ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 06 | June - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

COMPARATIVE EVALUATION OF REINFORCING GRAPHENE OXIDE ON FRACTURE TOUGHNESS AND TENSILE STRENGTH IN TWO DIFFERENT ACRYLIC DENTURE BASE RESINS- AN INVITRO STUDY

Dentistry

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ABSTRACT

Introduction: The acrylic resins, particularly polymethyl methacrylate, are peculiarly, adapted to the needs of dentistry, particularly for the fabrication of denture bases, both complete and partial that are used to replace the lost tissues and to transfer the masticatory forces from the denture to the residual ridges. Most fractures of the dentures occur inside the mouth during function, primarily because of resin fatigue. **Aim:** This study evaluated the effect of graphene oxide nano particles on Fracture toughness and tensile strength, reinforced in two different denture base resins with and without veined acrylic. **Materials And Methods:** Customized metal die specimens where fabricated of dimensions 60mm x 10mm x 2mm (tensile strength), and five die specimens of dimensions 40mm x 8mm x 4mm (fracture toughness). These specimens where flasked and when opened created a mould space of aforementioned dimensions which where then packed with conventional PMMA material and veined PMMA with and without incorporation of graphene and acrylised, **Results And Discussion:** The mean, standard deviation, standard error, and 95% independent samples t-tests were conducted to compare the means of two confidence intervals were calculated for each group, there was significant difference in tensile strength and fracture toughness with incorporating 1% graphene in PMMA. Among the groups tested, the addition of graphene oxide nanoparticles to the heat cure acrylic resin with or without veined acrylic showed greater fracture toughness and tensile strength.

KEYWORDS

Graphene oxide , nanoparticle, Polymethyl methacrylate, fracture toughness, tensile strength.

INTRODUCTION:

The acrylic resins, particularly polymethyl methacrylate, are peculiarly adapted to the needs of dentistry, particularly for the fabrication of denture bases, both complete and partial that are used to replace the lost tissues and to transfer the masticatory forces from the denture to the residual ridge. The quest for an ideal denture base material has remained a challenge in dentistry since time immemorial. Most fractures of the dentures occur inside the mouth during function, primarily because of resin fatigue. Flexural fatigue occurs after repeated flexing of a material; it is a mode of fracture whereby a structure eventually fails after being repeatedly subjected to small loads that individually are not detrimental to the component. To overcome these shortcomings, several experiments have been conducted in order to try and improve the fracture toughness and tensile strength, and basic mechanical properties of PMMA.

Graphene oxide is recently used since it increases the surface hydrophobicity. The flexural strength of PMMA denture base increased with the addition of graphene nano particle concentration [0.4 %, 0.6%, 0.8%, 1.2% and 1.4%] to the polymethyl methacrylate denture base. Its high surface area, tensile strength, good thermal and electrical conductivity, flexibility, and low coefficient of thermal expansion impart it a better outcome than other conventional nanofillers. This study aimed to compare the flexural strength and compressive strength of Polymethylmethacrylate (PMMA) having addition of 1% Graphene as filler respectively with PMMA having no micro addition.

Aim Of The Study

To evaluate and compare fracture toughness and tensile strength using two different acrylic denture base materials reinforced with graphene.

1) To evaluate the tensile strength of polymethylmethacrylate reinforced with 1% graphene.
2) To evaluate and compare the tensile strength between conventional polymethylmethacrylate and veined polymethyl methacry late reinforced with 1% graphene.

MATERIALS AND METHODS:

Four customized metal die specimens where fabricated of dimensions 60mm x 10mm x 2mm (tensile strength), and five die specimens of dimensions 40mm x 8mm x 4mm (fracture toughness) (Fig 1 and Fig 2). These specimens where flasked and when opened created a mould space of aforementioned dimensions which where then packed with conventional PMMA material and veined PMMA with and without incorporation of graphene and acrylised.

- A total of 80 samples were prepared using denture base resin. The samples divided in to eight groups containing 10 samples each, group 1 (A1,A2,B1,B2) and group 2 (C1,C2,D1,D2) with rectangular shape.

Fig1: Stainless steel mould for tensile strength
Fig 2: Stainless steel mould for fracture toughness

Preparation Of PMMA Resin Samples:

Preparation Of Samples For Group 1 For Fracture Toughness:

Sample for group-1and group -2 were fabricated using polymer and monomer and graphene was measured using digital weighing machine. Nano particles were added to powder as per indicated in the subgroup below table. Polymer and monomer along with nanoparticles were mixed until a homogeneous mixture was obtained, and packed into the moulds created for fracture toughness measuring 40 mm length x 8 mm width x 4 mm thickness and for tensile strength measuring 60 mm length x 10 mm width x 2 mm thickness .10 samples were prepared in each subgroup. The flask was closed, and trial closure was carried out using hydraulic press.

The flask was then clamped and then pressure was maintained for 30 minutes to allow proper penetration of monomer into polymer. Bench curing was done for 30 mins.

Group- 1:
A1- PMMA without nanoparticle
A2- PMMA + 1% graphene oxide
B1- Veined PMMA without nanoparticle
B2- Veined PMMA + 1% graphene oxide

Group- 2:
C1- PMMA without nanoparticle
C2- PMMA + 1% graphene oxide

D1- Veined PMMA without nanoparticle
D2- Veined PMMA + 1% graphene oxide

Storage Of The Specimens:
Prior to fracture toughness and tensile strength tests, the specimens were stored in 37°C distilled water for 50 ± 2 hrs to stimulate oral environment.

Testing Of Specimens:
After fabrication of all samples, they were tested for fracture toughness and tensile strength. Each sample was tested using Universal Testing Machine (computerized, software based) ACME engineers, India, Model number Unitest10 at a cross head speed 1.0mm /min.

RESULTS:
Descriptive statistics were computed for all groups to summarize the central Tendency and dispersion of the data. The mean, standard deviation, standard error, and 95% confidence intervals were calculated for each group. Minimum and maximum values were also recorded to provide an overview of the data distribution. Independent samples t-tests were conducted to compare the means of two groups. (Table 1 and Table 2).

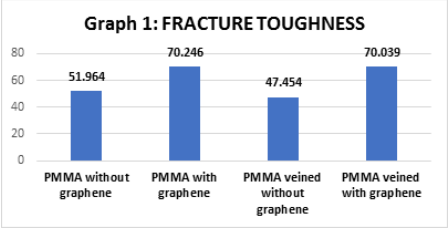
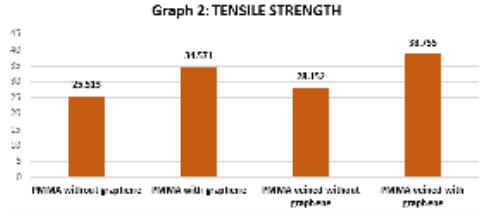


Table 1: Fracture Toughness

	N	Mean	Std. Deviation	95% confidence interval for mean		Min	Max
				Lower bound	Upper bound		
PMMA without graphene	10	51.9640	5.48059	48.0434	55.8846	42.26	59.77
PMMA with graphene	10	70.2460	7.79279	64.6714	75.8206	62.10	85.10
PMMA veined without graphene	10	47.4540	7.20595	42.2992	52.6088	37.46	58.11
PMMA veined with graphene	10	70.0390	11.99181	61.4606	78.6174	56.12	87.30
Total	40	59.9257	13.25841	55.6855	64.1660	37.46	87.30

Table 2: Tensile Strength

	N	Mean	Std. Deviation	95% confidence interval for mean		Min	Max
				Lower bound	Upper bound		
PMMA without graphene	10	25.5130	6.01677	21.20	29.8171	17.06	35.86
PMMA with graphene	10	34.5710	5.73013	30.47	38.6701	27.39	46.95
PMMA veined without graphene	10	28.1520	3.36220	25.74	30.5572	19.72	31.95
PMMA veined with graphene	10	38.7550	5.85833	34.5642	42.9458	30.19	48.45
Total	40	31.7477	7.37404	29.3894	34.1061	17.06	48.45



DISCUSSION
The principle behind the usage of nanoparticles is that alteration of filler size is considered responsible for the performance of the material (PMMA) in aspects of both polishability and fracture resistance.

According to previous studies, incorporation of graphene in PMMA materials might further enhance resin's mechanical properties In the present study, the PMMA incorporated with 1% graphene showed higher fracture toughness and tensile strength as compared to unmodified PMMA (15%). Based on this study it can be concluded that the fracture toughness and tensile strength of PMMA is increased affected by incorporation of 1% graphene.

The results of the present study are in consistent with S. Di carlo ,et.al, in their article Flexural strength and elastic modulus evaluation of structures made by conventional PMMA and PMMA reinforced with graphene in 2020 concluded that addition of 1% of graphene to PMMA leads to an increase of 80% in the value of the EM and of 20% in the value of the tensile strength. They concluded that decrease in flexural strength of PMMA may be due to the effect of nano sized oxides on the internal structure of polymerized PMMA. The above study demonstrated that fracture toughness and tensile strength increased by the addition of extra additive to acrylic resin, which acted as a filler.

According to previous studies, by Cecilia Bacali , in their article The Influence of Graphene in Improvement of Physio - Mechanical Properties in PMMA Denture Base Resins it was found that 1% Gr-Ag content would be sufficient for the material to endure higher applied loads, to exhibit higher flexural strength and compressive strength compared to the unmodified PMMA. However, a content of 2% Gr- Ag showed lower ratios of absorbed water, which could reduce the risks of water mediated degradation effects.

Few studies also demonstrates that increase in silver Nano particles by 2% by weight decreased the compressive strength, hence for this study 0.005% of sliver Nano particles was used.

CONCLUSION:
This study evaluated the effect of graphene oxide nano particles on fracture toughness and tensile strength, reinforced in two different denture base resins with and without veined acrylic. Specimens of Heat-cured acrylic resin materials were fabricated by reinforcing with graphene oxide nanoparticles to polymethyl methacrylate with and with-out veined acrylic and with and without reinforcing nanoparticles. Among the groups tested, the addition of graphene oxide nanoparticles to the heat cure acrylic resin with or without veined acrylic showed greater fracture toughness and tensile strength.

There was no significant difference for group between veined or non veined heat cure acrylic resin.

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