

Evaluation of Effect of Different Surface Treatments on Graphene Incorporated Polymethyl Methacrylate Crowns Cemented with Resin Cement: An *In Vitro* Study

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Abstract

Background: The present study was conducted to evaluate the effect of different surface treatments on Graphene incorporated polymethyl methacrylate crowns cemented with resin cement. **Materials and Methods:** Thirty healthy extracted teeth were mounted in resin and prepared to receive the crowns. The prepared teeth were divided into three groups of 10 each: Group A: Sandblasting, Group B: Acid etching, and Group C: Control group. These crowns were fabricated with an added occlusal bar, a crucial element that facilitated the removal of cemented crowns. The above-mentioned surface treatments were carried out, and the crowns were cemented with a resin cement. The crowns were then subjected to removal in the axial direction using a universal testing machine, and the dislodgment forces were calculated. **Results:** One-way Analysis of Variance test was used for comparison of the dislodgment forces between the three groups. Within the limitations of the study, sandblasting treatment increased the bond strength compared to acid etching and the control group. The mean difference was statistically significant at $P > 0.05$.

Keywords: Acid etching, G-CAM, Polymethyl methacrylate, Sandblasting, Surface treatments.

INTRODUCTION

Teeth have been considered an integral part of beauty. Missing teeth not only cause the functional and structural problem but it also influences a person's psychology and social interactions. Since historic times, different materials were used to make artificial teeth such as wood, bone, ivory, vulcanite, wax, metal, acrylic resin, ceramic, and zirconia.

Polymethyl methacrylate (PMMA), also known as acrylic or plexiglass, is a transparent thermoplastic with exceptional optical clarity, high-impact resistance, and excellent weatherability. Certain drawbacks such as low flexural strength, residual monomer allergy, porosity, polymerization shrinkage, poor conduction of heat, poor adhesion to metal and high co-efficient of thermal expansion, and low impact strength. This leads to creation of newer or chemically modified materials which could avoid the drawbacks in the most possible manner.^[1]

Graphene is a 2D single layer of sp^2 hybridized carbon atoms with hexagonal packed configuration. It is a suitable material to enhance the performance of autopolymerizing acrylic resins for dental use. As graphene is one of the allotropic form of carbon, it is available in abundance in nature. It is currently

one of the most explored nanomaterials due to its excellent mechanical, optical, properties, and its ability to enhance the properties when incorporated to other materials.

The Graphene nano-reinforced biopolymer G-CAM disc, which was created specifically for permanent dental structures, is available in a variety of chromatic crowns with an incredibly natural-looking esthetic appearance and addresses most of the mechanical, physicochemical, and biological shortcomings of the other materials presently being used in the industry. Its ability to be enhanced with pink composite makes it a particularly good option for implant solutions. With the use of specialized tools, it may be machined extremely thin and any modifications are simple.^[1] Since there was limited literature and studies conducted on this material due to its recent development, the present study was conducted to

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evaluate the bond strength of graphene-incorporated PMMA (G-CAM) crowns treated with two different surface treatments (sandblasting and acid etching) when bonded with resin cement.

MATERIALS AND METHODS

The present study is original research conducted in the department of prosthodontics, crown and bridge, and implantology at Sri Balaji Dental College and Hospital, Yenkepally, Hyderabad, Telangana, with technical assistance from Virtue-Meta Sol, material solutions - ISO 9001:2015 certified in Hyderabad. This study was undertaken to evaluate the effect of different surface treatments for G-CAM crowns bonded with resin cement.

In the present study, 30 healthy extracted teeth which are non-carious, unrestored, and extracted for reasons other than infection were selected. The extracted teeth are cleaned and stored in distilled water then prepared using CAD-CAM technology to receive the crowns. Individual impressions were made for each sample, using putty and light body elastomeric impression material, followed by scanning by the intraoral scanner, and then, crowns were designed using CAD (Hyperdent) software. The crowns were divided into three groups of 10 samples each. Graphene crowns were treated with different surface treatments such as sandblasting with 110 μ m alumina particles and acid etching with 37% phosphoric acid and the other group as the control group which is not pre-treated before cementation. The designed crowns were cemented to the respective extracted teeth with cement (3M Relyx U200) and initially seated with firm finger pressure. Excess cement was cleaned from the margins. After the cementation, past the setting time, the samples were subjected to dislodgment forces using a universal testing machine, and dislodgment forces were calculated.

RESULTS

The following results were obtained and tabulated in Table 1 for Group A, Table 2 for Group B, and Table 3 for Group C. The comparison of the means and standard deviation between the three groups is tabulated in Table 4.

The same data were represented on Bar Graphs 1, 2, and 3 for Group A, B, and C, respectively, for the ease of visual comparison.

The mean comparison of bond strength among the three groups is represented graphically in Graph 4.

The above-mentioned data were subjected to statistical evaluation for the comparison of bond strength between the three groups using one-way analysis of variance test.

DISCUSSION

Air abrasion, also known as sandblasting, was created in 1945 with the intention of reducing pain and discomfort during

Table 1: Dislodgment force in N for Group A sandblasting

S. No.	Dislodgment force (N)
1.	43.05 N
2.	53.35 N
3.	72.47 N
4.	81.46 N
5.	67.32 N
6.	90.56 N
7.	66.92 N
8.	76.93 N
9.	110.23 N
10.	56.23 N

Table 2: Dislodgment force in N for Group B acid etching

S. No.	Dislodgment force (N)
1.	31.71 N
2.	35.58 N
3.	41.36 N
4.	36.68 N
5.	45.06 N
6.	54.23 N
7.	36.81 N
8.	41.23 N
9.	38.96 N
10.	40.25 N

Table 3: Dislodgment force in N for Group C control group.

S. No.	Dislodgment force (N)
1.	13.13 N
2.	14.91 N
3.	23.69 N
4.	25.52 N
5.	30.23 N
6.	17.95 N
7.	18.32 N
8.	22.38 N
9.	26.95 N
10.	25.63 N

carries excavation. However, it was hardly used in dental clinical practice because it could not produce the well-defined walls and angles needed for self-retentive amalgam and direct gold foil restorations. Devices designed for air abrasion generate a high-speed flow of aluminum oxide particles that hit tooth structures and dental materials. The impact of these alumina particles results in a rough surface.

Chintapalli *et al.* showed that the extent of subsurface transformation and substrate damage caused by sandblasting were dependent on sandblasting conditions, that is, abrasive particle size and pressure. They concluded that mild sandblasting was more beneficial than the harsh one since the former induced limited damage.^[2]

Table 4: Comparison of mean and standard deviation between the three groups.

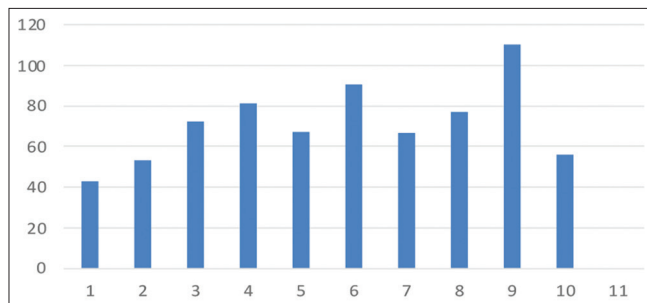
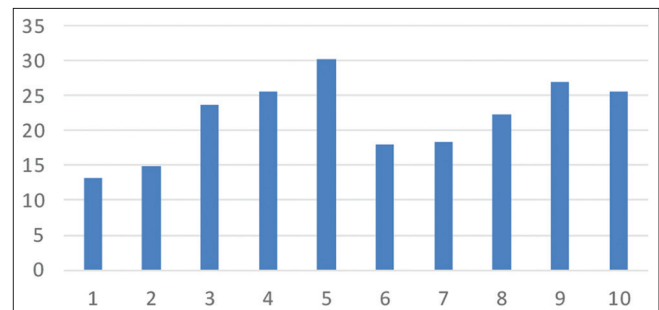
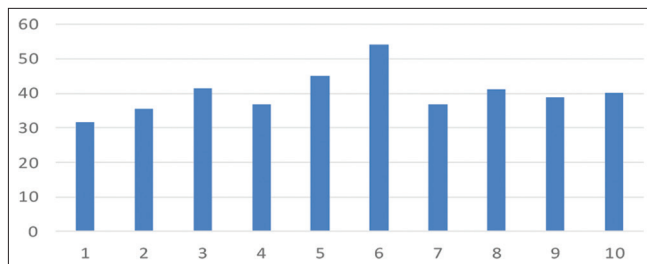
Descriptives								
Bond strength								
S. No.	n	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	10	73.5878	19.78310	6.59437	58.3811	88.7944	43.05	110.23
2	10	40.1800	6.53556	2.17852	35.1563	45.2037	31.71	54.23
3	10	21.4533	5.74268	1.91423	17.0391	25.8675	13.13	30.23
Total	30	45.0737	25.03137	4.81729	35.1716	54.9758	13.13	110.23

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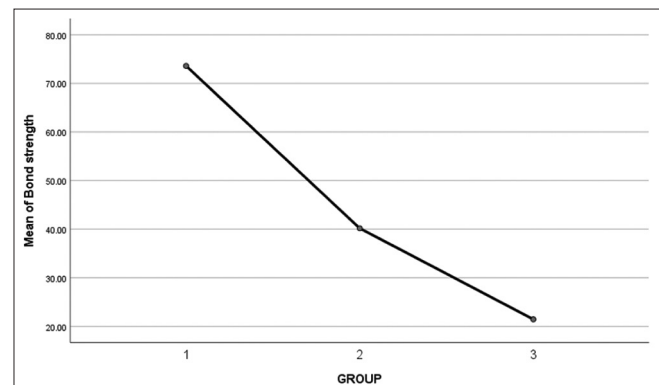
Table 5: Represents multiple comparisons of mean strengths using *post hoc* test

Multiple Comparisons							
Dependent Variable: Bond strength							
Dunnett T3							
(I) GROUP	(J) GROUP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval		
					Lower Bound	Upper Bound	
1	2	33.40778*	6.94490	0.002	13.6633	53.1522	AQ9
	3	52.13444*	6.86658	0.000	32.4644	71.8045	
2	1	-33.40778*	6.94490	0.002	-53.1522	-13.6633	
	3	18.72667*	2.90003	0.000	11.0279	26.4255	
3	1	-52.13444*	6.86658	0.000	-71.8045	-32.4644	
	2	-18.72667*	2.90003	0.000	-26.4255	-11.0279	

*The mean difference is significant at the 0.05 level

**Graph 1: Dislodgment force in N for Group A sandblasting****Graph 3: Dislodgment force in N for Group C control group****Graph 2: Dislodgment force in N for Group B acid etching**

In a study conducted by Kwon *et al.*, the effect of four different sandblasting conditions, that is, two blasting particle sizes and two pressures on the resin bonding to zirconia was investigated in terms of residual stress. Stresses created in the zirconia surface directly dependent on the aggressiveness of sandblasting.^[3,7]

**Graph 4: The mean comparison of bond strength among the three groups**

In a study done by Uhrenbacher *et al.*, they have evaluated the retention strength of differently pretreated and conditioned

PEEK crowns luted to dental abutments. They have observed that airborne particle abrasion increased the bond strength compared to non-pre-treated PEEK surfaces.^[3]

The acid etching of silica-based dental ceramics was first introduced in 1983 by Simonson and Calamia. The acids that are used for ceramic etching are hydrofluoric acid, acidulated phosphate fluoride, and the ammonium hydrogen difluoride.

In a study done by Ha *et al.*, they have determined the effects of different surface treatments on the shear bond strength of temporary crown and FPD materials. The surface treatment of bis acryl resins with sandblasting produced better shear bond strength. However, chemical treatment did not improve the shear bond strength.^[5]

Proper selection of luting agents is an important decision in a series of steps that require meticulous execution and will determine the long-term success of fixed restorations.

As an alternative to acid-base reaction cements, resin cements were introduced in the mid-1980's, they have a setting reaction based on polymerization. Resin cements are polymers to which filler has been added as well as fluoride.

Dual polymerizing resin cement provided higher bond strength for airborne particle abraded, nano-hybrid composite resin materials. When silica surface treatments are applied, the type of resin cement did not affect the bond strength of resin nanoceramic material. However, light-cured polymerizing resin cement achieved a higher bond strength when used with nanoparticle filled resin and polymer infiltrated ceramic network materials.^[6] Therefore, dual polymerizing resin cement was used in the study.

In the present study, extracted teeth were prepared using CAD-CAM technology, as discussed in a study done by Fernandez-Estevan *et al.*, where they have designed a metal stump and it was scanned, data were digitalized, standardizing the dimensions.^[7]

The extracted teeth were designed to receive the Graphene crowns, after the preparation of teeth to the specific dimensions, polyvinyl siloxane impressions were made for each individual teeth and are scanned, and then, the crowns are milled from the Graphene disc.

For cementation of the crowns, 30 teeth were distributed into three groups

Group 1: Sandblasting

Group 2: Acid etching

Group 3: Control group.

CONCLUSION

In this study, we have concluded that sandblasting group has found more bond strength compared to the acid etching and control groups.

Extraction teeth do not simulate some intra-oral factors such as salivary content and complexity of mastication forces and patterns.

Cementation in the clinical scenario is different than with the controlled cementation in this study.

Surface area of the extracted teeth to be taken into consideration as the surface area also determines bond strength.

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