

## To Evaluate the Effect of Steel Strengtheners on Fracture Resistance of Heat Cured Methyl Methacrylic Resin – An in Vitro Study

Anantha Reddy<sup>1\*</sup> Vijay Prasad Koganti<sup>2</sup> Parth Satwalekar<sup>3</sup> Sudharshan Reddy<sup>4</sup> Ramaswamy Reddy<sup>5</sup> N Sandeep<sup>6</sup>

<sup>1</sup>Professor, Department of Prosthodontics, Sri Venkata Sai Institute of Dental Sciences, Hyderabad, India.

<sup>2</sup>Professor and Head, Department of Periodontology, Dr. B.R Ambedkar Institute of Dental Sciences and Hospital, Patna, Bihar, India.

<sup>3</sup>Professor, Department of Prosthodontics, Sri Venkata Sai Institute of Dental Sciences, Hyderabad, India.

<sup>4</sup>Professor, Department of Prosthodontics, Index Dental College, Indore, India.

<sup>5</sup>Professor, Department of Prosthodontics, Sri Venkata Sai Institute of Dental Sciences, Hyderabad, India.

<sup>6</sup>Senior Lecturer, Department of Prosthodontics, Sri Venkata Sai Institute of Dental Sciences, Hyderabad, India.

### ABSTRACT

**Aim:** The acrylic resin material is an indispensable material in removable prosthodontics. There has been continuous search to reduce processing time and enhance physical properties such as strength deformation. Fracture of acrylic resin is an unresolved problem in removable prosthodontics. Numerous attempts have been made to determine its causes. The present study was done to compare the fracture resistance of acrylic resin denture base reinforced with steel strengtheners.

**Materials and Methods:** To measure the fracture resistance of heat cure acrylic resin, a total of 45 specimens were prepared and divided into 3 categories: Group 1: No strengtheners, Group 2: Thin gauge strengtheners and Group 3: Thick gauge (0.6 mm X 7 mm). All the samples prepared were of specific dimensions i.e. 55 mm in length, 22 mm in width and 3 mm in thickness as a means for standardization. The flexural strength of the samples was recorded using a universal testing machine and the data obtained was statistically analysed. The statistical analysis was done by calculating the average and standard deviation for each parameter used in the study. To find out the significant difference between different concentrations and different time intervals unpaired 't' test was performed. Here 'p' and 't' value is used to evaluate the fracture resistance.

**Results:** Acrylic samples with steel strengtheners fared better when compared to those without steel strengtheners. Thick gauge strengtheners were found to be more resistant to fracture. The difference was statistically significant.

**Conclusion:** The incorporation of thick steel strengtheners few millimetres apart and perpendicular to anticipated line of fracture will produce significant resistance to flexure and reduce the likelihood of fracture of the acrylic resin denture base.

**Keywords:** Acrylic resin, Steel, Dentures.



### INTRODUCTION

Heat cure methyl methacrylates have been the denture base material of choice

for the fabrication of conventional complete dentures. The advantages of acrylic are mainly its strength, durability, relative biocompatibility and absence of taste. A realistic appraisal of the

Received: Mar. 05, 2013: Accepted: Apr. 06, 2013

\*Correspondence: Dr Anantha Reddy

Dept of Periodontology, Sri Venkata Sai Institute Of Dental Sciences, Mehbubnagar, Hyderabad, India.

Email: zeereddyananth@gmail.com

mechanical properties of denture base materials can be carried out only on the basis of the clinical requirements for the material. These requirements are generally described as adequate strength, resilience and hardness and abrasion resistance. Inherent disadvantage of these materials is the liability of an acrylic denture to break during service as a result of fatigue in the mouth or impact failure outside the mouth.

Smith<sup>1</sup> noted that denture failure depends on the shape, conditions of loading, inherent residual stresses and mechanical properties of the denture base. Fracture of acrylic resin denture base poses a problem for patients, dentists and laboratory technicians. A common site of fracture is along an anteroposterior line that coincides with the notch for the relief of the labial frenum of either maxillary or mandibular complete dentures. This type of fracture is caused by flexure of the denture base caused by tissue changes such as alveolar resorption, which results in superiorly deflected left and right halves of the denture with a fulcrum along the midline of the palate. Breakage of the denture may occur by accidental dropping and is also prevalent among neuropsychiatric patients with poor motor skills.

The fracture resistance of acrylic dentures can be increased by the use of high impact acrylic resins. Glass fibres, polyethylene fibres, grid strengtheners, vitallium strengtheners have also been used<sup>2-4</sup>. In the present study the steel strengtheners of thin and thick gauge were used. Comparison of the flexural resistance of conventional heat cured denture base resins was done with and without the use of steel strengtheners.

## MATERIALS AND METHODS

### Fabrication of Master Die:

A master die (ADA Specification No.18) was used in the study in order to control the dimensions of the acrylic specimen. A brass die of specific dimension i.e. 55 mm in length, 22 mm in breadth and 3 mm in width was prepared for the same. (Figure 1)

## METHOD

To measure the fracture resistance of heat cure acrylic resin, a total of 45 specimens were prepared which included 15 samples for each category. All the samples prepared were of specific dimensions i.e. 55 mm in length, 22 mm in width and 3 mm in thickness as a means for standardization.

The steel strengtheners (Figure 2) were embedded into the specimens at the stage of packaging the acrylic resin dough into the moulds (Figure 3). The strengtheners used were basically of two types.

- i. Smaller size - thin gauge (0.3 mm X 5 mm)
- ii. Larger size - thick gauge (0.6 mm X 7 mm)

The control specimens were devoid of any strengtheners. Hence, the specimens were categorized into 3 groups:-

S0- Acrylic specimen without any strengtheners.

S1- Acrylic specimen with thin gauge steel strengtheners placed along the fracture line.

S2- Acrylic specimen with thick gauge steel strengtheners placed along the fracture line.

### Flasking

Flasking included the investing of the metallic brass die. The first step was similar to the flasking of complete denture. The base was painted with model plaster and the die was sealed in the lower half of the flask until the impression plaster was in level with the land area of brass die in the centre. It was important that a small indentation be made between the edge of the die and plaster. Once set, the plaster was painted with separating media. The flask was soaked in slurry water for few minutes. The second mix of plaster was same as first mix, following the manufacturer's directions for the water powder ratio. The flask was then closed with a clamp till the plaster set i.e. for about 1/2 hour. The die was removed once the flask had completely cooled down. Separating medium was applied and allowed to dry.

Steel strengtheners were made ready. They were dipped in monomer to allow proper wetting. Polymer and monomer were proportioned approximately 3:1 by volume. The powder and liquid were mixed with a stainless steel spatula and

then kept in the sealed jar, to avoid loss of monomer in the initial stages of polymerisation. The polymer and monomer mixture passed through distinct consistencies. When mixture was doughy it was packed in the die flask. Steel strengtheners were placed in the centre of acrylic according to desired direction.

The acrylic dough was packed into the flask in slight excess. The excess was removed during closure by means of a hydraulic press. A damp cellophane sheet was used as a separator for the two halves of the flask. The closing force of the press was applied slowly during the trial packing to allow the excess or flash to flow out between the halves of the flask.

The flask was reopened, arrangement of steel strengtheners checked, if they were not centred they were reoriented in the midline. During final closure of the flasks, metal to metal contact of the flask halves was ensured, the flasks were placed in a flask press (clamp) that maintained pressure and the specimens were processed.

The specimens were processed at 74°C for 1.5 hr with a terminal boil of one hour. After polymerization, the flasks were removed from the water bath and bench cooled overnight. Then specimens were retrieved carefully. The specimens were then finished by rubbing them against 400 grit

wet-dry sandpaper held on a flat surface i.e. glass slab. The specimens were supported by triangular blocks of 38 mm and subject to a deflecting tensile stress on a universal testing machine (Figure 4). The stress was applied by a round rod of 20 mm diameter, perpendicular to the long axis and at a constant speed of 5 mm/min. The resistance offered by each specimen was recorded.

**RESULTS**

When the fracture resistance of specimens with and without strengthener was compared, it was seen that strengtheners had enhanced the fracture load values of test specimens. Table 1 shows the fracture resistance of the various samples with and without steel strengtheners. Table 2 shows Mean values and Standard Deviations of Acrylic samples without strengtheners and with thin - thick gauge steel strengtheners. Table 3 shows p- value, and t-value comparing the acrylic samples with steel strengtheners in relation to those without steel strengtheners. Thick gauge strengtheners were found to be more resistant to fracture with highly significant values. Table 4 shows p-value, t-value comparing acrylic specimens with strengtheners in respect to thickness of strengtheners used (Thin gauge Vs. Thick gauge). Specimens with thick gauge steel strengtheners were found to be more resistant to fracture with highly significant values.

**Table 1:** Shows the fracture resistance of the various samples with and without steel strengtheners.

| Samples | Stress required to cause the fracture |       |           |       |           |       |
|---------|---------------------------------------|-------|-----------|-------|-----------|-------|
|         | So                                    |       | S1        |       | S2        |       |
|         | Divisions                             | Kg/m2 | Divisions | Kg/m2 | Divisions | Kg/m2 |
| 1       | 38                                    | 11.49 | 40        | 12.1  | 72        | 21.78 |
| 2       | 62                                    | 18.75 | 35        | 10.58 | 62        | 18.75 |
| 3       | 43                                    | 13.0  | 47        | 14.21 | 57        | 17.24 |
| 4       | 52                                    | 15.7  | 40        | 12.1  | 64        | 19.36 |
| 5       | 57                                    | 17.2  | 42        | 12.7  | 57        | 17.24 |
| 6       | 48                                    | 14.5  | 55        | 16.64 | 66        | 19.96 |
| 7       | 52                                    | 15.7  | 50        | 15.12 | 62        | 18.76 |
| 8       | 45                                    | 13.6  | 35        | 10.55 | 63        | 19.06 |
| 9       | 44                                    | 13.31 | 46        | 13.91 | 72        | 21.78 |
| 10      | 54                                    | 16.33 | 43        | 13.0  | 64        | 19.36 |
| 11      | 57                                    | 17.24 | 39        | 11.79 | 67        | 20.27 |
| 12      | 39                                    | 11.79 | 37        | 11.19 | 51        | 15.42 |

|    |    |      |    |       |    |       |
|----|----|------|----|-------|----|-------|
| 13 | 40 | 12.1 | 42 | 12.7  | 57 | 17.24 |
| 14 | 42 | 12.7 | 45 | 13.61 | 62 | 18.75 |
| 15 | 40 | 12.1 | 37 | 11.19 | 60 | 18.15 |

**Table 2:** Mean values and Standard Deviations of Acrylic samples without strengtheners and with thin - thick gauge steel strengtheners.

| S.No | Specimen | Mean Value | Standrad Deviation |
|------|----------|------------|--------------------|
| 1    | S0       | 14.36733   | 2.313067           |
| 2    | S1       | 12.76133   | 1.713038           |
| 3    | 2        | 18.874     | 1.712040           |

**Table 3:** Comparison of acrylic specimens without steel strengtheners to samples with steel strengtheners.

|          | t value     | P value  | Inference          |
|----------|-------------|----------|--------------------|
| S1 Vs So | 0.2087705   | 0.039401 | Not significant    |
| S2 Vs So | 5.859608463 | 1.53561  | Highly significant |

**Table 4:** Comparison of Acrylic Specimens with Strengtheners with Respect to Thickness of Strengtheners used (Thin gauge Vs. Thick gauge)

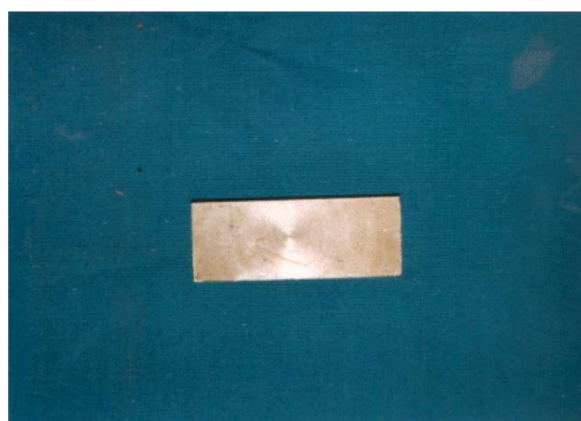
|          | P value | T value | Inference          |
|----------|---------|---------|--------------------|
| S1 Vs S2 | 1.59    | 9.55    | Highly significant |

## DISCUSSION

Since early 1940 polymethyl methacrylate has become most commonly used denture base material<sup>5</sup>. The three properties that have contributed most to the success of the material as a denture base are excellent appearance, simple processing and ease of repair. An inherent disadvantage is the liability of an acrylic denture to break during service as a result of fatigue failure in the mouth or impact failure out of the mouth.

The problem of denture breakage is fatigue failure and common site of fracture is the anteroposterior line that coincides with the notch for the relief of the labial frenum of either maxillary or mandibular denture. Various studies have been done on reinforcement of acrylic with carbon fibres, sapphire fibres<sup>2-5</sup> etc. The major disadvantage of these materials is that they are aesthetically unacceptable. This can be overcome by cost

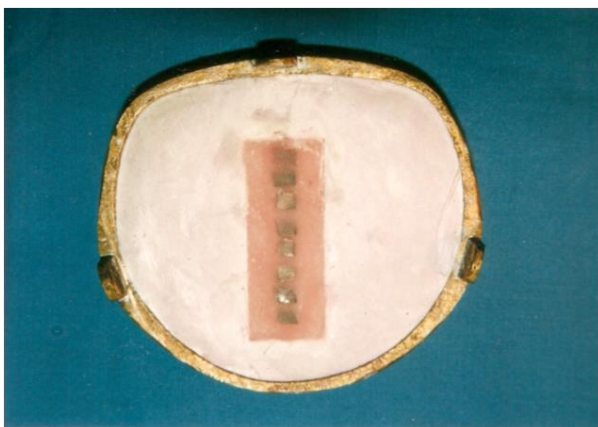
effective, aesthetically pleasing materials such as steel strengtheners.



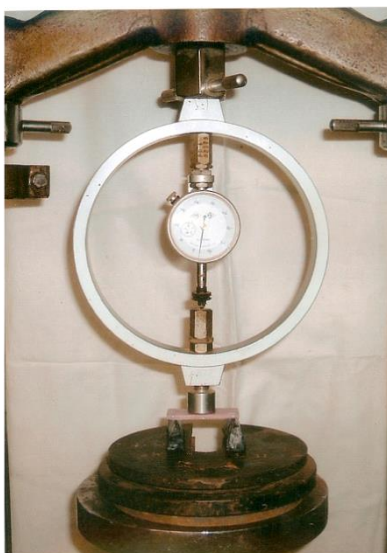
**Fig 1:** Brass Die.



**Fig 2:** Steel strengtheners.



**Fig 3:** Placement of steel strengtheners in the mould.



**Fig 4:** Universal testing machine.

Here in this study, it was found that an increase in thickness and size of steel strengtheners embedded in the acrylic resin polymer matrix enhanced the

fracture resistance of the test specimens. This is in accordance with previous studies<sup>6,7</sup>.

The mean fracture resistance of acrylic resin without the steel strengtheners and with the strengtheners is shown in Table 3. The difference is statistically significant. The fracture resistance of the acrylic samples which contained thick and thin gauge steel strengtheners i.e. placed perpendicular and parallel to fracture line; is as shown in Table 4. The difference was found to be statistically significant. Therefore, it is evident that the fracture resistance of heat cured acrylic resin, reinforced with thick gauge steel strengthener showed an enhanced resistance to fracture when compared to thin gauge. This is attributed to the nature of the joint and flexibility of the specimen while the strength is basically affected by the flexural characteristics.

Thin gauge strengtheners showed no increase in the fracture resistance as they do not resist deflection sufficiently so as to compensate for the discontinuity they produce in acrylic. On the other hand, incorporation of thick gauge steel strengtheners perpendicular or parallel to the anticipated fracture line will produce significant resistance to flexure and reduce the likelihood of acrylic resin denture base fracture.

## CONCLUSION

The present study confirmed that heat cured methyl methacrylic resin can be strengthened by the incorporation of low cost steel strengtheners. The thick gauge steel strengtheners fared better when compared to thin gauge steel strengtheners.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

## REFERENCES

1. Smith DC. The Acrylic denture –mechanical evaluation of midline fracture. *Br Dent J* 196;110:257-67.
2. San-Yue Chen, Wen-Miin Liang, Pau-Su Yen. Reinforcement of acrylic denture base resin by incorporation of various fibres. *J Biomed Mater Res* 200;58:203-8.

3. Uzun G, Hersek N, Tincer T. Effect of five woven fiber reinforcements on the impact and transverse strength of a denture base resin. *J Prosthet Dent* 1999; 81:616-20.
4. Vallittu PK. Flexural properties of acrylic resin polymers reinforced with unidirectional and woven glass fibers. *J Prosthet Dent* 1999;81:318-26.
5. Schreiber CK. Polymethylmethacrylate reinforced with carbon fibers. *Br Dent J* 1971;130:29-30.
6. Vallittu PK, Lassila VP. Effect of metal strengthener's surface roughness on fracture resistance of acrylic denture base materials. *J Oral Rehabil* 1992;19:385-91.
7. Vallittu PK, Lassila VP. Reinforcement of acrylic resin denture base material with metal or fiber strengtheners. *J Oral Rehabil* 1992;19:225-30.