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COMPARATIVE EVALUATION OF WATER SORPTION OF HEAT CURE POLYMERIZED POLYMETHYL METHACRYLATE DENTURE BASE RESIN REINFORCED WITH DIFFERENT CONCENTRATIONS OF ZINC OXIDE AND ALUMINIUM OXIDE NANOPARTICLES"-AN INVITRO STUDY

Dentistry

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ABSTRACT

Aims: This study aims to Compare and Evaluate Water Sorption of heat cure PMMA denture base reinforced with different concentrations of nanoparticles. **Materials and Methods:-** In this study, a total of 80 samples were prepared using denture base resins, the samples were divided into two groups containing 40 samples each, Group 1 was divided into 4 subgroups containing 10 samples each; group 1a, sample with 0wt% concentration of nanoparticles, 1b,1c,1d with 1wt%,2wt%,3wt% of aluminium oxide nanoparticles respectively. Group 2 was divided into 4 subgroups containing 10 samples each, group 2a, a sample with 0% concentration of nanoparticles, 2b,2c, and 2d with 1wt%,2wt%, and 3wt% of zinc oxide nanoparticles respectively. A water sorption test was then conducted on each sample. **Results:** Our study showed that by increasing the wt% of nanoparticles, there is a significant decrease in water sorption of denture base resin from 2.3 to 0.61 mean wt%.There was a significant difference between the control group and different concentrations of nanoparticles ($p \leq 0.05$). There is no statistically significant ($p > 0.05$) between the two groups i.e aluminium and zinc oxide nanoparticles. **Conclusions:** This study concluded that the maximum decrease in water sorption was observed in denture base resin incorporated with 3wt% aluminium and zinc oxide nanoparticles.

KEYWORDS

Zinc Oxide nanoparticles, Aluminium Oxide Nanoparticles, water sorption, Kruskal Wallis test

INTRODUCTION

A denture is one of the treatment modalities to rehabilitate patients with missing teeth. The material most commonly used for the fabrication of dentures is the acrylic resin, polymethyl methacrylate due to its favourable properties, but it also tends to absorb water; this water absorbed by the acrylic resin can act as a plasticizer and cause softening discolouration, and loss of mechanical properties of acrylic resin such as hardness, transverse strength, and fatigue limit. As the complete denture has to be used for a longer duration by patients in intraoral moist conditions due to water sorption by PMMA results in dimensional changes in the denture which in turn can change the adaptability of the denture.[1,2]

Aluminium oxide, commonly referred to as alumina, possesses strong ionic interatomic bonding, giving rise to its desirable material characteristics. Its high hardness, excellent dielectric properties, refractoriness, and good thermal properties make it the material of choice for a wide range of applications.[3]

Zinc oxide is described as a functional, strategic, promising, and versatile inorganic material with a broad range of applications, it has excellent antibacterial and antifungal properties. ZnO in blending with denture base resins can improve the properties of denture base resins, significantly the biological properties of acrylic resins.[4,5]

Figure :1

Figure :2

MATERIALS AND METHODOLOGY:-

MOULD PREPARATION

According to the American Dental Association specification No. 12 and ISO No. 20795, for the water sorption test, disc-shaped metal dies of 50 ± 1 mm in diameter and 1 ± 0.1 mm in thickness were used to create uniform mould spaces in gypsum and replica blocks of the samples were produced. (Figure:1and 2)

METHODOLOGY:

A total of 80 samples were prepared using denture base resins, the samples were divided into two groups containing 40 samples each, group 1 with aluminium oxide nanoparticles, and group 2 with zinc oxide nanoparticles. (Figure 3)

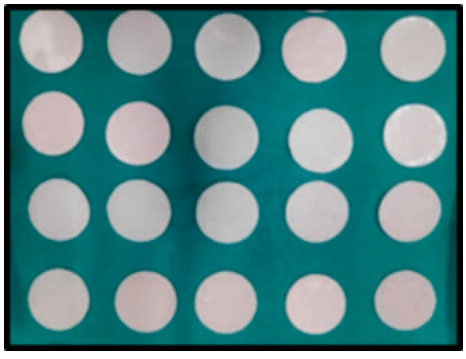


Figure :3

Group 1 was divided into 4 subgroups containing 10 samples each, group 1a, sample with 0wt% concentration of nanoparticles, 1b,1c,1d with 1wt%,2wt%, and 3wt% of aluminium oxide nanoparticles respectively. Group 2 was divided into 4 subgroups containing 10 samples each, group 2a, a sample with 0% concentration of nanoparticles, 2b,2c, and 2d with 1wt%,2wt%, and 3wt% of zinc oxide nanoparticles respectively.

Each sample containing different concentrations of nanoparticles is incorporated in heat cure acrylic with motar and pestle.

Al2O3/zinc oxide concentration	Amount of Al2O3/zinc oxide	Amount of polymer	Amount of monomer
Group a (0%)	0 mg	5000mg	2ml
Group b (1%)	50mg	4950mg	2ml
Group c (2%)	100mg	4900mg	2ml
Group d (3%)	150mg	4850mg	2ml

After curing and polishing, the samples are tested for water sorption. All the samples were immersed in distilled water and then kept in an incubator at 37 ± 2°C for 7 days to simulate the intraoral condition. Then, samples were removed from the water and wiped with a tissue and with the help of high accuracy digital weighing scale and the mass of each sample was measured 60 s after removal from the water (Ws). After weighing all samples, they were kept in a desiccator containing fresh silica gel for desiccation at 37 ± 2°C for 4 days and then the dry weight of each desiccated sample was measured (Wd).[6]

The following formula was utilized to obtain the water sorption values.
Water sorption: (Ws-Wd)/Wd* 100%
Where : Ws: represent the weight of the saturated sample in water.
Wd: weight of the dried sample.

RESULTS:-

The results of the water sorption measurement were calculated after data collection, mean values and standard deviation. Data were analysed by using a statistical package for social science (SPSS) software. The comparison between the control group and PMMA reinforced with aluminium oxide and zinc oxide was evaluated by the Kruskal Wallis test, Post Hoc analysis respectively. The results of water sorption were given in the below table.

Table-1: Mean Comparison Of Water Absorption Between The Subgroups Of Group 1

Group 1	N	Mean	SD	Minimum	Maximum
Control	10	2.4240	0.03438	2.34	2.46
Al_2O_3 1%	10	1.5740	0.05481	1.52	1.65
Al_2O_3 2%	10	0.9800	0.04422	0.92	1.05
Al_2O_3 3%	10	0.6150	0.12660	0.53	0.96
Z value	36.122				
P value	0.000*				

Kruskal Wallis test; p≤0.05 considered statistically significant

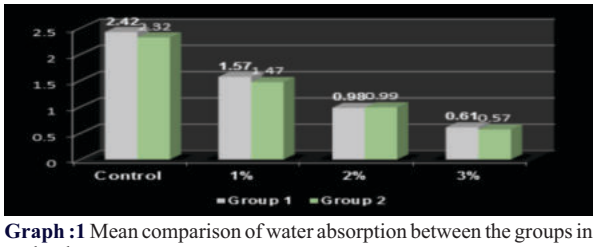
Table 1 shows the Kruskal Wallis test between the control group and aluminium oxide with different concentrations (1%,2%,3%) and it was observed there was a statistically significant difference present in the mean values of different groups.

It was observed that the mean of the control group is higher compared to different concentrations of aluminium oxide (1%,2%,3%), and aluminium oxide with 3 % is lower when compared with the control group and 1%,2% aluminium oxide.

Table-2: Mean Comparison Of Water Absorption Between The Subgroups Of Group 2

Group 2	N	Mean	SD	Minimum	Maximum
Control	10	2.3200	0.09672	2.15	2.45
Zinc oxide 1%	10	1.4770	0.12676	1.24	1.70
Zinc oxide 2%	10	0.9910	0.07852	0.86	1.12
Zinc oxide 3%	10	0.5750	0.03808	0.53	0.66
Z value	36.633				
P value	0.000*				

Kruskal Wallis test; p≤0.05 considered statistically significant



Graph :1 Mean comparison of water absorption between the groups in each subgroup

Table3 it shows the Kruskal Wallis test between the control group and zinc oxide with different concentrations (1%,2%,3%) and it was observed there was a statistically significant difference present in the mean values of different groups.

It was observed that the mean of the control group is higher compared to different concentrations of zinc oxide (1%,2%,3%), and zinc oxide with 3 % is lower when compared with the control group and 1%,2% zinc oxide.

The above graph shows a mean comparison between group 1 (aluminium oxide) and group 2 (zinc oxide) It has been observed that the mean value for both group 1 and group 2 didn't show any statistical significance.

DISCUSSION:

Acrylic resins are widely used in dentistry. One of the properties of acrylic resins is water sorption, increasing water sorption leads to dimensional instability, thereby subjecting the material to internal stresses that may result in crack formation and eventually, denture fractures.[7]

Recently much attention has been directed towards the incorporation of inorganic nanoparticles into PMMA to improve its properties. The properties of polymer nanocomposites depend on the type of incorporating nanoparticles, their size, shape, concentration, and interaction with the polymer matrix. Many experiments have been undertaken to reduce the water sorption of PMMA to prevent clinical failure. This study's results show a significant decrease in water sorption when aluminium oxide and zinc oxide nanoparticles were added to PMMA.[8,12]

This might be because of the physical presence of nano-sized particles in the free spaces between polymer chains of polymerized PMMA resin, and it also might have attracted resin molecules creating more complicated network chains during the curing process, further eliminating space for water sorption.

Arima et al suggested that the chemical nature of the polymer versus that of the water molecule directly affected the water sorption of resin. Water is biopolymers into a polymer by the polarity of the molecules in the polymers by unsaturated bonds of the molecules or unbalanced intermolecular forces in the polymers.[9]

Abdulhamed et al reported that there was no change in the surface roughness, however, water sorption was decreased in acrylic dentures reinforced with aluminium oxide at 5 wt. % (Abdulhamed & Mohammed, 2010; Vojdani et al., 2012).[10]

Neset Volkan Asar. et.al reported that the incorporation of Al2O3, TiO2 and ZrO2 fillers resulted in a significant increase in impact strength and fracture toughness and a significant decrease in water sorption and solubility.[11]

Rahul G.tekle, tushar k.mowade, and Usha conducted an in-vitro study to evaluate water sorption of heat polymerized polymethyl methacrylate denture base resin reinforced with different concentrations of silanized titanium dioxide nanoparticles (1wt%,3wt%,5wt%). They concluded water sorption decreased by incorporating 5% of nanoparticles.[13]

The limitation of the study is that after incorporation of zinc oxide and aluminium oxide nanoparticles into PMMA in increasing wt%, there is a consistent decrease in water sorption; therefore, further study is required to find out the optimum concentration of zinc oxide and aluminium oxide nanoparticles for water sorption by increasing the wt% of zinc oxide and aluminium oxide >3wt%.

CONCLUSION:

Within the limitations of this study, it was concluded that:

- Reinforcement of Aluminium oxide and zinc oxide nanoparticles in PMMA showed decreased water sorption when compared with the control group
- When compared with different concentrations of aluminium oxide and zinc oxide nanoparticles,3% aluminium oxide and zinc oxide showed decreased water sorption.
- But when both aluminium oxide and zinc oxide nanoparticles were compared, they did not show any statistical changes.

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