RESEARCH PAPER

The effect of incorporating zirconium oxide nano particles on flexural strength of two different commercially available PMMA denture base materials: In vitro study

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ABSTRACT
Background and Introduction : Poly methyl methacrylate (PMMA) is widely used for denture bases but has limited flexural strength. Incorporating zirconia (ZrO_2) nanoparticles can enhance the mechanical properties of PMMA. This study evaluates the effect of zirconia oxide nanoparticles on the flexural strength of two commercial PMMA denture materials. The goal is to improve denture durability for clinical use.
Materials : ARMAMENTARIUM -Ultra bath sonicator (RC SYSTEMS) ,Digital weighing scale (INDICA) ,Magnetic stirrer (REMI INDIA),Hot air oven (ALMICRO INSRTUMENTS),Dental flasks and clamps (JABBAR & CO) ,Hydraulic press (SIRIO) ,Acrylizing unit (UNIDENT) ,Universal testing machine (MECMESIN MULTI TEST 10-i, INDIA) Digital Vernier Caliper (ANY JEW95VC200), Micromotor with handpiece (MARATHON) ,Lathe machine ,Dappen Dish Stainless Steel Spatula , Acrylic trimming burs and Polishing burs . Heat-cured acrylic resin (Lucitone and Acryton H) Materials--Dental stone (KALABHAI),Zirconium oxide nanoparticles. (SISCO Research Laboratories PVT. LTD.) , (Methyl Benzene) ,99% (3- Amino propyl) triethoxysilane (SIGMA ALDRICH),Rectangular shaped metal plates of dimensions 65×10×3.3±0.03mm (ISO standard #1567) for fabrication of specimens for flexural strength,Separating Media and Distilled water .
Method :120 specimens fabricated and divided into two groups to test flexural strength. Each group further subdivided into four groups each containing 15 specimens. Metal plates designed with dimensions of 65 × 10 × 3.3 ± 0.03 mm (ISO1567) for flexural strength invested in dental stone in the flask to create empty cavity for the denture base material.
Results: When zirconium oxide nanoparticles were incorporated at 1% (w/w %), there was a noticeable improvement in flexural strength of both the materials compared to the control group. A further increase in nanoparticle concentration to 2.5% (w/w %) resulted in a more pronounced enhancement, indicating that reinforcement at this level contributed substantially to the mechanical performance of the material. The highest flexural strength was observed in the group with 5% (w/w %) zirconium oxide nanoparticles.
Conclusion: Lucitone PMMA denture base material demonstrated higher flexural strength than Acryton H across all corresponding groups, indicating that Lucitone responded more favorably to zirconium oxide nanoparticle reinforcement.
Keywords: Pmma,Zirconium Oxide Nanoparticles,Flexural Strength,Denture Base Resin,Nanocomposite,Universal Testing Machine

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INTRODUCTION

The Rapid advancements in various fields have raised expectations, and individuals now seek high-end treatments that closely mimic natural conditions, because of innovations in materials and technologies. The development of denture base materials has evolved significantly, driven by the growing demand for high-end treatments that mimic natural conditions. As individuals increasingly expect advanced and natural-looking dental solutions, the need for improved materials has become paramount.

Polymethylmethacrylate (PMMA) has been the widely used material for denture fabrication due to its desirable properties such as good aesthetics, ease of manipulation, repairability, accurate surface details reproduction, nontoxic and economical.[1,2] Despite being popular it has certain inadequacies and poor mechanical properties, which leads to fracture of denture or affects the durability of the dentures.[3,4]

The advent of nanotechnology in the field of prosthodontics has diverted attention towards application of nano sized filler particles into various dental materials. Theses enhanced dental materials such as PMMA have shown improvement in its mechanical properties. These effects are observed due to polymer-particle interface, the size of the particles, the method of fabrication and dispersion of particles within the resin matrix.[6] When nano particles such as aluminium oxide, zirconium oxide, silver oxide, titanium oxide etc., were used properties like wear and tear resistance, fracture resistance and high polish ability was achieved.[7-8]

The technological importance of zirconia oxide is greatly appreciated. It has a good natural white colour, high strength, transformation toughness, good chemical stability, and outstanding corrosion, chemical and microbial resistance. Several studies have reported that PMMA when incorporated with zirconia oxide fillers exhibit a significant increase in its flexural strength,[5-9]but few other studies have observed that flexural strength had slightly decreased due to the clustering of the particles within the resin matrix, these clusters reduces the strength of the material. In addition, when this zirconia oxide - PMMA composite was tested for impact strength, fracture toughness and hardness a significant increase was observed. However, one of the studies found that the increase in impact strength and surface hardness of zirconia oxide reinforced resin when compared to unreinforced PMMA. Zirconia oxide - PMMA composite also showed increase in thermal conductivity which is beneficial for the patient. Therefore, adding zirconia oxide nano particles was proposed to improve the mechanical properties. This resulted in improved impact strength, flexural strength, fatigue strength, compressive strength and also its fracture toughness and hardness.

AIM AND OBJECTIVES :

AIM: The aim is to investigate the effect of incorporating zirconium oxide nano particles on flexural strength of different commercially available PMMA denture base material

OBJECTIVES:

1.To Incorporate nano particles of zirconium oxide in two different commercially available PMMA denture base material.

2.To evaluate the flexural strength of two different PMMA denture base material with incorporated zirconium oxide nano particles.

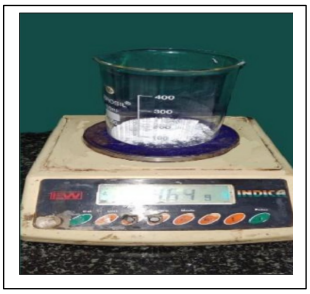
MATERIALS AND METHODS : This *in vitro* study was carried out in Department of Prosthodontics, Mithila Minority Dental College and Hospital, Darbhanga.

ARMAMENTARIUM:Ultra bath sonicator (RC SYSTEMS),Digital weighing scale (INDICA),Magnetic stirrer (REMI INDIA),Hot air oven (ALMICRO INSRTUMENTS),Dental flasks and clamps (JABBAR & CO),Hydraulic press (SIRIO),Acrylizing unit (UNIDENT),Universal testing machine (MECMESIN MULTI TEST 10-i, INDIA),Digital Vernier Caliper (ANY JEW95VC200),Micromotor with handpiece (MARATHON),Lathe machine,Dappen Dish,Stainless Steel Spatula,Acrylic trimming burs and Polishing burs.

MATERIALS :Heat-cured acrylic resin (Lucitone and Acryton H), Dental stone (KALABHAI)Zirconium oxide nanoparticles. (SISCO Research Laboratories PVT. LTD.),Toluene (Methyl Benzene), 99% (3- Amino propyl) triethoxysilane (SIGMA ALDRICH),Rectangular shaped metal plates of dimensions 65×10×3.3±0.03mm (ISO standard #1567) for fabrication of specimens for flexural strength, Separating Media and Distilled water .

FIGURE 1. MATERIALS USED IN THE STUDY

Toluene **99% APTES** **Zirconium Oxide Nanopowder** **Acrylic Resin(Lucitone and Acryton- H)**



Electronic weighing Balance

Ultra Bath Sonicator

FIGURE 2. ELECTRONIC DEVICES USED IN THE STUDY

1% PMMA ZrO_2

2.5 % PMMA ZrO_2

5 % PMMA ZrO_2

FIGURE 3. PMMA/ZRO_2 NANO-COMPOSITE IN DIFFERENT CONCENTRATIONS.

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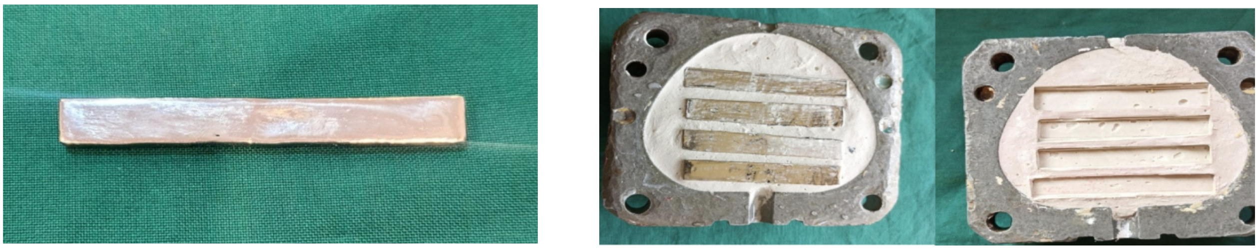

FIGURE 4. METAL PLATE AND INVESTMENT OF PLATES IN DENTAL STONE AND MOULD SPACE

Method :In this study 120 specimens will be divided into 2 groups to test Flexural Strength, further they will be divided into 4 groups each containing 15 specimens.

TABLE 1 :STUDY DESIGN OF SPECIMENS FOR FLEXURAL STRENGTH

Groups	Sample size	Percentage of SiZrO$_2$ nanoparticles	Shape of the specimens
for Flexural strength(Lucitone)			
A	15	Control	
B	15	1% w/w	
C	15	2.5% w/w	
D	15	5% w/w	

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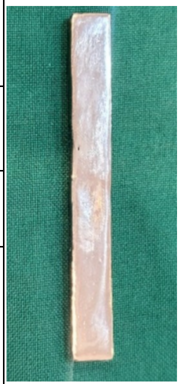
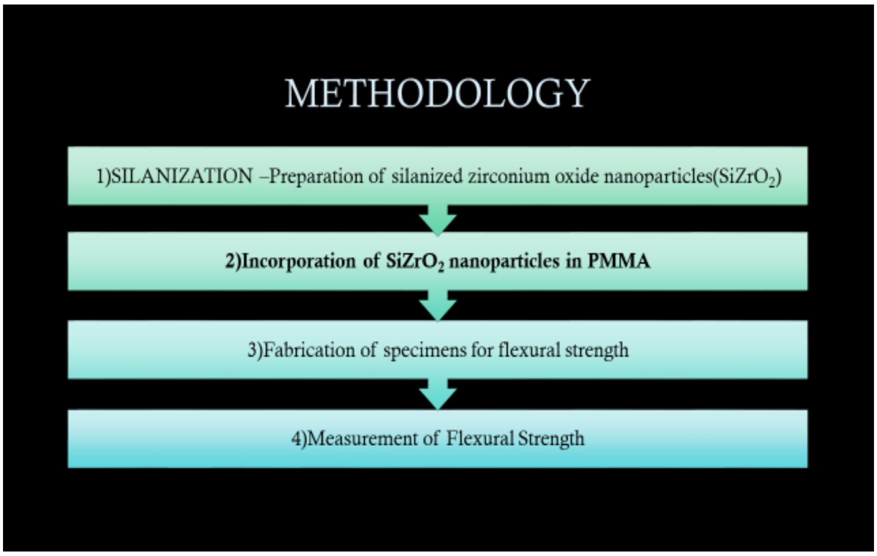
For Flexural strength(Acryton- H)			
E	**15**	**Control**	
F	**15**	**1% w/w**	
G	**15**	**2.5% w/w**	
H	**15**	**5% w/w**	



PREPARATION OF SILANIZED ZrO_2 NANOPARTICLES ($SiZrO_2$):

Purpose of silanization: -To create a strong stable chemical bond and improve dispersion between the inorganic zirconia particles and PMMA ..

In silanization ,APTES {(3-amino propyl) triethoxysilane}is the reactive molecule that functionalizes a surface with an amine group to enable the attachment of biomolecules ,while toluene is a solvent that is often used to dissolve the APTES and promote the formation of a uniform monolayer. The silanization process was carried out in two stages:

Stage I: Accurately measured volume about 1ml of APTES was dissolved in 100 ml of toluene. To this accurately weighed 2 grams of ZrO_2 nanopowder was added, the mixture was kept aside for 10 minutes for saturation of the solution, followed by sonication for 20 minutes for intermittent mixing. The mixture was stirred for 24 hours in thermally controlled magnetic stirrer. It was further kept at controlled temperature to allow evaporation of toluene to obtain the silanized ZrO_2 nanopowder.

Stage II: The obtained silanized ZrO_2 nanopowder was heated at 120ºC for 2 hours in an hot air oven for complete activation.

INCORPORATION OF $SiZrO_2$NANOPARTICLES IN PMMA:

Desired concentration of $SiZrO_2$ nanoparticles viz., 1%, 2.5% and 5% was separately mixed with known ratios of heat cured conventional PMMA resin by geometric dilution technique.

This technique results in uniform distribution of $SiZrO_2$ nanoparticles in PMMA resin .

Later on this mixture was added to monomer in the ratio of 3:1 by volume and the specimens were fabricated by standard technique.

FABRICATION OF SPECIMENS

A total of 120 specimens were fabricated from heat cured conventional PMMA resin.Metal plates having dimensions 65×10×3.3±0.03 mm (ISO standard #1567) were used to fabricate specimens for flexural strength test.These metal plates were invested in dental stone which was poured in the lower half portion of the flask, followed by application of separating media on the surface of the stone. The upper half portion of the flask was then seated and filled with next layer of stone. When the stone was set, flasks were opened and the plates of metal were removed. Hence empty mold spaces were obtained.The cavities were then filled with $SiZrO_2$ nanoparticles previously mixed with PMMA resin to obtain rectangular shaped specimens.

PROCEDURE :

The monomer and polymer were mixed and left to polymerize for 7 to 11 minutes at 22ºC, till it reaches dough stage.When the material reached dough stage it was kneaded with fingers and placed in the mould in the metal flasks.The trail closures were carried out using the hydraulic press. Later the flask was clamped and left for 1hour before curing.After 1hr the flasks were immersed in water for acrylization. Polymerization was accomplished by immersion in water bath for 1hour and 30 minutes at 74º C and for 1hour at 100ºC.Flasks were cooled to room temperature and then deflasked to avoid any sort of distortion. The acrylic samples were then retrieved, finishing was done on surfaces by a standardized method using progressively smoother aluminium oxide papers (grit number 200, 400, 600, 800) and polished with pumice slurry.The fabricated specimens were verified for its dimension and quality as per the standards and immersed in distilled water for further study.

EVALUATION :

Quality: The specimens were observed and evaluated for their quality with respect to colour, texture and appearanceas per the standard methods

FIGURE 5: RECTANGULAR SHAPED SPECIMENS FOR FLEXURAL STRENGTH

Dimensions: The fabricated specimens were evaluated for its dimensions. In each specimen the length, width and thickness was confirmed by using digital vernier calliper.

FIGURE 6: MEASUREMENT OF DIMENSIONS OF RECTANGULAR SHAPED SPECIMENS

MEASURING FLEXURAL STRENGTH :

Each specimen was tested for flexural strength using three point bending test in a universal testing machine. The UTM consists of loading wedges which are placed 50mm apart. The specimen is then centered on the device such that the loading edges were set to engage the center of the upper surface of all specimens at a cross head speed of 5mm/minute. These specimens are loaded until fracture occurs. Flexural strength was calculated using the formula:

$S=3PL/2bd^2$ Where

S is the flexural strength ,

P is peak load applied,

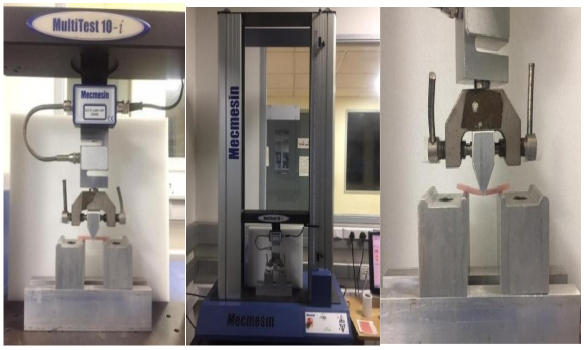
L is the span length (50mm),

b is the specimen width (10 mm)

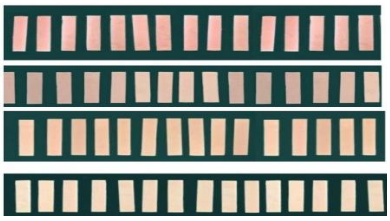
d is the specimen thickness (3.3 mm).

Mean flexural strength was calculated in MPa

Figure 7 : a. UTM, b. and c. loading of specimens.



a **b** **c**



RESULTS :

Each specimen was tested for flexural strength using three point bending test in a universal testing machine. The UTM consists of loading wedges which are placed 50mm apart. The specimen is then centered on the device such that the loading edges were set to engage the center of the upper surface of all specimens at a cross head speed of 5mm/minute. These specimens are loaded until fracture occurs. Flexural strength was calculated using the formula:

$S=3PL/2bd^2$

After the calculation of flexural strength the results where tabulated as follows

Table no. 2 Comparison of mean Flexural Strength (in Mpa) b/w different conc. of zirconium oxide Nano particles incorporated into Acryton-H PMMA denture base material using One-way ANOVA test

Groups	N	Mean	SD	Min	Max	p-value

Group 1	15	81.245	1.195	79.16	83.17	<0.001*
Group 2	15	93.338	5.676	83.83	100.25	
Group 3	15	107.544	3.617	101.83	113.33	
Group 4	15	135.951	12.075	119.50	157.42	

- Statistically Significant

Note: Group 1: Conventional heat cure Acryton-H PMMA resin (control group); **Group 2:** Conventional heat cure Acryton-H PMMA resin incorporated with ZrO_2 nanoparticles 1% (w/w %); **Group 3:** Conventional heat cure Acryton-H PMMA resin incorporated with ZrO_2 nanoparticles 2.5% (w/w %) **& Group 4:** Conventional heat cure Acryton-H PMMA resin incorporated with ZrO_2 nanoparticles 5% (w/w %).

Table no. 3 Comparison of mean Flexural Strength (in Mpa) b/w different conc. of zirconium oxide Nano particles incorporated into Lucitone PMMA denture base material using One-way ANOVA test

Groups	N	Mean	SD	Min	Max	p-value
Group 1	15	86.589	0.800	84.89	87.83	<0.001*
Group 2	15	97.413	4.397	88.83	105.70	
Group 3	15	114.879	6.294	105.41	130.09	
Group 4	15	145.927	10.040	127.74	163.27	

- Statistically Significant

Note: Group 1: Conventional heat cure Lucitone PMMA resin (control group); **Group 2:** Conventional heat cure Lucitone PMMA resin incorporated with ZrO_2 nanoparticles 1% (w/w %); **Group 3:** Conventional heat cure Lucitone PMMA resin incorporated with ZrO_2 nanoparticles 2.5% (w/w %) **& Group 4:** Conventional heat cure Lucitone PMMA resin incorporated with ZrO_2 nanoparticles 5% (w/w %).

STATISTICAL ANALYSIS : Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses. Descriptive Statistics: Descriptive analysis includes expression of Flexural strength in terms of Mean & SD for each group. Inferential Statistics: One-way ANOVA Test followed by Tukey's post hoc Test was used to compare the mean Flexural Strength (in MPa) between different concentrations of Zirconium oxide nanoparticles incorporated into Acyrton-H and lucitone PMMA denture base materials. The level of significance was set at $p<0.05$.

Research Question Does the incorporation of zirconium oxide nanoparticles at different concentrations improve the flexural strength of conventional heat cure Acryton-H and lucitone PMMA denture base resin compared to the unmodified control?

Null Hypothesis (H_0)

The incorporation of zirconium oxide nanoparticles at different concentrations into conventional heat cure Acryton-H and lucitone PMMA denture base resin does not produce any difference in flexural strength when compared to the control group without nanoparticles.

Alternative Hypothesis (H_1)

The incorporation of zirconium oxide nanoparticles at different concentrations into conventional heat cure Acryton-H and lucitone PMMA denture base resin does produce any difference in flexural strength when compared to the control group without nanoparticles.

Table no. 4 Multiple comparison of mean difference in Flexural Strength b/w different conc. of zirconium oxide Nano particles incorporated into Acryton-H PMMA denture base material using Tukey's HSD Post hoc Analysis

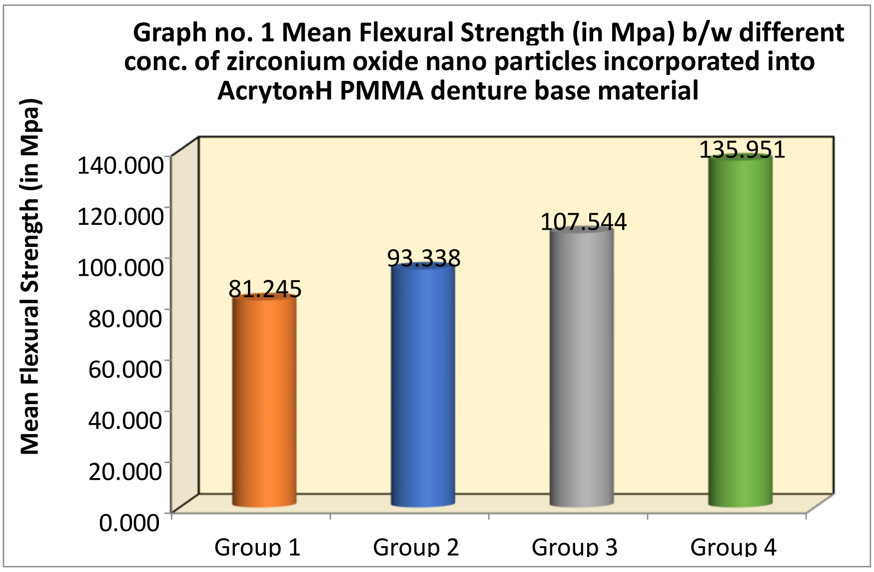
Material	(I) Groups	(J)Groups	Mean Diff. (I-J)	95% CI of the Diff.		p-value
				Lower	Upper	
Acryton-H PMMA denture base material	Group 1	Group 2	-12.093	-18.801	-5.385	<0.001*
		Group 3	-26.299	-33.007	-19.591	<0.001*
		Group 4	-54.707	-61.415	-47.999	<0.001*
	Group 2	Group 3	-14.206	-20.914	-7.498	<0.001*
		Group 4	-42.613	-49.321	-35.905	<0.001*
	Group 3	Group 4	-28.407	-35.115	-21.699	<0.001*

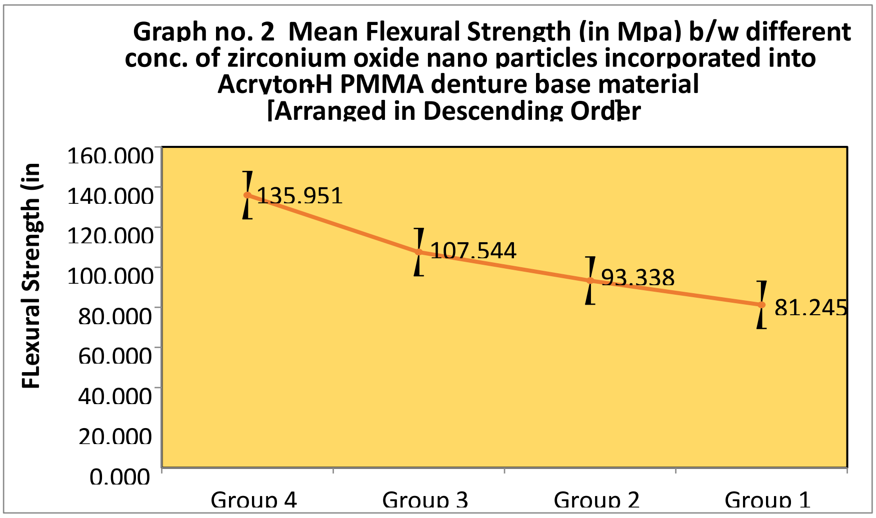
* Statistically Significant

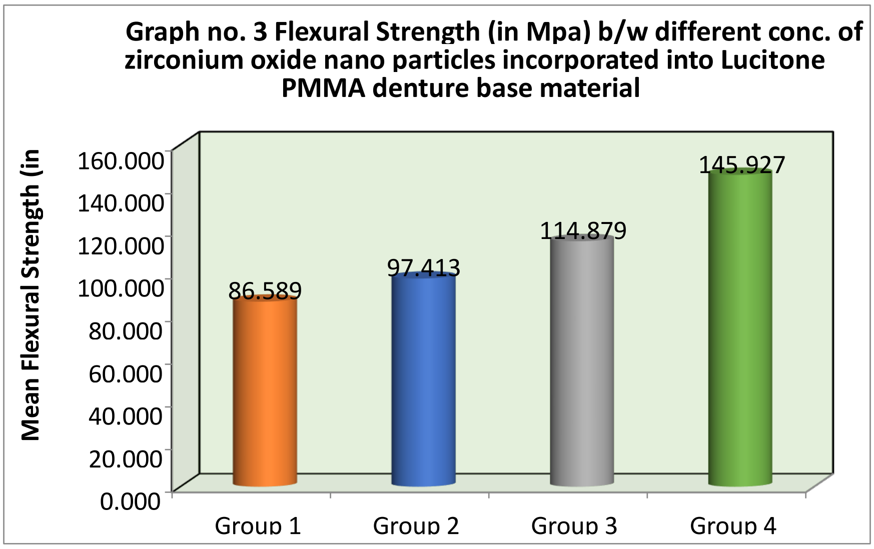
Table no. 5 Multiple comparison of mean difference in Flexural Strength b/w different conc. of zirconium oxide Nano particles incorporated into Lucitone PMMA denture base material using Tukey's HSD Post hoc Analysis

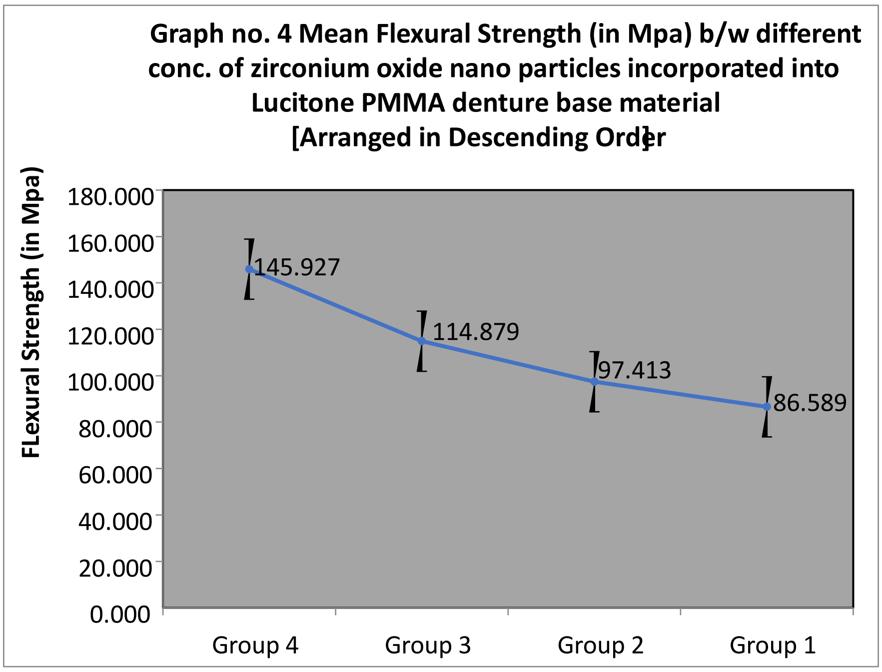
Material	(I) Groups	(J)Groups	Mean Diff. (I-J)	95% CI of the Diff.		p-value
				Lower	Upper	
Lucitone PMMA denture base material	Group 1	Group 2	-10.824	-16.947	-4.701	<0.001*
		Group 3	-28.290	-34.412	-22.167	<0.001*
		Group 4	-59.337	-65.460	-53.215	<0.001*
	Group 2	Group 3	-17.466	-23.588	-11.343	<0.001*
		Group 4	-48.513	-54.636	-42.391	<0.001*
	Group 3	Group 4	-31.048	-37.170	-24.925	<0.001*

* Statistically Significant


Graph no. 1 Mean Flexural Strength (in Mpa) b/w different conc. of zirconium oxide nano particles incorporated into AcrytonH PMMA denture base material
Mean Flexural Strength (in Mpa)
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
81.245
93.338
107.544
135.951
Group 1
Group 2
Group 3
Group 4


Graph no. 2 Mean Flexural Strength (in Mpa) b/w different conc. of zirconium oxide nano particles incorporated into AcrytonH PMMA denture base material [Arranged in Descending Order]
FLexural Strength (in
160.000
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
135.951
107.544
93.338
81.245
Group 4
Group 3
Group 2
Group 1


Graph no. 3 Flexural Strength (in Mpa) b/w different conc. of zirconium oxide nano particles incorporated into Lucitone PMMA denture base material
Mean Flexural Strength (in
160.000
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
86.589
97.413
114.879
145.927
Group 1
Group 2
Group 3
Group 4



DISCUSSION :Polymethylmethacrylate (PMMA) acrylic resin is often the material of choice for the fabrication of denture bases due to their low cost, favorable esthetics, stability in oral environment and other favorable characteristics.[12-13]The major drawback of these resins is fracture or breakage due to fatigue because of poor transverse, impact and flexural strengths leading to crack development. In the mouth the type of loading that is experienced by the denture can be represented by the transverse strength and flexural strength. Hence for an exceptional clinical performance of the denture a high value of flexural strength and transverse strength is suitable. In dentures, an effect is seen called Fatigue phenomenon, which is a low and repetitive stress rate that mostly occurs with time. Small stresses that are caused due to mastication with time might contribute to the formation of minute cracks that can propagate through the dentures hence resulting in fracture. Therefore, improvement in strength of PMMA resin was necessary.[14]In the past to improve the mechanical properties of PMMA, several attempts were made. This included the modification of composition with copolymers, by using different methods of curing or by reinforcing with fibers like Al_2O_3, ZrO_2, TiO_2, SiO_2 etc. In the present study an *in vitro* study was carried out to improve the mechanical strength and test flexural strength of two conventional PMMA resins i.e Acrytone H and Lucitone by incorporating modified zirconium oxide i.e., silanized zirconium oxide nano powder. The mechanical properties of PMMA resins are anticipated to be improved with the addition of zirconia oxide nano particles. This was because in previous studies the mechanical properties were found to be improved when ZrO_2 was added into PMMA. This material was used also because it has excellent biocompatibility and white colour, which is not likely to alter aesthetics. The ratios of the zirconia oxide nano particles should be such that its distribution within the resin matrix should not interrupt the continuity of the matrix. Gad et al[10] stated that zirconia oxide nano particles incorporation in PMMA results in significant increase in flexural strength values and this was due to good distribution of the nano size particles that has filled the spaces between the polymeric chain.

Flexural strength: For Flexural strength analysis, In this study 120 specimens were divided into 2 groups which were further divided into 4 groups each containing 15 specimens having dimensions of 65×10×3.3±0.03mm (ISO standard #1567) were subjected to three-point bending test on the universal testing machine. The results obtained suggested a statistically highly significant ($p<0.0001$) increase in the flexural strength of test groups i.e., 1%, 2.5% and 5% groups when compared with the control groups ($p < 0.0001$). The highest mean for zirconium oxide Nano particles incorporated into Acryton-H PMMA denture base material using One-way ANOVA test was 139.40 ±12.32 MPa was observed in 5% group, then 2.5% group with 107.6 ±3.246MPa, then 1% group with 93.93 ±5.075 MPa and the least in control group with 81.28 ±1.097 MPa. Similar results were observed in different conc. of zirconium oxide Nano particles incorporated into Lucitone PMMA denture base material werein the highest mean was 145.927±10.040 as observed in 5% group followed by 114.879±6.294 for 2.5% group then 1% group with 97.413±4.397 and the least in control group with 86.589±0.800 MPa .The results obtained were in agreement with the outcome reported by the others who concluded that the incorporation of zirconia in ceramics, dental restorative resins as well as acrylic resin exhibited an improvement in their mechanical properties.[12,22,28] The evaluation of flexural strength in Acryton-H PMMA denture base material revealed a clear and progressive trend across the experimental groups. The control group, which consisted of conventional heat cure Acryton-H PMMA resin without any modification, demonstrated the lowest flexural strength values. When zirconium oxide nanoparticles were incorporated at 1% (w/w %), there was a noticeable improvement in flexural strength compared to the control group. A further increase in nanoparticle concentration to 2.5% (w/w %) resulted in a more pronounced enhancement, indicating that reinforcement at this level contributed substantially to the mechanical performance of the material. The highest flexural strength was observed in the group with 5% (w/w %) zirconium oxide nanoparticles, where the improvement was most significant, establishing a clear concentration-dependent strengthening effect. Pairwise comparisons between the groups confirmed that each incremental increase in nanoparticle concentration led to a meaningful improvement in flexural strength. The difference between the control group and the 1% group was evident, and the gap widened further when the 2.5% group was compared with both the control and the 1% group. The most striking difference was observed between the control group and the 5% group, highlighting the substantial reinforcement achieved at the highest concentration. Comparisons among the intermediate groups also demonstrated consistent improvements, with the 2.5% group outperforming the 1% group, and the 5% group surpassing all others. A similar pattern was observed in Lucitone PMMA denture base material. The control group of Lucitone resin exhibited the lowest flexural strength, while the incorporation of zirconium oxide nanoparticles at 1% (w/w %) produced a measurable increase. The 2.5% (w/w %) group showed a further enhancement, and the 5% (w/w %) group achieved the highest flexural strength values among all groups. The progression across the groups demonstrated that the reinforcing effect of zirconium oxide nanoparticles was consistent and concentration-dependent in Lucitone resin as well. Pairwise comparisons within Lucitone groups also reflected the same trend. The control group differed significantly from each of the nanoparticle-reinforced groups, with the magnitude of difference increasing as the concentration rose. The 1% group was outperformed by the 2.5% group, and the 5% group consistently demonstrated superior flexural strength compared to all other groups. The stepwise improvement across concentrations confirmed that zirconium oxide nanoparticles imparted a cumulative strengthening effect on Lucitone resin. When the two denture base materials were considered together, both Acryton-H and Lucitone PMMA resins exhibited a similar pattern of reinforcement. In both materials, the control groups showed the lowest flexural strength, while the incorporation of zirconium oxide nanoparticles at increasing concentrations led to progressive improvements. The 5% (w/w %) groups consistently achieved the highest flexural strength values, underscoring the effectiveness of nanoparticle reinforcement. Importantly, when the two materials were compared, Lucitone PMMA denture base material demonstrated higher flexural strength than Acryton-H across all corresponding groups, indicating that Lucitone responded more favorably to zirconium oxide nanoparticle reinforcement.

The increase in strength in this study was due to silanization of the zirconia oxide nanoparticles, which improved the wettability of the zirconium oxide nano particle to the resin matrix. The increase in mechanical properties can be attributed to the nano size of the zirconia oxide nano particles that helps in filling the interstitial matrix. This leads to homogenous dispersion of the nano-zirconia fillers. Furthermore, a strong adhesion is formed between the surface of zirconia oxide nano particle and the coupling agents which increases the mechanical properties of the zirconia oxide- PMMA nano composite.[7-15]In addition to this, a greater number of contact points are formed between the PMMA and nano-zirconia oxide fillers due to the large interfacial area of nano particles. This improves the mechanical interlocking and allows changes in the properties of zirconia-PMMA nano composite provided by plastic deformation and an increase in the ductility of the PMMA matrix.[16-17] Therefore the homogenous distribution of the zirconia oxide nano particles transfer the PMMA matrix to the strong nano-ZrO_2 filler. Several issues such as long processing time, un even positioning of fibers within the denture, heterogeneous distribution of the fibers in the matrix, poor wettability of fibers in areas where denture is thin and poor bonding among the fibers and the matrix because of lack of polymerization can be avoided when zirconia reinforced PMMA is used.[18] Clinical trials need to be done because this study was carried out under in vitro conditions. This study is also limited with the use of zirconia. Whereas, other forms of zirconia like Yittria stabilized zirconia and nano-composites of titanium, aluminium with zirconium oxide can also be used for reinforcement. In-situ studies are suggested to investigate the clinical performance of this material in oral cavity. Hence, this study would contribute in the development of PMMA/Zr composite reinforcements.

CONCLUSION :The present in vitro study demonstrated that the incorporation of zirconium oxide nanoparticles into heat-cured PMMA denture base resins significantly enhanced their flexural strength in a concentration-dependent manner. Both Acryton-H and Lucitone resins showed progressive improvements as the nanoparticle concentration increased from 1% to 5% (w/w %). The control groups consistently exhibited the lowest flexural strength, while the groups reinforced with 5% zirconium oxide nanoparticles achieved the highest values. These findings confirmed that zirconium oxide acted as an effective reinforcing agent, improving the mechanical performance of PMMA denture base materials and potentially overcoming one of the major limitations of conventional acrylic resins.

When the two materials were considered, Lucitone PMMA resin consistently demonstrated higher flexural strength than Acryton-H across all corresponding groups, suggesting that the intrinsic properties of Lucitone allowed it to respond more favourably to nanoparticle reinforcement. The overall results highlighted that both materials benefited from zirconium oxide incorporation, but Lucitone exhibited superior reinforcement potential. Within the limitations of this study, it may be concluded that the addition of zirconium oxide nanoparticles, particularly at higher concentrations, can substantially improve the flexural strength of PMMA denture base resins, thereby enhancing their clinical durability and performance..

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