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# A comparative evaluation of flexural strength of heat cure acrylic resin onreinforcement of zinc oxide nanoparticle and E-Glass fiber- An experimental study

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**ABSTRACT**

**Background:** Poly methylmethacrylate (PMMA) resin, commonly known as acrylic resin, is a standard material for denture base construction, yet challenges persist in balancing natural aesthetics with durability. This study compares the flexural strength of heat cure acrylic resin reinforced with zinc oxide nanoparticles and E-glass fiber, aiming to enhance denture longevity and resilience.

**Method:** A total of 30 specimens of DPI Heat Cure, India, were classified as Group A without reinforcement, Group B reinforced with 1.4% Zinc oxide nanoparticles, and Group C reinforced with E-glass fiber. The fabrication process included mixing the resin, packing, and polymerization and finishing. ANOVA tests were used for statistical analysis.

**Results:** Flexural strength testing was performed using a Universal Testing Machine, with results indicating significant differences among the groups. The mean flexural strengths were: ZnOE Nanoparticle group 93.34 MPa, E-glass fiber group 81.59 MPa, and Heat Cure acrylic resin group 59.54 MPa. Statistical analysis confirmed the ZnOE Nanoparticle group showed the highest flexural strength, followed by the E-glass fiber group, and the heat-cure acrylic resin group exhibited the lowest.

**Conclusion:** Reinforcement with ZnOE Nanoparticles significantly improved the flexural strength of heat-cure acrylic denture base specimens compared to E-glass fiber and Heat Cure acrylic resin. E-glass fiber also demonstrated significantly higher strength than heat-cure acrylic resin. These findings underscore the importance of material selection in denture base construction for enhanced durability.

**Keywords:** ***Denture Prosthesis, Polymethylmethacrylate (PMMA), Acrylic Resin, Flexural Strength, Reinforcement, ZnOE Nanoparticles, E-glass Fiber, Heat Cure Acrylic, Universal Testing Machine***

## INTRODUCTION

The durability and effectiveness of denture prostheses greatly depend on selecting the right materials. Achieving a natural look and ensuring dentures can endure the harsh conditions of the mouth and strong biting forces remains a challenge for dental professionals.[1] For the last eighty years, polymethylmethacrylate (PMMA) resin has remained the primary material used in constructing denture bases. Polymethylmethacrylate (PMMA) is often referred to as acrylic resin in various contexts.[1] These biocompatible materials are chemically inert, and dimensionally stable and have ease in their processing.[2]

Since the 1940s, acrylic resins, specifically heat-cured acrylic resin, have served as the primary restorative materials utilized for denture base construction.[3,4] These materials are typically cost-effective and easily handled by dental technicians,[5,6] allowing for the restoration of patients' function, appearance, and psychological well-being.[7,8] Despite their desirable properties, these materials have some drawbacks, including poor strength and dimensional changes.[9]However, with advancements, researchers have explored the potential of nanoparticles as reinforcement agents.

Zinc Oxide hasproven to be a potentially useful metal oxide for improving the mechanical properties of acrylic resin.[10] It is a white-colored powder, insoluble in water with a chemical formula of ZnO.[11] It is naturally found as the mineral zincite and can also be produced synthetically. In dentistry, Zinc oxide is widely used for various applications, including gutta-percha and root canal sealers.[12] The physical properties of heat-cured acrylic resins can be affected by the ZnO powder addition.[9]

Another approach involves reinforcing acrylic resin dentures with different fibers including carbon/graphite, aramid, glass, and polyethylene. Glass fibers are the most commonly used type of fibers due to their ease of manipulation, good bonding to polymers, and aesthetic properties. This reinforcement has long been recognized for its superior strength and biocompatibility.[13,14]

Despite the growing interest in these reinforcement materials, there remains a gap in the literature regarding a direct comparison between Zinc Oxide nanoparticles and E-Glass fiber in terms of their effectiveness in enhancing the flexural strength of heat cure acrylic resin. Therefore, the present study aims to compare the flexural strength of heat cure acrylic resin on reinforcement of zinc oxide nanoparticle and E-glass fiber.

**METHODOLOGY:**

The present in vitro study was conducted in the Department of Prosthodontics at ACPM Dental College, Dhule, for three months. The study involved the fabrication and testing of heat cure acrylic denture base specimens, to evaluate their flexural strength under different reinforcement conditions. The samples were prepared following ADA (American Dental Association) specifications, ensuring specimens of 65×10×2.5 mm dimensions with polished surfaces. Exclusion criteria included specimens with incorrect dimensions, voids, or defects, ensuring a total of 30 specimens of DPI Heat Cure, India, were selected.

These specimens were divided as: Group A without any reinforcement, Group B with reinforcement of 1.4% Zinc oxide nanoparticles, and Group C with reinforcement using E-glass fiber. The fabrication process began with mixing the heat cure acrylic resin, followed by packing in the dough stage. The mixing ration of acrylic resin is 2 part of powder mixed with 1 part of liquid. The powder is mix with liquid by manual method. In powder the reinforced material were added by weight of 2mg which were measure on weighting scale. For Group A, the specimens were then placed in a thermal chamber at 74°C for 2 hours, followed by 100°C for 1 hour for polymerization. Subsequently, finishing and polishing were performed after the completion of the polymerization process.

For Group B, the same fabrication steps were followed, with the addition of 1.4% Zinc oxide nanoparticles to the acrylic resin during mixing. Similarly, for Group C, E-glass fiber reinforcement was added during the mixing stage before the specimens were packed and subjected to the same polymerization process as Group A. Finishing and polishing were also conducted after polymerization for Group B and Group C specimens.

To evaluate the flexural strength of the fabricated specimens, testing was carried out using a Universal Testing Machine. The specimens were loaded using a ball end, and the flexural strength values were recorded for each group. This sequential process of sample preparation, including mixing, packing, polymerization, and testing, ensured a systematic evaluation of the flexural strength of heat-cure acrylic denture base specimens under various reinforcement conditions.

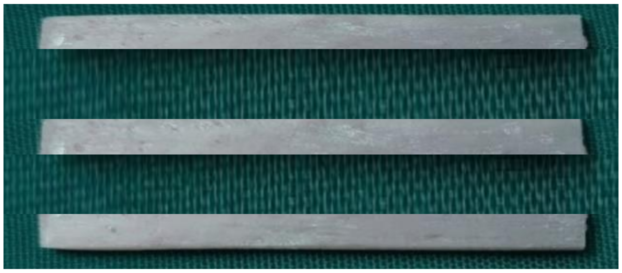

FIG. 1 E-GLASS FIBER REINFORCED HEAT CURE ACRYLIC RESIN SAMPLE

FIG.2 ZnO NANOPARTICLE REINFORCED HEAT CURE ACRYLIC RESIN SAMPLE


**FIG.3 UNIVERSAL TESTING MACHINE**

**Statistical analysis:**

The collected data on flexural strength from the three groups were subjected to comprehensive statistical analysis to determine any significant differences between the groups. Statistical software, such as SPSS (Statistical Package for the Social Sciences), was utilized for the analysis. Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were calculated for the flexural strength measurements of each group. To compare the mean flexural strength values among the three groups, a one-way ANOVA test was conducted.

**RESULTS:**

**Table 1: Comparison of flexural strength of three groups**

| Group | N | Mean | SD | Minimum | Maximum | p-value |
|---|---|---|---|---|---|---|
| ZnOE Nanoparticle | 10 | 92.81 | 2.62 | 89.5 | 97.6 | <0.001* |
| E-glass fibre | 10 | 81.98 | 2.65 | 78.1 | 85.5 | |
| Heat Cure acrylic resin | 10 | 59.24 | 2.80 | 55.8 | 64.5 | |

On-way ANOVA test; * indicates a significant difference at $p \leq 0.05$

This table compares the flexural strength of three groups. Highest flexural strength was seen in ZnOE Nano particle group followed by E-glass fibre group and least in Heat Cure acrylic resin. This difference in flexural strength of the three groups was statistically significant.

**Table 2: Pairwise comparison of flexural strength of three groups**

| Group | Mean difference | p-value |
|---|---|---|
| ZnOE Nano particle vs E-glass fibre | 10.83 | <0.001* |
| ZnOE Nano particle vs Heat Cure acrylic resin | 33.57 | <0.001* |
| E-glass fibre vs Heat Cure acrylic resin | 22.74 | <0.001* |

Post hoc Tukey test; * indicates a significant difference at $p \leq 0.05$

This table presents the pairwise comparison of flexural strength of three groups. ZnOE Nano particle group showed significantly greater flexural strength than E-glass fibre group and Heat Cure acrylic resin. Also, the E-glass fibre group showed significantly greater flexural strength'

**DISCUSSION:**

The outcomes of the study show the significant impact of reinforcement materials on the flexural strength of heat cure acrylic resin used in denture base construction. The incorporation of reinforcement agents, specifically Zinc Oxide nanoparticles and E-glass fiber, demonstrated marked improvements in flexural strength in comparison with the unreinforced heat cure acrylic resin group.

Zinc Oxide nanoparticles, known for their mechanical properties and compatibility with acrylic resin, exhibited the highest flexural strength among the tested groups. This outcome is consistent with previous studies suggesting the reinforcing effect of nanoparticles on polymer matrices. **R. Sathish Kumar et al.**[15] found that adding different nanoparticles to the matrix phase improved stress transfer between fiber layers, thereby enhancing mechanical properties. **Firas Abd Kati**[16] observed a rise in flexural strength with the inclusion of zinc oxide powder, attributing it to improved bonding between the ZnO particles and the polymer matrix. This finding aligns with our study where increase in the mean values of flexural strength (**97.6)** was observed following the addition of zinc oxide. **Li et al.'s**[17] study, also reported heightened flexural strength in micro-composite dentures with zinc oxide fillers.

Similarly, incorporating E-glass fiber reinforcement showed a significant increase in flexural strength relative to the unreinforced resin group. E-glass fibers, renowned for their high tensile strength and biocompatibility, provided additional structural support to the acrylic resin matrix.[18] The interfacial bonding between the fibers and resin matrix effectively distributed applied loads, there by minimizing crack propagation and improving overall mechanical properties.[19]

The observed differences in flexural strength between the reinforcement groups can be attributed to variations in their reinforcing mechanisms and structural characteristics. While Zinc Oxide nanoparticles enhance the matrix's intrinsic properties through particle dispersion and interfacial bonding, E-glass fibers directly reinforce the resin matrix through physical reinforcement.

Moreover, the statistical analysis reaffirmed the significant differences in flexural strength among the reinforcement groups, underscoring the importance of material selection in denture base fabrication. These findings offer valuable insights for dental professionals and prosthodontists in optimizing denture material composition to ensure long-term durability and patient satisfaction.

## CONCLUSION:

This study provides compelling evidence supporting the efficacy of Zinc Oxide nanoparticles and E-glass fiber as reinforcement materials for improving the flexural strength of heat cure acrylic resin in denture base construction. Both reinforcement agents demonstrated significant enhancements in flexural strength compared to unreinforced acrylic resin, with Zinc Oxide nanoparticles exhibiting the highest reinforcement efficiency.

The superior mechanical properties exhibited by the reinforced specimens highlight the potential of these materials in enhancing denture longevity and resilience against functional stresses. Dental professionals can utilize these insights to make well-informed choices about material selection and manufacturing methods, resulting in the creation of more durable and effective denture prostheses.

To explore the long-term performance and biocompatibility of reinforced denture materials in clinical settings, further research is warranted. Additionally, investigations into novel reinforcement strategies and composite formulations hold promise for advancing the field of prosthodontics and improving patient outcomes in dental prosthetic rehabilitation.

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