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Original Article

Comparative Evaluation of Flexural Strength in Three Types of Denture Base Resins: An *In Vitro* Study

K. Sayed Akber Pasha[1], Manu Rana[2], Swagat Kumar Mahanta[3]

[1]Prosthodontist, Salmar, Karkala, Karnataka, India, [2]Department of Conservative Dentistry and Endodontics, ,College Of Medical Sciences, Bharatpur,[3]Department Of Community Dentistry M.B. Kedia Dental College Birgunj,

***ABSTRACT*:**
Aim: To evaluate the effect of the addition of C-glass flakes on flexural strength of commercial available heat cure denture base resin and to compare it with a high impact strength denture base resin. **Materials and Methods**: Test specimens were divided into Group1 - poly(methyl methacrylate)(PMMA)(Trevalon), Group 2 - Trevalon High impact, Group 3 -5% glass flake(GF003m) +95% PMMA (Trevalon). For glass flake modified groups, percentage of powder was substituted with the same weight of glass flake as required, to bring it to 100% powder. The specimens were loaded until failure on a three-point bending test machine. An one-way analysis of variance was used to determine statistical differences among the flexural strength of three groups. Data were analyzed by SPSS software. **Results:** HI PMMA, showed the highest value of flexural strength followed by plain PMMA. C-Glass reinforced PMMA group showed least value of flexion resistance. **Conclusion:** Flexural strength of plain PMMA denture base resin did not increase significantly with addition of glass flakes.
Key Words: Flexural strength, glass flakes, high impact denture base resin, poly (methyl methacrylate)

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Corresponding Author: Dr. Manu Rana, Department of Conservative Dentistry And Endodontics, ,College Of Medical Sciences, Bharatpur, Nepal. E-mail: ranamau86@gmail.com

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INTRODUCTION

As civilization has progressed there has been continued refinement of the materials available for dental practice. As time passed and civilization advanced with the development of biological, chemical and physical sciences, there occurred a slow but steady increase in both the quantity and quality of useful materials available for dental prosthesis. The material should be biological compatible, readily available, reasonably inexpensive and simple to manipulate with a readily controlled technical procedure, to develop a prosthesis that is functionally effective and pleasing in appearance.[1]

Poly (methyl methacrylate) (PMMA)has many advantages, particularly its appearance and ease of manipulation, but it has certain drawbacks. Fractures may occur in use because of its inadequatetransverse strength, impact strength or fatigue resistance. Many efforts have been made to improve the mechanical properties of acrylic resin by giving maximum bulk to the material in the areas most heavily stressed, by copolymerization and cross-linking, reinforcement with carbon fibers.[2]The fracture of acrylic resin dentures is an unresolved problem inprosthodontics despite of many attempts to determine its causes.[3] Flexural strength of denture base resin is considered the primary mode of clinical failure.[4,5] Hence, the aim of this study was to evaluate whether the flexural strength of a commercially available, heat polymerized acrylic denture base material could be improved using reinforcements.

MATERIALS AND METHODS

In this study, 30 acrylic specimens were prepared. Based on the type of acrylic resin used, the specimens were divided into three groups with 10 specimens each. They were Group 1 - conventional denture base resins, Group 2 - high impact denture base resins, and Group 3 - 5% glass flake reinforced denture base resins. Each group was subjected to flexural strength evaluation.

Making Of Acrylic Specimen

To make the mold space for the specimens, three stainless steel cuboidal dies were milled measuring 65.5 mm × 10.5 mm × 3.5 mm in length, breadth, and thickness, respectively(Figure 1).Thirty acrylic specimens were

fabricated using these three stainless steel dies. The metal dies were flasked using type II dental plaster to complete the flasking procedure. The plaster was allowed to set for an hour, and parts of the flask were separated (Figure 2).The stainless steel dies were retrieved to create the mold space for the acrylic specimen. The separating medium (cold mold seal) was applied to the mold space created and is allowed to set for 20 min. Three different PMMA were evaluated, namely:-

Group 1 - Conventional denture base resins(Trevalon)
Group 2 - High impact denture base resins (Trevalon HI)
Group 3 - 5% glass flake + 95% PMMA (Trevalon)

Figure 1

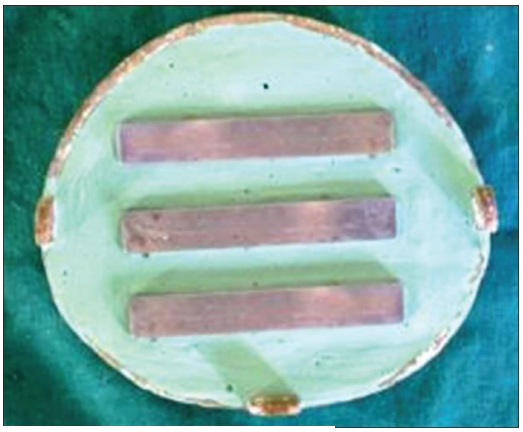


Figure 2

For Group 1 and Group 2 the polymer and monomer were proportioned as suggested by the manufacturer in a ratio of 3:1 by volume. For Glass flake modified poly (methyl methacrylate) group processing, part of methyl PMMA (powder) was substituted with the same weight of glass flake (GF003m) as required, to bring it to 100% powder. For example, in 5% glass flake modified PMMA group, 5% w/w (5 g) glass flakes were added to 95% (95 g) PMMA polymer to bring polymer powder to 100% (100 g) and then mixed with liquid as per manufacturer's recommendation. All the manipulation was done at the same room temperature. The acrylic resin was packed into the mold, after trial closure the flask was tightened to their final position. The specimens were subjected to curing cycle starting from room temperature to reach 74°C in 30 min and held at this temperature for approximately 2 h and then terminal boiling point was done at 100°C for 1 h. After bench cooling, the acrylic specimens were retrieved, trimmed, finished, and polished to the required dimension measuring 65 mm × 10 mm × 3 mm in length, breadth, and thickness, respectively (according to International Organization for Standardization [ISO] standardization 1567). The polished specimens were measured using a digital verniercaliper. The exclusion criteria for the samples were specimens with smaller dimensions, internal porosity, external porosity, worn out edges, and surface defects. All the thirty specimens were immersed in distilled water for 28 days at room temperature to simulate the oral conditions.(Figure 3)

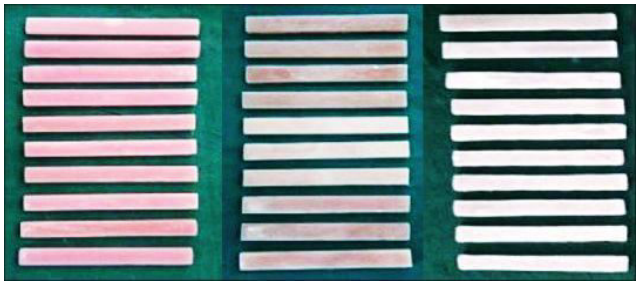


Figure 3

Evaluation of flexural strength

Flexural strength of the samples was accessed using the universal testing machine. The specimens were prepared by marking three lines A, B, and C. The first line A was drawn at a distance of 10 mm from the border of the specimen. The second line B was marked at 45 mm away from line A. These two lines A and B correspond to the location of supporting arm in the universal testing machine. A midline between these lines A and B was marked as line C, and it is the location the striker of the testing machine would come and contact with the specimen (Figure 4). As the universal testing machine plunges into the specimen, the specimen would fracture at a particular load (Figure 5).This maximum load before fracture (F) is given in Newtons in the display of the testing machine. The flexural strength of the given sample in megapascals was computed from the maximum load by using the formula

$S = 3FL/2BD2$

- S → Flexural strength
- F → Maximum load (force) before fracture
- L → Length of the support arm (45 mm)
- B → Width of the specimen
- D → Thickness of the specimen.

The mean value of the flexural strength of all the groups was computed and then statistically analyzed using one-way analysis of variance (ANOVA), using SPSS software version 21.0 (IBM Corporation, Armonk, NY, USA).

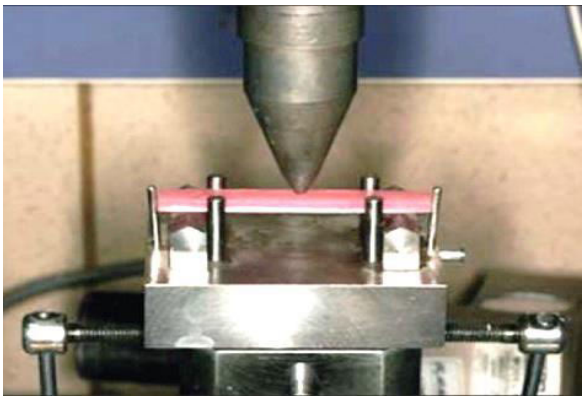


Figure 4

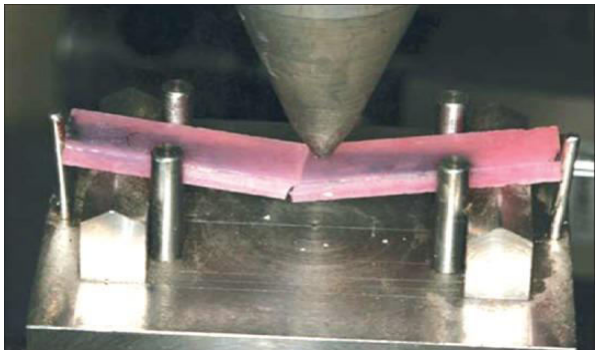


Figure 5

RESULTS

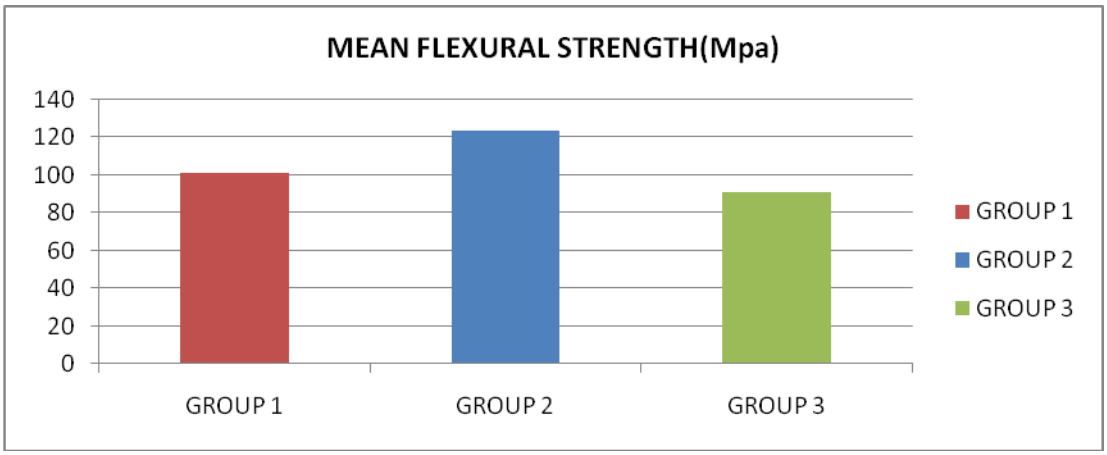
One-way ANOVA was used to determine statistical differences among the flexural strength of three groups. Data were analyzed by SPSS software, and the results were obtained [Tables 1-3]. The mean flexural strength of conventional PMMA (Group 1) was 100.79Mpa, for high impact PMMA (Group 2) it was 123.52Mpa, and for Glass flake reinforced PMMA (Group 3) it was 90.97Mpa. The results of the statistical analysis for flexural strength were shown in the bar diagram.

Table 1

GROUP 1 (Mpa)	GROUP 2(Mpa)	GROUP 3 (Mpa)
101.18	121.5	101.25
108.00	127.5	90.25
90.00	135.0	94.75
108.75	108.75	82.5
93.75	101.25	88
82.50	135.0	85.25
112.5	120.0	89.5
112.5	135.0	100.25
90.00	127.5	92.25
108.75	123.75	85.75

Table 2

Variables	Groups	n	Mean	SD
Flexural strength	Plain PMMA	10	100.79	10.98550
	HI PMMA	10	123.52	13.36974
	5%Glass flake + PMMA	10	90.97	6.24438



Statistical Figure 1 (Graphical representation of data on flexural strength)

Table 3

	Sum of square(SS)	Degree of freedom(df)	Mean square (MS)	F	p
Between group	5557.054	2	27778.527	29.135	1.809
Within group	2574.903	27	95.36681		

One way ANOVA on flexural strength.

Table 4

	Mean difference	SE	p
Group 1:Group 2	10.700	9.412	0.0195S
Group 1:Group 3	6.050	9.412	0.3715
Group 2:Group 3	16.750	9.412	0.00006 HS

Post‑hoc analysis by Bonferroni test.Maximum bending stress atmaximum load (MPa).S: Significant, HS: Highly significant, SE: Standard error

DISCUSSION

The prime and most frequent site of fracture in the upper denture is in the medial line. During chewing, denture base material is subjected to flexural deformation. Flexural strength is a measure to know the resistance of the polymer to flexural deformation. Therefore, in this study, flexural were evaluated for the above three denture base resins. Over the years, there have been various modifications attempted to improve the mechanical properties of PMMA. The modifications include chemical modification of PMMA, through the incorporation of butadiene styrene to produce graft copolymer (high impact denture base resins) and mechanical reinforcement through the inclusion of various fibers (fiber reinforced denture base resins.[5,6,7]Therefore, all the three denture base resins (conventional resins, high impact, and glass reinforced) were included in this study. Artificial aging such as underwater storage in thermally controlled condition was simulated in this study. Different authors use different time periods of underwater storage, but the important influence of water on the flexural strength occurs during the first 4 weeks of immersion causing decrease of the flexural strength values. Hence, a 28 days immersion in distilled water at 37°C was used in this study. Regarding the fiber reinforcement in denture base resins, it has long been hypothesized that the addition of synthetic fibers to the monomer-polymer mixture may strengthen the resultant acrylic resin. Different authors used various types of fibers such as carbon, aramid, glass, polyethylene fibers.[6,7,8]

In this study ECRGlassflake micronized Grade GF003m (Glassflake Ltd., Leeds, Yorkshire, UK)which is a high-aspect-ratio reinforcing additive with many commercial applications is used. The flake is a modified "C" glass composition and is supplied in a range of varies thicknesses. There are also three particle size distributions to choose from: Unmilled milled and micronized. As yet very less literature exists regarding its ability to reinforce acrylic, though the manufacturers claim that its addition to some thermoplastics has resulted in significantly improved flexural modulus and planar reinforcement. They also claim the effect of adding to polytetrafluoroethylene (PTFE) outperformed glass fiber reinforced PTFE in terms of tensile strength, compressive modulus, dimensional stability, wear resistance and creep.

Flakes were arranged randomly in the resin matrix as there is no chemical bonding between flakes and the resin. Glass flakes can be seen on the fractured surface and also areas in the acrylic where flakes have been lost. The flexural strength of a material is a combination of compressive, tensile, and shear strengths. As the tensile and the compressive strength increases, the force required to fracture the material also increases.

Table 2 shows the mean flexural strength (MPa) of specimens among three study groups and HI Trevalon shows highest mean flexural strength as compared to other groups. Table 4 shows post-hoc analysis with Bonferroni test of unmodified Trevalonwhen compared to Trevalon HI, Trevalon + 5% glass flake depict that Trevalon HI shows highest flexural strength whereas plain Trevalon, when compared to Trevalon + 5% glass flake, shows a mean difference of 6.050MPa. $P = 0.371$ and hence its flexural strength is not significantly high as compared to Trevalon + 5% glass flake.

Specimens reinforced with butadiene styrene showed the highest flexural strength values, followed by specimensconventional unreinforced acrylic resin and followed by specimens reinforced with glass flakes. The addition of rubber to PMMA produces a matrix of PMMA within which is dispersed an interpenetrating network of rubber and PMMA. If a crack develops in a rubber reinforced acrylic resin then it will propagate through the PMMA but will decelerate at the rubber interface. The rubber reinforced acrylic resins are believed to absorb greater amounts of energy at higher strain rate before fracture than the conventional acrylic resins and, therefore, offer improved flexural strength. A popular concept is that the rubber particles cause dispersion or deflection of the cracks.[9]

CONCLUSION

Within the limitation of the current study, the following conclusions were drawn

- The flexural strength values of heat polymerized PMMA were considerably enhanced by addition of butadiene styrene.
- Polymethyl methacrylate reinforced with glass flakes showed the lowest flexural strength values.

Hence, addition of glass flakes to improve physical properties[10] is contradicted by this study and adds to the drawback of using this material in dentistry.

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