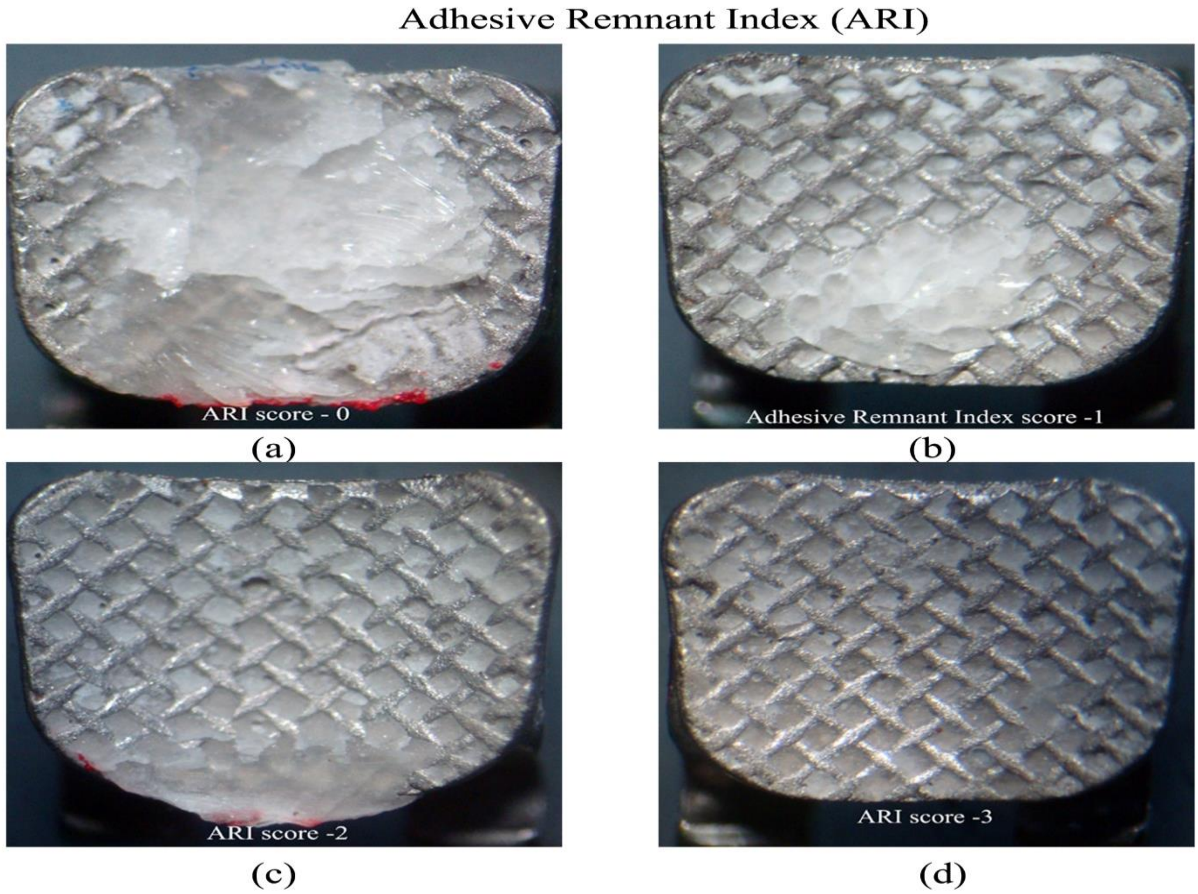


Fig 4 a, b, c, d

Descriptive statistics including mean and standard deviation values were calculated for each group of teeth tested.

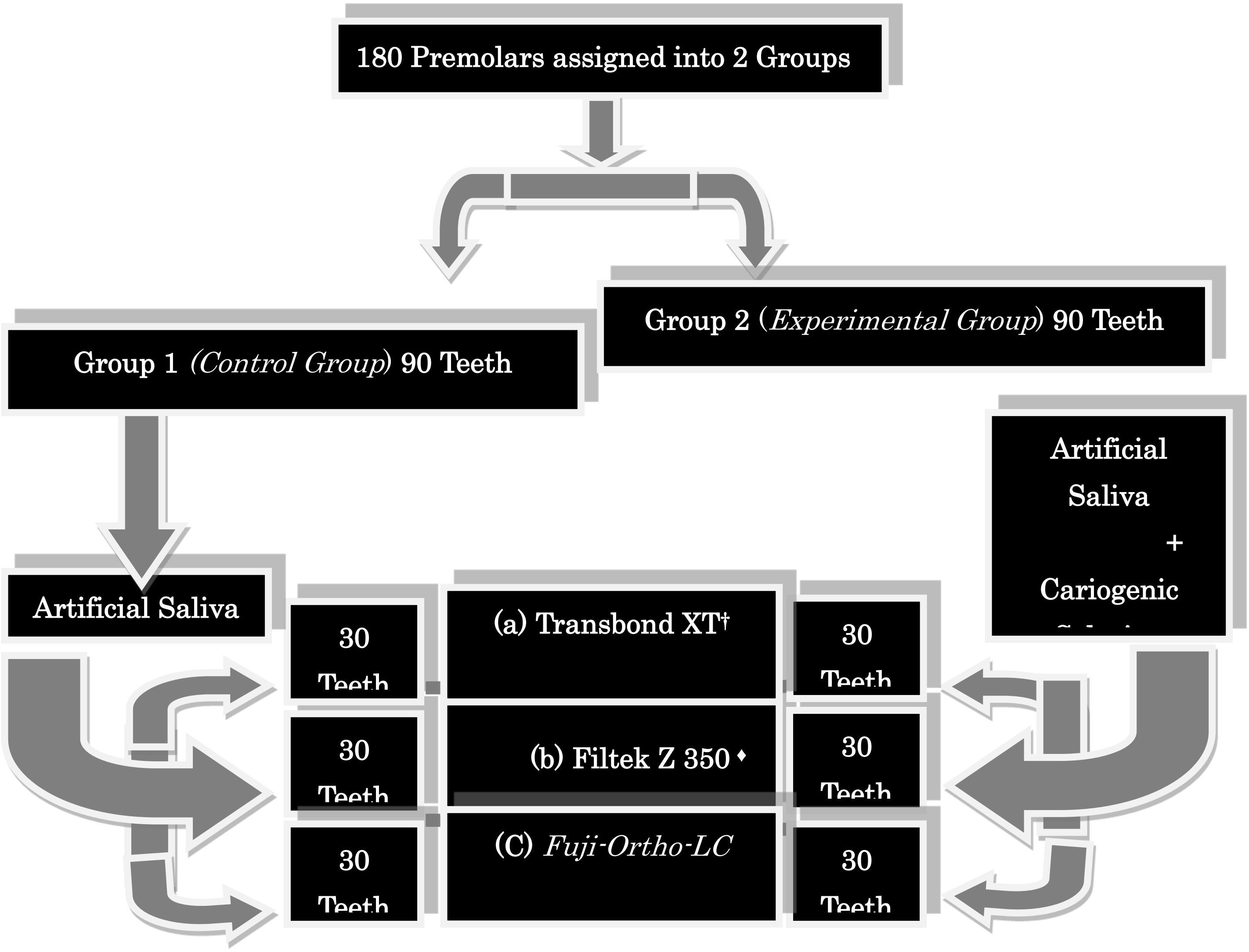
Two -Way ANOVA: was used to determine comparison between materials (Transbond XT †, Filtek Z 350 ♦, Fuji-Ortho-LC•) and groups (artificial saliva and artificial saliva + caries producing solution)

Tukey's HSD Post-hoc test: was used to determine pair wise comparison of materials (Transbond XT†, Filtek Z 350 ♦, Fuji-Ortho-LC •) and groups (artificial saliva and artificial saliva + caries producing solution). Comparison of interaction effects of groups (artificial saliva and artificial saliva + caries producing solution) and materials (Transbond XT †, Filtek Z 350 ♦, Fuji-Ortho-LC •) with respect to shear bond strength was calculated using the same test.

Chi square test: was used to determine comparison of materials (Transbond XT †, Filtek Z 350 ♦, Fuji-Ortho-LC ᵜ) & in groups (artificial saliva and artificial saliva + caries producing solution) with respect to ARI score.

Significance for all statistical tests was predetermined at p≤ 0.05.

Schematic diagram-1 Depicting distribution of sample size



3. RESULT AND DISCUSSION

When SBS of these materials, before and after subjecting the material to demineralizing solution was compared it was not statistically significant (P<0.5439) as evidenced by a Two way ANOVA (Table-1, 2). Transbond XT† had highest shear bond strength (10.8 ± 1.2; 11.26 ± 1.15) followed by Fuji-Ortho-LC ᵜ (8.69 ± 0.87; 8.64 ± 0.83) and Filtek Z 350♦ (5.73 ± 1.17; 5.60 ± 0.88). First value denotes shear bond strength before demineralization whilst second value denotes shear bond strength following demineralization. These values were statistically significant amongst the materials as evidenced by Tukeys HSD posthoc procedure (Table- 2, 3, 4) (P < 0.0000*). ARI scores for all materials were significantly different from each other (P=0.0000) (Table 5). However ARI scores before demineralization did not differ from that after demineralization. (Table 6) (Fig -4a – 4e)

Transbond XT† showed 23.33%; 16.67% of teeth showed ARI score of 2; 66.67%; 66.67% of teeth with score 1, and 10%; 16.67% of samples showing ARI score of 0. Filtek Z 350 ♦ showed 33.33%; 23.33% of teeth showing ARI score of 1 and 66.67%; 76.67% of teeth with score 0. Fuji-Ortho-LC• showed 40%; 26.67 % of teeth showing ARI score of 1 and 60 %; 73.33% of teeth with score 0.

Table1: Shear Bond Strength (MPa) of materials before and after subjecting it to demineralization solution (Mean ± SD in MPa)

Subgroup	Materials	Group 1 Mean SBS of teeth in artificial saliva	Group 2 Mean SBS of teeth after subjecting to demineralization solution
a	Transbond XT†	10.80 ± 1.20	11.26 ± 1.15
b	Filtek Z 350♦	5.73 ± 1.17	5.60 ± 0.88
c	Fuji-Ortho-LC*	8.69 ± 0.87	8.64 ± 0.83

Table 2: Comparison between materials (Transbond XT†, Filtek Z 350 ♦, Fuji-Ortho-LC •) and groups (Artificial Saliva and Artificial Saliva + Caries Producing Solution) by two-way ANOVA

SV	DF	SS	MSS	F-value	P-value
Main effects					
Groups	1	0.3920	0.3920	0.3699	0.5439
Materials	2	865.8991	432.9496	408.4946	0.0000*
2-way interactions					
Groups x materials	2	3.0813	1.5407	1.4536	0.2365
Error	174	184.4167	1.0599		
Total	179	1053.7891			

*p<0.05

Table 3: Pair wise comparison of materials (Transbond XT†, Filtek Z 350♦, Fuji-Ortho-LC*) by Tukeys HSD posthoc procedure

Materials	Transbond XT†	Filtek Z 350♦	Fuji-Ortho-LC*
Mean	11.03	5.67	8.66
Transbond XT†	-		
Filtek Z 350♦	0.0000*	-	
Fuji-Ortho-LC*	0.0000*	0.0000*	-

***p<0.05**

Table 4: Comparison of interaction effects of groups (Artificial Saliva and Artificial Saliva + Caries Producing Solution) and materials (Transbond XT†, Filtek Z 350♦, Fuji-Ortho-LC*) by Tukeys HSD posthoc procedures

Interactions	**TXT** of Group 1	**FZ350** of Group 1	**Fuji** of Group 1	**TXT** of Group 2	**FZ350** of Group 2	**Fuji** of Group 2
Mean	10.80	5.73	8.69	11.25	5.60	8.64
TXT of Group 1	-					
FZ350 of Group 1	0.0000*	-				
Fuji of Group 1	0.0000*	0.0000*	-			
TXT of Group 2	0.5114	0.0000*	0.0000*	-		
FZ350 of Group 2	0.0000*	0.9961	0.0000*	0.0000*	-	
Fuji of Group 2	0.0000*	0.0000*	1.0000	0.0000*	0.0000*	-

***p<0.05**

TXT = Transbond XT†; FZ350 = Filtek Z 350♦; Fuji = Fuji-Ortho-LC*

Table 5: Comparison of materials (Transbond XT†, Filtek Z 350♦, Fuji-Ortho-LC*) in groups (Artificial Saliva and Artificial Saliva + Caries Producing Solution) with respect to ARI score by chi-square test

Groups	**Materials**	**0**	**%**	**1**	**%**	**2**	**%**
(Group 1) ***Artificial saliva***	**Transbond XT†**	3	10.00	20	66.67	7	23.33
	Filtek Z 350♦	20	66.67	10	33.33	0	0.00
	Fuji-Ortho-LC*	18	60.00	12	40.00	0	0.00
	Total	41	45.56	42	46.67	7	7.78
	Chi-square= 31.2510 df=4 p=.00000*						
(Group 2) ***Artificial caries + caries producing solution***	**Transbond XT†**	5	16.67	20	66.67	5	16.67
	Filtek Z 350♦	23	76.67	7	23.33	0	0.00
	Fuji-Ortho-LC*	22	73.33	8	26.67	0	0.00
	Total	50	55.56	35	38.89	5	5.56
	Chi-square= 30.6343 df=4 p=.00000*						

***p<0.05**

Table 6: Comparison of each material (Transbond XT†, Filtek Z 350♦, Fuji-Ortho-LC*) with groups (Artificial Saliva and Artificial Saliva + Caries Producing Solution) with respect to ARI score by chi-square test

Subgroups	Main	0	%	1	%	2	%	Total
Transbond XT†	(Group 1) Artificial saliva	3	10.00	20	66.67	7	23.33	30
	(Group 2) Artificial saliva + Caries solution	5	16.67	20	66.67	5	16.67	30
	Total	8	13.33	40	66.67	12	20.00	60
	Chi-square=0.8332 df=2 p=.6592							
Filtek Z 350 ♦	(Group 1) Artificial saliva	20	66.67	10	33.33	0	0.00	30
	(Group 2) Artificial saliva + Caries solution	23	76.67	7	23.33	0	0.00	30
	Total	43	71.67	17	28.33	0	0.00	60
	Chi-square= 0.7392 df=1 p=.3900							
Fuji-Ortho-LC*	(Group 1) Artificial saliva	18	60.00	12	40.00	0	0.00	30
	(Group 2) Artificial saliva + Caries solution	22	73.33	8	26.67	0	0.00	30
	Total	40	66.67	20	33.33	0	0.00	60
	Chi-square= 1.2002 df=1 p=.2733							

Introduction of visible light cured material in orthodontics allowed orthodontist to place archwires immediately on bonded brackets.[4] After pumicing and polishing, enamel surface was etched for 15 seconds. Barkmeirer WW[8], Gwinnett AJ[9] and Ireland AJ[10] showed that enamel pumicing before etching has limited value when tooth surface is free from visible plaque, since neither bond strength nor enamel surface etch pattern is altered by pumicing clean enamel. Lindauer S et al[11] showed increased shear bond strength of brackets bonded to pumiced teeth than unpumiced samples. In this study, pumicing and polishing of all teeth was done so its effect on bond strength would be universal to entire sample if any.Chow LC and Brown WE[12] showed that optimum enamel conditioning occurs with phosphoric acid concentrations between 30% and 50%. Etching of enamel surface was done using 37% phosphoric acid for 30 seconds in both groups before bonding brackets. This percentage of phosphoric acid showed better etch pattern than nitric acid and increased the surface area of enamel for better bonding according to Gardener A and Hobson R.[13] According to Nordenvall KJ et al[14], Brannstrom M et al[15] and Bishara SE et al[16] an effective etching time of 30 to 60 seconds is recommended, but applications of etchant for a period of 10 to 15 seconds is effective to create good retentive conditions in enamel . Hence 30 second etching time was maintained for both groups. Wang and Meng[17] studied about curing time for Transbond XT† and recommended it to be 40 seconds. But manufacturer of *3M UNITEK* Transbond XT† recommended 20 seconds of curing time. Both nano ceramic restorative composite (Filtek Z 350♦) and resin modified GIC (Fuji-Ortho-LC *)adhesive was cured for 20 seconds, that is, 10 seconds from incisal and 10 seconds from gingival according to manufacturer's protocol for curing.

Comparison of Filtek Z 350♦, Fuji-Ortho-LC* with Transbond XT†

Shear bond strength measurement was done as proposed by D'Attilio M[18], Tecco T[19] and Ryou D[20] . Shear bond strength for Transbond XT† was highest followed by Fuji-Ortho-LC* and Filtek Z 350♦ in that order. Comparison between groups and materials done by *two way ANOVA test* and it revealed statistically significant differences amongst materials of both groups (Table 2). Tukeys HSD posthoc procedure showed significant values when materials in both groups were compared ($P < 0.05$) (Table 4). Bond strength of convention orthodontic composite Transbond XT†, was 10.80 MPa ± 1.20 and 11.26 MPa ± 1.15 for both group 1 and 2 of Transbond XT† which are in close proximity to Vicente A and Bravo LA[21] (12.27 MPa ± 11.13), Ryou.D and Park[20] (10.9 MPa ± 1.7). But were *less* than D'Attilio M[18](23.47 MPa ± 4.86) , Rix D[22](20.19 MPa ± 4.71) , Bishara S[16] (20 MPa ± 4.6) and Uysal T[23] (17.10 MPa ± 2.48); and higher than Ajlouni R[24](4.6 MPa ± 3.2) and Bezerra J[25] (4.09 MPa ± 0.56). These variations between investigators suggested that factors, such as study design, bracket base design, and enamel pre-treatment in determining shear bond strength could be responsible for differences in values. Shear bond strength value for Filtek Z 350♦ for group 1 and 2 showed 5.73 MPa ± 1.16 and 5.6 MPa ± 0.88. Values were lower than Khatri.A[26] (21.04 MPa ± 0.56), on Grandio^{TMx} by Bishara SE[16] (17 MPa ± 4.1), on Filtek Z 250^{TM*} (6.8 MPa ±1.2) and on Filtek Supreme Plus Universal$^{TM\leq}$ by Ryou DM, Park HS et al[20] and Uysal T[23]. Shear bond strength of Fuji-Ortho-LC* for group 1 and 2 showed 8.69 MPa ± 0.87 and 8.64 MPa ± 0.83 respectively. Markovic E et al [27] and Chung CH et al[28] showed values in close proximity (8.10 MPa ± 3.07) to our study. But less than Toledano M[29] (34.42 MPa ± 6.62), Vincente A[21] (22.75 MPa ± 6.64) and Rix D[22] (13.57 MPa ± 4.91) and more than Bezerra J[25] (3.88 MPa ±0.54). Shear bond strength of Fuji-Ortho-LC *(8.69 ± 0.87; Gr-1 and 8.64 ± 0.83; Gr-2) and Filtek Z 350♦ (5.73 ± 1.17; Gr-1 and 5.60 ± 0.88; Gr-2) were less in present study when compared to Transbond XT†(10.80 ± 1.20;Gr-1 and 11.26 ± 1.15; Gr-2). However, Filtek Z 350♦ adhesive attained a shear bond strength value equal to 5.9 MPa as recommended by Reynolds[30] (5.9 MPa) and Fuji-Ortho-LC*showed shear bond strength value greater than 5.9 MPa which is considered adequate for routine clinical use. Hence, concluded that Filtek Z 350♦ and Fuji-Ortho-LC*could be used to bond orthodontic brackets. Increased viscosity of Filtek Z 350♦ responsible for decreased bond strength for orthodontic bonding.

ARI and Transbond XT†

Transbond XT† in both group 1 and 2 showed an ARI score of ‘0’ in 10% and 16.67% , this indicated that only 10-16% of samples in both groups 1 and 2 had no adhesive left on tooth surfaces when Transbond XT† was used. This was statistically significant ($P < 0.05$). Ryou DM[20] (1%) , Rix D[12] (2.5%) ,Tecco T[19] and D’Attilio M [18] (5%) and Northrup RG[31] (8%) showed less percentage of samples to have an ARI score of 0. 66.67% samples from both groups of Transbond XT† showed an ARI score of 1 and 2 respectively. This indicated that there was cohesive failure in adhesive. These percentages were in accordance to Ryou D[20]. Samples in both groups did not exhibit an ARI score of 3. However, Northrup RG[31], Lee Y and Lim Y[32], shown ARI score of 3 in 90% and 40% of samples. Values indicated that debonding with Transbond XT† caused most of material to be left on tooth surface (ARI score 1,2). However, kind of failure observed was cohesive, i.e within the material. Cleanup time with Transbond XT† would be relatively increased. These differences in ARI scores with Ryou D[20], Northrup RG[31], Lee Y and Lim Y[32] suggest influence of other variables such as study design, bracket base and enamel pre-treatment in determining type of bond failures.

ARI for Filtek Z 350♦

Brackets bonded with Filtek Z 350♦ showed 66.67% and 76.67% of samples with ARI score of ‘0’ in group 1 and 2. 33.33% and 23.33% of samples from both groups showed ARI scores of ‘1’ respectively. This indicated that bond strength at enamel adhesive interface is less than at bracket adhesive interface. These percentages were more when compared with bracket adhesive interface. No studies were available to compare our study utilizing Filtek Z 350♦ to best of our knowledge. When compared with Ryou D and Park H et al[20] on Filtek Z 250*, Filtek Z 350♦ showed marginally more adhesive material on tooth than Filtek Z 250*. (ARI for Filtek Z 250* according to Ryou D and Park H et al [20] showed score of ‘0’ in 90% and ‘1’ in 10% of samples; while Filtek Z 350♦ in our study showed 66.67% and 76.67% with score ‘0’ and 33.33% and 23.33% with score ‘1’ (for group 1 and 2 respectively). None of the samples bonded with Filtek Z 350♦ have ARI score of 2 and 3, this signifies a cohesive fracture of adhesive. Poor bond strength at enamel adhesive interface attributed to poor penetration of resin into enamel and failure in formation of resin tags of adhesive into enamel due to decreased flow or increased viscosity of adhesive. However, cleanup procedure following debonding would be easier with this material.

**ARI for Fuji-Ortho-LC*

60% and 73.33% of samples from group 1 and 2 bonded with Fuji-Ortho-LC* showed ARI score of ‘0’. 40% and 26.67% of samples from both groups showed ARI scores of 2 respectively. These values indicated that bond strength at enamel adhesive interface is less than that at bracket adhesive interface and more when compared with Rix D and Foley T etal[22] (Score ‘0’- 30%; Score ‘1’-15%; Score ‘2’- 12.5% samples). None of the samples bonded with Fuji-Ortho-LC* have ARI score of 2 and 3, which signifies less cohesive fracture of adhesive occurred. Decreased bond strength at enamel adhesive interface attributed to improper penetration of resin into enamel and thus lacking ability to form resin tags of adhesive into enamel. However, Fuji-Ortho-LC* would leave less material on enamel surface which would need less cleanup time spent.

4. CONCLUSION

Shear bond strength of all three materials were 10.80 MPa ± 1.20; (Gr1) and 11.26 MPa ± 1.15; (Gr2) for Transbond XT†, 8.69 MPa ± 0.87; (Gr1) and 8.64 MPa ± 0.83; (Gr2) for Fuji-Ortho-LC* and 5.73 MPa ± 1.17; (Gr1) and 5.60 MPa ± 0.88; (Gr2) for Filtek Z 350♦ in decreasing order. Although Filtek Z 350♦ had least bond strength which was within acceptable limits for orthodontic bonding (Reynolds[30] -5.9 MPa). There was no difference in bond strength before and after subjecting sample to a 30 day, 1hour twice daily in demineralizing solution. Transbond XT† ,Fuji-Ortho-LC* and Filtek Z 350♦ showed cohesive fracture of adhesive in 10.0%;16.67%, 66.67%; 76.67% and 60.0%;73.33% of specimens respectively. No specimens tested showed failure site at adhesive-bracket interface. Orthodontic composite resin (Transbond XT†) displayed greater shear bond strength values than Resin modified GIC (Fuji-Ortho-LC*) and nanoceramic restorative composite (Filtek Z 350♦), in that order; shear bond strength of both composites and resin based cement were clinically acceptable if evaluated against Reynolds[30] standards for optimum bond strength. However, clinical conditions will differ from an in-vitro setting. Besides, heat and humidity in oral cavity is highly variable. Owing to probable differences in in-vivo and in-vitro conditions, further clinical research (in vivo) is recommended.

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