

COMPARATIVE EVALUATION OF FLEXURAL STRENGTH AND MARGINAL INTEGRITY OF BIS-ACRYL COMPOSITE RESIN AND FIBER REINFORCED HEAT CURE AND SELF CURE PMMA RESIN USED IN PROVISIONAL RESTORATION: AN IN-VITRO STUDY

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ABSTRACT:

Provisional means established for the time being, pending permanent arrangement^{10, 12}. An optimal provisional restoration must satisfy many interrelated factors, which can be classified as biological, mechanical, esthetic¹⁰. Flexural strength and marginal integrity are an important mechanical property particularly when patient use provisional restoration for an extended period of time such as for long span bridges and when patient exhibits Para-functional habits. Various materials have been used as a provisional restoration. Poly methyl - methacrylate is most commonly used materials as provisional restorative material. Bis-GMA resins have become popular due to their capability to overcome some of the disadvantages of conventional poly methyl and ethyl methacrylate resins. They are resin composites and represent an improvement over the acrylics as they shrink less, give off less heat during setting, can be polished at chair side. The purpose of this study is to evaluate and compare marginal integrity of three materials Bis-acryl composite resin, self cure and heat cure acrylic resin and flexural strength of unreinforced Bis –acryl composite with fiber reinforced heat cure and self cure acrylic resins.

Keywords: Bis-acryl composite, Glass Fiber, Polyethylene fiber, Heat cure resin, Self cure resin, Flexural strength, Marginal integrity.



INTRODUCTION:

Aims And Objectives: To evaluate the flexural strength of unreinforced Bis- acryl composite resins and fiber reinforced heat and fiber reinforced heat cure and self cure tooth colour acrylic resin. To

evaluate the marginal integrity of Bis-acryl composite resin and heat cure and self cure tooth colour acrylic resin. To compare the flexural strength of unreinforced Bis-acryl composite resin with fiber reinforced heat cure and self cure acrylic resin. To compare the

marginal integrity of Bis-acryl composite resin with heat cure and self cure acrylic resin. To compare the flexural strength and marginal integrity of fiber reinforced heat cure acrylic resin with self cure acrylic resin.^[1-6]

Fixed prosthodontics is the art and science of restoring damaged teeth with cast metal, metal ceramic, or all ceramic restorations, and of replacing missing teeth with fixed prosthesis. Provisional restoration is an important clinical procedure in achieving a successful fixed prosthetic treatment. After tooth preparation, the tooth is protected by provisional restoration, until definitive restoration is fabricated. This type of restoration has also been known for many years as a temporary restoration ^[7-12].

The term interim prosthesis is often used as synonym for provisional prosthesis. The basic requirements of an interim restoration are essentially the same for definitive restoration, with the exception of longevity and possibly the sophistication of colour. The biological requirements are pulpal protection, maintenance of periodontal health, occlusal equilibrium, arch integrity, tooth position and protection against fracture, the polished surface, proper contours, with reasonably close shade matching are the esthetic requirements of the interim restorations ^[10].

The importance of provisional restoration among the procedures required for successful completion of a fixed partial denture is

often over looked. The ideal provisional restoration should cover and protect the prepared abutments, maintain occlusal and proximal contacts to prevent supra eruption or drifting of teeth, preserve marginal integrity provide acceptable contour and maintain esthetics. Provisional restorations must be sufficiently strong to resist mastication forces during function.

Newer materials provide increased fracture resistance. However long span restorations and restorations with an intended long duration may require additional methods to improve their durability. Several approaches have been made to improve the mechanical properties which include strengthening, modifying and reinforcing the resins, by various scientific workers and dental professionals. Ewing E Joseph described the usefulness of fixed partial restorations luted with temporary cement and his emphasis that it can serve satisfactorily over long period ^[6].

Smith D.C. compared the physical properties of various dental polymers and concluded that no material is outstanding in all respects. William et al conducted study to evaluate the relationship of crown margin placement to gingival inflammation. Doherty described a technique using various metals for direct fabrication of long term provisional restoration with self cure PMMA ^[5].

MATERIALS AND METHODS:

This in-vitro study was conducted to evaluate and compare marginal integrity and flexural strength of provisional restorative materials routinely used in fixed prosthesis following the incorporation of fibers. The provisional restorative material selected for the study were commercially available heat cure polymerizing poly methyl methacrylate, self cure poly methyl methacrylate and self cure Bis-acryl composite resin. The fibers selected for this study were S-glass and ultra high molecular weight polyethylene fiber.

GROUPING OF SAMPLES:

(A) FOR FLEXURAL STRENGTH: The samples prepared were divided into three groups namely group 1,2 and 3 based on type of resin used. Each group has three subdivisions such as A, B based on fiber selected. Total 30 samples of 6 samples for each group. Group 1 (**control group**): Bis-acryl composite resin. Group 2: Self cure pmma resin. 2a – Glass fiber reinforced PMMA resin. 2b- Polyethylene fiber reinforced PMMA resin. Group 3: Heat cure PMMA resin. 3a- Glass fiber reinforced PMMA resin. 3b- polyethylene fiber reinforced PMMA resin.

METHODOLOGY:

1.FOR FLEXURAL STRENGTH:

A. Preparation of test samples

1. Tooth mounting and preparation:

Mandibular premolar and molar typhodont tooth were mounted with

pontic space for missing molar with type 3 dental stone base. Tooth preparation of molar and premolar was done with 1 mm of shoulder finish line, 1.5 mm of axial reduction, 2 mm of occlusal reduction. Indexing notches of 5 mm depth was created in each end of model for proper orientation of silicone index.

2. Impression making and model preparation: Impression of prepared tooth along with die stone model is recorded with addition silicone impression material.

3. Preparation of silicone index for primary resin coping: The die stone cast was lubricated with petroleum jelly and wax pattern was fabricated with type 2 inlay wax for primary resin coping with uniform thickness of 1 mm. spheroidal pontic was designed. Putty consistency of A – silicone was adapted over the wax pattern.

4. Preparation of silicone index for final resin coping: Wax pattern is prepared using type 2 inlay wax over the initial wax pattern for creating occlusal morphology of 2 mm thickness. Secondary silicone index is prepared by the same method used for fabricating primary silicone index.

5. Preparation of resin samples for control group: Samples for control group is fabricated by Bis- acryl composite resin. Final silicone index is used for fabrication of control group samples without incorporating fibers.

6. Preparation of self cure acrylic resin reinforcing glass and polyethylene fibers:

For glass fibers Primary resin coping is fabricated by primary silicone index. The unidirectional S- glass fibers placed over the initial resin coping. Self cure resin poured in the final silicone index and placed over the primary coping carrying the glass fibers and secured with rubber band till polymerization is over. The same procedure is done for polyethelene fiber.

7. Preparation of heat cure acrylic resin

sample: Secondary putty index was placed over the die stone model and fixed using sticky wax. This assembly is flaked using POP. Open dewaxing was done to remove sticky wax. Primary resin coping is fabricated using primary silicone index. The heat cure resin is placed in the primary silicone index and packed. Glass fiber is placed over the primary coping. Heat cure resin is packed over the primary coping carrying the glass fiber with the help of final putty index.

8. Finishing of test sample: After curing samples were removed, excess material was trimmed using acrylic trimmers and finished with sand paper in increasing order from 100 to 600 grits.

B. TESTING OF SAMPLES: The flexural strength for all specimens was tested by loading the specimen in the universal testing machine (INSTRON). The samples were placed horizontally and supported on 2 jig with a span of 28 mm between them. Linear contact was obtained between the samples and both supporting and loading levers and load was applied perpendicular to the samples at their centre. They were subjected to loading until fracture occurred and maximum

flexural load during fracture was recorded as fracture in Newtons using formula.

$$FS=3WL/2bd^2$$

FS=flexural strength (MPa or MN/m², W=maximum load before fracture(N), L=distance between the supports (mm), b=width of the samples (mm), d=thickness of the samples (mm).

2. FOR MARGINAL INTEGRITY:

A. PREPARATION OF TEST SAMPLES:

1. Tooth mounting and preparation:

Typhodont mandibular molar tooth was mounted in type III dental stone V shaped grooves of 5 mm depth was cut on each end of stone model for proper orientation of silicone matrix. Impression of unprepared tooth was made using addition silicone impression material in putty and light body consistency to record surface detail. This silicone index is used for making provisional crowns.

2. Impression making and model pouring:

Impression of prepared tooth along with stone model is made by addition silicone impression material. Six impression had been taken and three casts were poured from each impression by using type 4 dental stone and totally 18 models were prepared.

3. Preparation of resin samples for control group:

Bis-acrylic resin samples were prepared for control group. This mix is poured in silicone index that has been prepared from unprepared tooth. This resin filled mix is placed over the die stone model and pressed and secured with

rubber band. Provisional crown sample is removed and finished.

4. Preparation of self cure resin samples:

Self cure acrylic resin poured in putty silicone index. Provisional crown is placed to the die.

5. Preparation of heat cure resin samples for test group:

Silicone putty index of unprepared tooth was placed over die stone model. Die stone model with putty index was flaked using POP. Subsequently lab procedures was carried out.

6. Finishing of samples: After chemical and heat cure polymerization provisional crown samples are removed excess material is trimmed off. Finishing is done using sand paper in increasing order from 100 to 600 grits.

B. TESTING OF SAMPLES: Four reference points in samples had been marked at finish line. Prepared samples of provisional crowns were placed over that and marginal discrepancy was measured by using *TOOL MARKERS MICROSCOPE*. That is calibrated 0.005 mm of each small division and 0.01 mm of each big division. Marginal accuracy was recorded in mm.

PHOTOGRAPHS:



Mounted and prepared tooth



Impression of prepared tooth



Silicone putty index



Die stone models integrity



Samples for Flexural strength



Samples for Marginal



Tool marker microscope accuracy



Universal testing machine(INSTRON)



Measuring marginal accuracy



Fracture of unreinforced sample



Fracture of reinforced sample



Armamentarium

RESULTS:

The statistical analytical shows the following:

TABLE 1.1 Mean flexural strength of control group and fiber reinforced group

| Groups | Samples | Mean | Std. Deviation |
|-----------|---------|-----------|----------------|
| Control | 6 | 318.02667 | 11.296764 |
| Group 2 A | 6 | 246.05833 | 27.147665 |
| Group 2 B | 6 | 171.96867 | 35.950601 |
| Group 3 A | 6 | 264.52100 | 10.263743 |
| Group 3 B | 6 | 236.89700 | 45.879812 |

Table 1.1 : The difference between the flexural strength of Bis-acrylic composite resin (control group) 1 and fiber reinforced self cure resin group 2 is significant. P value >0.01. Flexural strength of Bis-acryl composite resin is much higher than self cure PMMA resin.

TABLE: 1.2 Flexural strength mean values, S.Ds and results of one-way ANOVA and Tukey HSD of group 2 and 3 test groups.

| Serial No | Groups | Mean | S.Ds | P value |
|-----------|--------|--------|-------|---------|
| 1. | 2 | 209.01 | 49.18 | 0.601 |
| 2. | 3 | 250.70 | 34.82 | |

Group 2 = Fiber reinforced self cure resin, Group 3 = Fiber reinforced heat cure resin.

Table 1.2: The difference between the flexural strength of fiber reinforced self cure resin 2 and heat cure resin 3 is non significant. P value > 0.05.

TABLE 1.3 Flexural strength mean values, S.Ds and results of one-way ANOVA and Tukey HSD of group 1 and 3 test groups.

| Serial No. | Groups | Maen | S.Ds | P value |
|------------|--------|--------|-------|---------|
| 1. | 1 | 318.02 | 11.29 | 0.117 |
| 2. | 3 | 250.70 | 34.82 | |

Group 1= Bis-acryl composite resin, Group 3= Fiber reinforced heat cure acrylic resin.

Table 1.3: The difference between the flexural strength of fiber reinforced heat cure resin 3 and Bis acryl composite resin 1 non significant. P value > 0.05.

TABLE 1.4 Flexural strength mean values, S.Ds and results of one-way ANOVA and Tukey HSD of subgroups 2A,2B,3A,3B

| Serial No. | Sub groups | Mean | S.Ds | P value |
|------------|------------|--------|-------|---------|
| 1. | 2A | 246.05 | 11.20 | 0.002 |
| 2. | 2B | 171.96 | 35.05 | 0.000 |
| 3. | 3A | 264.52 | 10.26 | 0.032 |
| 4. | 3B | 236.89 | 45.87 | 0.001 |

Group 2A= Glass fiber reinforced self cure resin, Group 2B= Polyethylene fiber reinforced heat cure resin, Group 3A= Glass fiber reinforced heat cure resin, Group 3B= Polyethylene fiber reinforced heat cure resin.

Table 1.4: The difference between the flexural strength of Bis-acryl composite resin (control group) and glass fiber reinforced self cure resin (2A) is highly significant. P vsalue < 0.01**

Difference between control group (1) and group 2B is stastically significant. P value > 0.01**
 Difference between control group (1) and group 3A is statistically non significant. P value is > 0.05

Difference between control group (1) and group 3B is statistically significant. P value is 0.01**

The highest flexural strength was seen in the group 1 followed by group 3A, then in decreasing order from 2A, 3A and 2B.

TABLE 1.5: Flexural strength mean values, S.Ds and results of one-way ANOVA and Tukey HSD of subgroups 2B and 3B

| Serial No. | Sub groups | Mean | S.Ds | P value |
|------------|------------|--------|-------|---------|
| 1. | 2B | 171.96 | 35.95 | 0.007 |
| 2. | 3B | 236.89 | 45.87 | |

Group 2B= Polyethylene fiber reinforced self cure resin, Group 3B= Polyethylene fiber reinforced heat cure resin.

Table 1.5: The difference between flexural strength of polyethylene fiber reinforced self cure resin (2B) and heat cure PMMA resin (3B) is highly significant. P value is < 0.010**. Flexural strength of group 3B is statistically higher than group 2B.

TABLE 1.6: Flexural strength mean values, S.Ds and results of one-way ANOVA and Tukey HSD of subgroups 2A and 2B

| Serial No. | Sub groups | Mean | S.Ds | P value |
|------------|------------|-----------|-----------|---------|
| 1. | 2A | 246.05833 | 27.147665 | 0.002 |
| 2. | 2B | 171.96867 | 35.950601 | |

Group 2A= Glass fiber reinforced self cure resin, Group 2B= polyethylene fiber reinforced heat cure resin

Table 1.6: The difference between the flexural strength of glass fiber reinforces self cure PMMA resin (2A) and polyethylene fiber reinforced heat cure PMMA resin (2B) is statistically significant. P value < 0.010**

TABLE 2.1: Marginal integrity mean values, S.Ds and results of one-way ANOVA and Tukey HSD of Groups 1 and 2

| Serial No. | Groups | Mean | S.Ds | P value |
|------------|--------|-------|-------|---------|
| 1. | 1 | 0.015 | 0.003 | 0.000 |
| 2. | 2 | 0.025 | 0.003 | |

Group 1= Bis-acryl composite resin, Group 2= Self cure acrylic resin.

Table 2.1: The difference between the marginal integrity of group 1 and group 2 is statistically significant. Value is 0.000**. The marginal accuracy of bis-acryl composite resin is 0.015 mm is good than self cure PMMA resin that is 0.025 mm.

TABLE 2.2: Marginal integrity mean values, S.Ds and results of one-way ANOVA and Tukey HSD of Groups 1 and 3

| Serial No. | Groups | Mean | S.Ds | P value |
|------------|--------|-------|--------|---------|
| 1. | 1 | 0.015 | 0.0013 | 0.015 |
| 2. | 3 | 0.020 | 0.0007 | |

Group 1= Bis-acryl composite resin, Group 3= Heat cure acrylic resin.

Table 2.2: The difference between the marginal integrity of group 1 and group 3 is statistically significant. P value is 0.015*. The marginal accuracy of bis acryl composite resin is 0.015 mm that is good as compared to heat cure PMMA resin that is 0.020mm.

TABLE 2.3: Marginal integrity mean values, S.Ds and results of one-way ANOVA and Tukey HSD of Groups 2 and 3

| Serial No. | Groups | Mean | S.Ds | P value |
|------------|--------|-------|--------|---------|
| 1. | 2 | 0.025 | 0.003 | 0.025 |
| 2. | 3 | 0.020 | 0.0007 | |

Group 2= Self cure resin, Group 3= Heat cure acrylic resin.

Table 2.3: The difference between the marginal integrity of group 2 and group 3 is significant. P value is 0.025*. The marginal accuracy of self cure PMMA resin is 0.025 mm that is less as compared to heat cure PMMA resin that is 0.020 mm.

than unreinforced Bis-acryl composite resin.

INTERPRETATION OF RESULTS:

1. Bis-acryl composite resin (318 MPa) had the greatest flexural strength as compared to reinforced self cure and heat cure PMMA resin.

2. Heat cure PMMA resin had better flexural strength compared to self cure PMMA resin and slightly less strength

3. Self cure (246.05 MPa) and heat cure PMMA resin (264.52 MPa) reinforced with glass fibers had good flexural strength as compared to polyethylene fiber reinforced PMMA resins. (171.96 MPa, 236.89 Mpa).

4. Heat cure PMMA resin reinforced with glass fibers (264.52 MPa) had comparable

flexural strength to bis- acryl composite resin (318.02 MPa).

5. Glass fiber reinforcement (246.05 MPa) had better strength than polyethylene fiber reinforcement. (171.96MPa).

6. Marginal accuracy of bis-acryl composite resin (0.015 mm) is good as compared to self cure PMMA resin (0.025 mm) and heat cure PMMA resin (0.020 mm).

7. Marginal accuracy of heat cure PMMA resin is (0.020 mm) is good as compared to heat cure PMMA resin(0.025 mm).

DISCUSSION:

Provisional restoration is an important phase in fixed prosthodontic therapy. It should provide both pulpal and periodontal protection, have good marginal integrity and esthetics, have sufficient durability to withstand the forces of mastication [9]. Various materials have been used as provisional restorative materials. The most commonly used material includes poly methyl methacrylate and Bis-acryl composite resin.

In studies have shown that Bis-acryl composite resin demonstrate some important properties compared to poly methyl methacrylate. At present there is no provisional restorative material is available that meets optimal requirements. In cases such as, patients with bruxism, patient whose treatment requires long term use of provisional restorations, provisional restorations with

improved physical properties are required.

Several attempts have been made by various workers to enhance property of these materials, by reinforcing metal wire [1] lingual cast metal reinforcement [9] A processed acrylic resin provisional restoration⁷, Different types of fibers such as carbon [8,10,12] aramid, polyethylene, glass fiber [11]. Gary S solnit in his study compared the effect of self cure methyl methacrylate resin reinforcement with silane treated and untreated glass fibers.

He concluded greatest strength was achieved by treating the glass fibers with silane before they are incorporated into the PMMA mixture. Silanized glass fibers exhibited better bonding with provisional material which in turn helps to increase the strength whereas the braided polyethylene fiber exhibited inadequate bonding with substrate material. Surface treatment is required for polyethylene fibers like plasma spraying, chromic acid and zirconium coupling agents to overcome this problem.

Treatment of a polymer with plasma can increase its surface energy by modifying the chemistry of its surface [2,3]. The mode of failure of fiber reinforced resin samples show a partial fracture pattern, where the joints remained intact and a small portion of the pontics was separated as a result of cohesive failure of resin material. In clinical situation, this is perhaps the most favourable mode of fracture of the

provisional prosthesis because the restoration remains intact and the treatment was unlikely to be compromised by partial separation of the pontics [12].

In this study polyvinyl siloxane impression material is used as a matrix for fabrication of provisional restoration. As various studies has been done to evaluate effect of fiber reinforcement in mechanical properties of provisional materials [4]. If we compare type of fiber which affects the mechanical property of provisional material then result was that glass reinforcement provides better strength as compared to polyethylene fibers.

Results showed the mean marginal gap of Bis-acryl composite resin is 0.015 mm, self cure PMMA is 0.025 mm, heat cure PMMA is 0.020 mm. The shrinkage in bis-acryl composite resin is negligible so it provides best marginal accuracy.

CONCLUSION:

In this in vitro study, for flexural strength two fibers (Silanized Glass Fibers and Polyethylene Fibers) reinforcements were experimented and their results analyzed to evaluate their influence on the flexural strength of the provisional restorative materials. For marginal integrity three materials (Bis-acryl composite resin, Heat cure and Self cure PMMA resin) were used to compare marginal integrity of these material used in provisionalization. Within the limitation of study following results

are made. For flexural strength Bis-acryl composite resin samples possessed greater flexural strength than the fiber reinforced group.

Glass fiber reinforced samples had the highest flexural strength than polyethylene fiber reinforced samples. Heat cure PMMA resin samples had highest flexural strength than the self cure PMMA resin samples. Heat cure PMMA resin samples reinforced with glass fiber had the flexural strength near to the Bis-acryl composite resin. Self cure and heat cure PMMA resin reinforced with glass fibers had good flexural strength as compared to polyethylene fiber reinforced PMMA resins. For marginal integrity marginal accuracy of Bis-acryl composite resin is good as compared to self cure PMMA resin and heat cure PMMA resin. Marginal accuracy of heat cure PMMA resin is good as compared to heat cure PMMA resin.

To conclude poly methyl methacrylate resin heat and self cure is most commonly used as provisional restorative material, so by fiber reinforcement the mechanical property of acrylic resin can be improved to with stand heavy occlusal forces in oral cavity. Though the property of Bis-acryl composite resin is good comparatively to acrylic resin but due to its high cost and difficult to repair there is limitations in its use.

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