COMPARISON OF SHEAR BOND STRENGTH OF ORTHODONTIC BRACKETS BONDED ON NANOCERAMIC RESTORATIVE COMPOSITE RESIN TREATED WITH DIFFERENT SURFACE TREATMENTS : AN IN-VITRO STUDY

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Introduction :

The demand for orthodontic treatment has been gradually increasing among the adult population.[1] In adults and adolescents, composite resin restorations are often present on the labial surfaces of anterior teeth and occasionally on the buccal surfaces of posterior teeth.[2,3]

Nanofilled composite resin has nano particles as filler that are both single (nanomer) and cluster (a group of nano particles called a nanocluster). The size of nano particles varies from 5–75nm.[4] These composites have good physical properties and improved esthetics. The small primary particle size also makes nanofills highly polishable. Because of these qualities, nanofill and nanohybrid composites are the most popular composite restorative materials in use.[5]

The difficulty of bonding orthodontic brackets to resin composite restorations or resin laminate veneers poses a challenge to clinicians. The chemical bonding of a composite resin to another composite resin surface is mediated through the reactive methacrylate groups. These reactive methacrylate groups are found in the oxygen-inhibited layer of unpolymerized resin on the surface of the composite, and is what allows for the incremental placement and build up of a composite resin restoration.[3,4,5]

Different methods of bonding to composites include chemical, mechanical and chemicomechanical methods. Chemical methods include etching with orthophosphoric acid, hydrofluoric acid, application of a silane primer (porcelain primer), dentine bonding agent or plastic conditioner. Mechanical method includes surface roughening by use of diamond burs, air abrasion and tungsten carbide burs. Chemicomechanical methods include roughening by diamond bur followed by application of hydrofluoric acid.[3,6,7]

A failure at the interface between two materials, such as the adhesive resin cement—restorative resin composite or the adhesive resin cement–bracket base, was described as an adhesive failure (breakage within the adhesive resin cement). By using the Modified Adhesive Remnant Index score, the association between bond failure and adhesive remaining on the bracket surface is evaluated. More adhesive is left adhering to bracket, less the damage to the composite surface. Hence it is desirable that the adhesive remains on the bracket while debonding. Therefore, score 1 is considered as ideal score.[8,9]

There have been previous studies on shear bond strength of orthodontic brackets bonded on nanofill and nanohybrid composite resins[7,10,11] , but there is sparse knowledge about bonding orthodontic brackets to nanoceramic restorative composite resin in the orthodontic literature.

The purpose of this in-vitro study was to compare the shear bond strength of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments.

Materials and Methods:

Nanoceramic composite resin discs were prepared by conventional condensation methods using a teflon mould (each circle of 10mm diameter and 2mm thickness) and nanoceramic composite syringe (Prevest Denpro Magma NT™). To create a smooth flat surface, the composite was compressed with a glass slab and excess material was extruded. The composite was light polymerized with a light-emitting diode device through the glass slab at a 90 degree angle to the top of the surface .The composite discs were then embedded into self cure acrylic blocks. Using polishing brush and composite polishing paste, the composite disc surface was cleaned.(Fig 1 and 2).

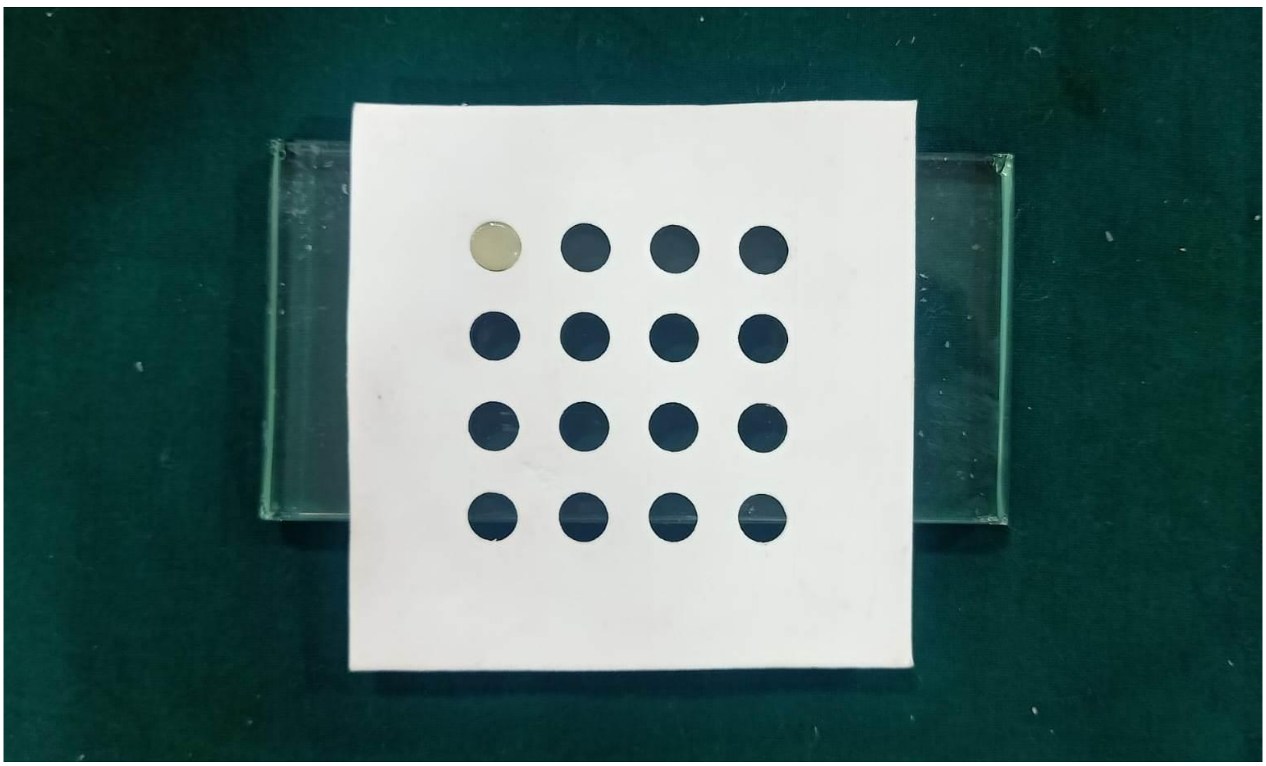

Fig 1 Mould for Composite disc

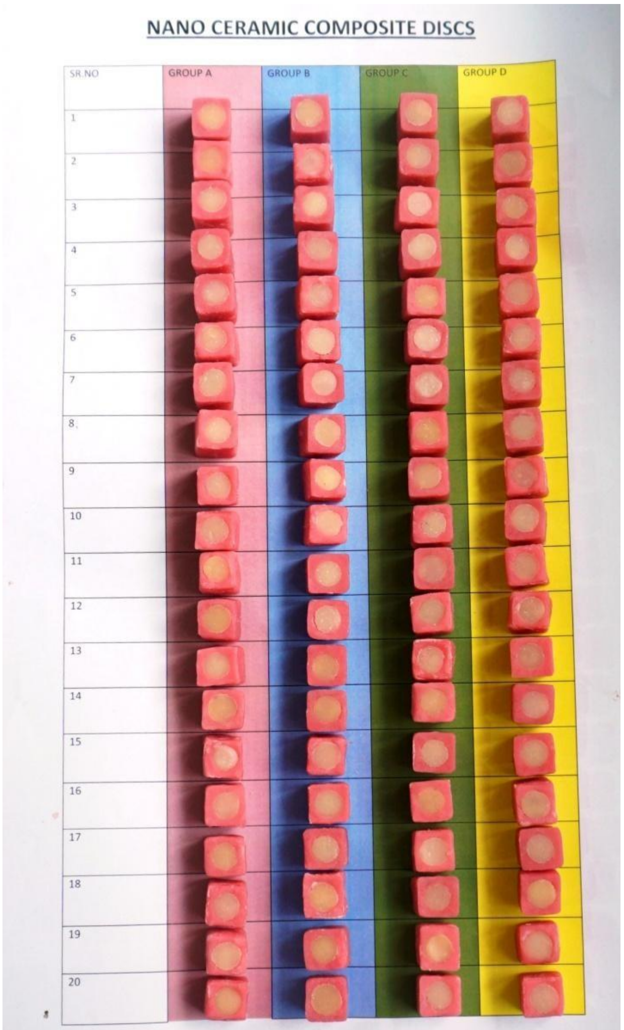

Fig 2 Nanoceramic composite discs in acrylic blocks

80 samples of such composite discs were prepared which were divided into four groups of surface treatments with 20 samples each. The light-cured orthodontic adhesive used in the present investigation for bonding the brackets to the composite discs was Transbond™ XT (3M Unitek, Monrovia, California, USA). Upper right stainless steel central incisor brackets were used for bonding to the composite surfaces. According to the manufacturer, the mean area of each bracket base was 10.88 mm^2.

Groups according to the procedure were:

GROUP A: Metallic brackets were bonded on nanoceramic composite discs with no surface treatment.

GROUP B : Metallic brackets were bonded on nanoceramic composite discs treated with hydrofluoric acid.

GROUP C : Metallic brackets were bonded on nanoceramic composite discs treated with diamond bur.
GROUP D: Metallic brackets were bonded on nanoceramic composite discs treated with diamond bur followed by application of hydrofluoric acid.

All samples were bonded, and shear bond strength was tested after being stored in distilled water for 24 hours at 37 degrees celsius. The brackets were debonded using a universal testing device in an occluso-gingival direction at a crosshead speed of 1 mm/minute[2] (Fig 3).All composite discs and brackets in the test groups were inspected after debonding using a stereomicroscope and a 10x magnification. According to the Modified Adhesive Remnant Index, any adhesive left over after debonding was evaluated and given a score.[8](Fig 4)

Fig 3 Shear bond strength testing

Modified Adhesive Remnant Index was calculated by viewing brackets under stereomicroscope for every group. Scoring criteria for Modified Adhesive Remnant Index[8] :

Score 1: 90–100% of adhesive remnants left on bracket base
Score 2: 10–90% of adhesive remnants left on bracket base
Score 3: 0–10% of adhesive remnants left on bracket base
Score 4: All composite remnants left on composite surface

Fig 4 Bracket surface viewed for Modified Adhesive Remnant Index

Results:

Table 1 depicts the shear bond strength of all samples.

Table 1: Master Table- Shear Bond Strength for all samples

	GROUP – A (MPa)	GROUP – B (MPa)	GROUP – C (MPa)	GROUP – D (MPa)
SHEAR BOND STRENGTH	6.02	9.66	14.02	9.87
	2.77	7.21	10.61	10.28
	3.32	4.99	11.12	9.65
	3.64	8.76	10.04	10.34
	2.67	9.07	12.43	11.76
	2.66	9.19	11.79	10.76
	2.08	8.66	12.37	9.45
	3.11	8.47	13.79	10.77
	2.78	9.09	9.36	10.68
	3.37	10.11	10.03	11.56
	3.25	7.89	10.76	9.36
	5.77	10.66	11.56	9.72
	2.32	10.34	10.88	10.04
	2.18	9.98	13.65	9.08
	3.14	9.11	12.97	11.78
	3.77	10.09	13.76	10.87
	3.19	7.17	14.88	10.66
	4.07	8.79	14.43	11.02
	2.54	9.73	10.87	9.88
	2.77	9.64	14.96	9.43
AVERAGE	3.27	8.93	12.21	10.34

On overall comparison of shear bond strength of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments, highly statistical significant ($p<0.001$) difference was observed among four study groups as depicted in Table 2.

Group C > Group D > Group B > Group A

Table 2: Overall comparison of shear bond strength of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments respectively

	Mean	**SD**	**One wayAnova F test**	**P value**
Group A (No surface treatment)	3.27	1.03	F = 181.289	p < 0.001**
Group B (Hydrofluoric acid)	8.93	1.33		
Group C (Diamond Bur)	12.21	1.74		
Group D (Diamond Bur +HF Acid)	10.34	0.80		

p>0.05 – no statistical significant difference

Table 4 report the pairwise comparative statistics of shear bond strength. On pairwise comparative statistics of shear bond strength using Tukeys post hoc test, it was observed that Group A had lower shear bond strength as compared to Group B, Group C and Group D and the difference was also found to be of highly statistical significance ($p<0.001$). Group C had higher shear bond strength as compared to Group D and the difference was also found to be of highly statistical significance ($p<0.001$).

Table 3: Pairwise comparative statistics of shear bond strength of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments respectively using Tukeys post hoc test

Group	Comparison Group	Mean Difference	P value, Significance
Group A (No surface treatment) vs	Group B (Hydrofluoric acid)	5.65	p< 0.001**
	Group C (Diamond Bur)	8.94	p< 0.001**
	Group D (Diamond Bur +HF Acid)	7.07	p< 0.001**
Group B (Hydrofluoric acid) vs	Group C (Diamond Bur)	3.28	p< 0.001**
	Group D (Diamond Bur +HF Acid)	1.41	P=0.004*
Group C (Diamond Bur) vs	Group D (Diamond Bur +HF Acid)	1.86	p< 0.001**

Table 4 depicts the values obtained by Modified ARI index. Modified ARI Score 1 was highest in Group C followed by Group B, Group D and least in Group A. Modified ARI score 2 was highest in Group D followed by Group B, Group C and least in Group A. Modified ARI Score 3 was highest in Group A followed by Group B and least in Group C and D. Modified ARI score 4 was highest in Group A while nil in Group B, C and D.

Table 4: Modified ARI result

Sr.No.	GROUP A	GROUP B	GROUP C	GROUP D
1.	3	2	1	2
2.	3	2	1	2
3.	4	2	1	3
4.	3	1	2	2
5.	4	3	2	2
6.	4	1	3	2
7.	3	2	2	2
8.	3	2	2	1
9.	3	1	1	2
10.	3	2	1	3
11.	3	2	2	2
12.	3	2	2	2
13.	2	3	2	2
14.	3	2	1	1
15.	2	2	2	2
16.	2	2	1	2
17.	3	3	1	2
18.	3	1	3	1
19.	2	2	1	2
20.	2	2	2	2

Table 5 shows the comparison of Modified ARI score. On comparison of Modified ARI score of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments using Chi square test, highly statistical significant difference ($p<0.001$) exist among four study groups.

Table 5: Comparison of modified ARI score of orthodontic brackets bonded on nanoceramic restorative composite resin treated with different surface treatments respectively using Chi square test

	Score 1 n (%)	**Score 2 n (%)**	**Score 3 n (%)**	**Score 4 n (%)**
Group A (No surface treatment)	0 (0%)	5 (25%)	12 (60 %)	3 (15 %)
Group B (Hydrofluoric acid)	4 (20 %)	13 (65 %)	3 (15 %)	0 (0%)
Group C (Diamond Bur)	9 (45 %)	9 (45 %)	2 (10%)	0 (0 %)
Group D (Diamond Bur +HF Acid)	3 (15 %)	15(75 %)	2 (10 %)	0 (0%)
	Chi square test value = 28.95, p<0.001** (highly statistical significant difference)			

Discussion:

Due to the increasing number of dental restorations using materials like composite resin, amalgam, and porcelain among patients, bonding orthodontic attachments to these materials can be challenging for orthodontists.[2]

A new universal restorative substance called nanofill composite resin has recently been introduced. The organically modified, ceramic-based, nanoceramic composite was created by combining nanotechnology and ormocer technology. This composite consists of a methacrylate-modified silicon dioxide-containing nanofiller and a matrix of extensively distributed methacrylate-modified polysiloxane particles in place of the original resin matrix.[5] Resin composites based on nanotechnology have certain advantages, such as reduced polymerization shrinkage, increased mechanical properties, better gloss retention and diminished wear.[6] Different types of composites react differently to the same conditioning method. Therefore in this study, nanoceramic composite discs were used. Since the composite discs had a flat surface, hence upper right stainless steel central incisor brackets (MBT 0.022” Gemini 3M Unitek, USA) were used for bonding to the composite surfaces.[10]

In the control group with no surface treatment on testing the shear bond strength, least bond strength was observed (Table 2). It was similar to previous study by Bayram et al (2011).[2] Around 60% samples had a Modified ARI score 3 (Table 5). Score 3 is considered as low score indicating loss of composite disc surface while cleaning and polishing it after debonding.

Metallic brackets were attached to nanoceramic composite discs in Group B after they had been treated for 60 seconds to 9.6% hydrofluoric acid. The procedure for preparing a ceramic surface for bracket placement involves etching it for 1 minute with 9.6% hydrofluoric acid, followed by a water rinse.[12] Since ceramic can be irreparably damaged by strong etchants like hydrofluoric acid, the repair or prosthesis' integrity may be at danger during the debonding process due to the high bond strength of the bracket to the ceramic.[3,13] On testing shear bond strength , Group B had higher shear bond strength compared to group A. Score 2 was observed in 65% samples of Group B .Score 2 is considered as good score indicating reduced loss of composite disc surface while cleaning and polishing it after debonding.

In the group where metallic brackets were bonded on nanoceramic composite discs treated with diamond bur had higher shear bond strength as compared to other groups(Table 4)[2]. Diamond bur has been tested as a conditioning technique by mechanically roughening the surface and increasing the surface area. The application of a diamond bur creates macro- and microretentive areas. These applications remove the resin and expose the filler particles, thus damaging the surface characteristics of the restoration. Thus, an increase in SBS values was expected from the particle abrasion and diamond bur groups.[14,15]. On comparison of Modified ARI scores among four groups, score 1 and score 2 was observed in 45% samples each of Group C . Score 1 is regarded as an excellent score since it shows that there has been little to no surface degradation after cleaning and polishing a composite disc after debonding.[8,10]

In the group where metallic brackets bonded on nanoceramic composite discs treated with diamond bur followed by application of 9.6% hydrofluoric acid,it higher shear bond strength as compared to Group A and B and lower shear bond strength as compared to group C(Table 2). Previous studies suggested that diamond bur roughening in combination with other surface modification methods may yield better bond strength, although they can cause a reduction in the strength of the restoration.[16,17] On comparison of Modified ARI scores among four groups, score

1 was observed in 15% samples of Group D (Table 5). Score 2 was observed in 75% samples of Group D.

Surface treatment techniques are another crucial factor influencing the bond strength values. Methods that increase mechanical interlocking are perhaps the most significant factor contributing to bond strength.[18] Therefore in the present study, shear bond strength was increased in groups treated with diamond bur and a combination of diamond bur and hydrofluoric acid as compared to groups with no surface treatment and treatment with only hydrofluoric acid. Nanoceramic composite resin contains glass filler particles that are more amenable to hydrofluoric acid etching. [3,8,10] Therefore in the present study, bracket bonded to surface treated with hydrofluoric acid showed sufficient bond strength.

Since Group C showed highest bond strength and good Modified ARI index score as compared to other groups, it can be concluded that it may be most acceptable surface treatment method for bonding brackets on nanoceramic composite.

Limitations of the present study:

It must be stressed that as this was an in vitro research, the test parameters were not exposed to the challenges of the oral environment. In this study, the emphasis of the experiment was on surface preparation only; however, there are many other factors that potentially influence the bond strength of orthodontic attachments to composite resin surfaces such as the type of composite resin, the film thickness of adhesive resin, moisture, contamination, the dimension and geometry of the bracket base, storage conditions, aging of the composite and method of testing.

Conclusion:

On overall comparison , highly statistical significant ($p<0.001$) difference was observed among four study groups. Metallic brackets bonded on nanoceramic composite discs treated with diamond bur had the highest shear bond strength. Since it showed highest bond strength and good Modified ARI index score as compared to other groups, it can be concluded that it may be most acceptable surface treatment method for bonding brackets on nanoceramic composite.

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