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EVALUATION THE EFFECT OF REINFORCEMENT MATERIALS AND THERMAL CYCLE TREATMENT ON SOME MECHANICAL AND PHYSICAL PROPERTIES OF SOFT LINER

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ABSTRACT

Back ground: Resilient denture liners may be advantageous for patients who are capable of delivering a relatively heavy occlusal load to unfavorable denture-bearing tissues. Without a resilient liner, surface hardness of polymethyl methacrylate may lead to chronic soreness, due to pressure on the mental foramen, sharp bony spicules, thin, atrophic mucosa, bony undercuts, particularly in the mylohyoid region, irregular bony resorption, poor fit of the denture base, incorrect occlusal relationship, bruxism, and/or debilitating disease.[1] During mastication the oral cavity gets in contact with food at different temperature, the most critical effect of temperature is due to chewing change of hot foods and drinking of cold fluids, temperature changes may affect the properties of soft liner.[2] **Objective:** This study was conducted to evaluation and compare the effect of added different reinforcement materials (Zirconium oxide and Titanium oxide Nano particles) incorporated with soft liner material in three concentration (0.5,1, and 1.5wt%) and thermal cycling treatment on the some properties of soft liner (roughness, hardness and water sorption). **Materials and methods:** Two hundred and ten (210) specimens were prepared from soft liner used in this study. Specimens were divided into three main groups according to the test (roughness, hardness, and water sorption), (70)specimens for each test, and then divided into three group (control group (10) specimens, ZrO_2 (30) specimens and TiO_2 (30) specimens) and then experimental groups subdivided in to three groups according the percentage each group have (10) specimens and then all groups divided in to equal halves one treated with thermal cycling treatment and another without thermal cycling treatment. The surface roughness was tested by (profilometer), while hardness was tested by(shore A) tested machine, and water sorption was tested by using (digital electronic balance). **Result:** The result show the surface roughness decrease when used ZrO_2 in all percentage compared with control groups, while increase surface roughness in all percentage of soft liner reinforced by Titanium oxide Nano particles. Hardness and water sorption in all experimental groups reinforced by Zirconium oxide and Titanium oxide Nano particles increase compared with control groups. **Conclusion:** In conclusion, according to the obtained result in this study, incorporating the Nano particles into soft liner result the ZrO_2 improvement the surface roughness in all percentage compared with control groups but increase in hardness and water sorption in all percentage compared with control groups, while incorporating the TiO_2 Nano particles into soft liner result the increase in all test compared with control groups.

KEYWORDS: Soft liner, Reinforcement, Thermal cycling treatment.

INTRODUCTION

Acrylic resins used in complete dentures and removable partial dentures are rigid materials, and may not be tolerated by some patients due to the discomfort caused to the oral mucosa. This discomfort is particularly experienced by patients with xerostomia or those with resorbed alveolar ridges, sensitivity in the mental foramen region, dentures antagonized by natural teeth, congenital or acquired defects.[3] One approach of improving the stability and adaptation of dentures, and thereby providing comfort for patients relies on the use of tissue conditioning agents or soft reline.[4] Denture liners have been used in dentistry for many years. They are classified into hard reline materials, permanent tissue liners, and tissue conditioners.[5] They are used to enhance the fit of poor fitting dentures and prevent trauma to sensitive mucosa, by forming a cushioned layer between the denture base and the oral mucosa.[6-7] They aid in the retention of extra oral prostheses and intraoral devices by engaging over denture bar attachments or modified abutments.[8] and undercuts present in defect sites such as in maxillofacial obturators Denture liners should be elastic, nontoxic, and nonirritant to oral tissues.[9] Relining is defined as the process of resurfacing the tissue side of heat cured acrylic denture base leading to an accurate foundation for denture bearing area.[10] Denture liner materials should have desirable properties such as elasticity, non-toxicity, non-irritant to oral tissues, dimensional stability and ability to bonding with acrylic base.[11-12] Such substances can be classified into silicone and soft acrylic (based on composition); cold cure, heat cure and light cure (based on curing); short and long liners (based on durability); and hydrophobic and hydrophilic(based on water sorption).[13-14]

As a result, dimensional alterations, distortion, stiffening, odor incorporation, microorganism retention, color change, and debonding from denture bases may occur.[15-16] During mastication, the oral cavity gets in contact with food at different temperatures. The most critical effect of temperature is due to chewing of hot food and drinking of cold fluid, this temperature changes may affect the mechanical properties of denture base, so[17] have shown that material ageing can dramatically affect the physical and mechanical properties. Over the recent years, preparation of important metal oxide Nano particles such as TiO_2, ZnO_2 have attracted increasing attention from the scientific communities because of their extraordinary physical and chemical properties. In the oral cavity, the denture prostheses are usually under conditions of thermal variations due to the ingestion of hot and cold liquids.[18-19-20] Such thermal cycling in a wet environment may cause degradation of the denture polymers.[21-22] And the heat stress may increase water sorption because of an extension of the distance between the polymer chains. Absorbed water can act as a plasticizer and soften the denture, thus reducing the mechanical properties of the material.[21-23] Conversely, heating the acrylic resins may enhance further polymerization reactions consequently, an improvement in the mechanical properties can be expected. Hence, the possible effect of thermal cycling on the mechanical properties of the acrylic resins must performance of the relined removable prostheses.[24]

MATERIALS AND METHODS

Two hundred and ten specimens were constructed and processed by conventional methods and divided into 3 groups according to the test and each group was subdivided into 7sub-groups according to the percentage of added(ZrO_2 and TiO_2) and each group divided in two group with and without thermal cycling treatment instead of wax pattern preparation which need more time and effort in its preparation a wax elimination procedure three different metal pattern were constructed with different shapes and dimensions according each test the dimension of the roughness test (25mm width. 14mm length, 3mmthickness).[25] And the dimension of hardness test (30mmdiameter, 3mm thickness).[26] While the dimension of water sorption (50±1mm diameter and 0.5±0.05mm thickness) according to.[27] The conventional flasking technique for complete denture was followed in the mold preparation. The metal patterns were coated with separating medium and allowed to dry.

The experimental samples were prepared by mixed Zirconium oxide and Titanium oxide with soft liner monomer in three different concentrations(0,5-1- and 1, 5wt%) by weight with the powder.

As following when added 0,5% concentration of reinforcement material to the soft liner monomer and remove 0,5% from powder and the same procedure used when added other concentration (1%,1,5%) show in table(1). Then the resilient lining liquid was added to the powder and the material was mixed in accordance to the manufacturer instructions, the weight of the zirconium oxide and titanium oxide powder that had been added to the monomer soft liner was taking into account and subtracted from soft liner monomer volume to achieve correct P/L ratio. Flasking, packing, curing and finishing work was done in the conventional method.

Table (1): Percentage of reinforcement material and amounts of powder and liquid of soft liner material.

Reinforcement Material percentage	Amount of powder	Amount of liquid
0%	12g	10ml
0.5%	11.5g	10ml
1%	11g	10ml
1.5%	10.5g	10ml

Conditioning

After complete curing the flask was opened and the specimens were removed from the flask and by using sharp blade, the excess of material was removed show in figure (1) and all specimens were stored in distilled water containers in an incubator at 37C° for 24 hours.[28]

A B C

Fig (1): Prepared soft liner specimens A. for roughness specimens, B. for hardness specimens and C. for water sorption specimens.

Then the profilometer device was used. It is supplied with a surface analyzer (stylus) made from diamond to trace the profile of the surface irregularities and recording all the peaks and recess which characterize the surface. This stylus moved 4 mm on the tested samples. To ensure that measurements were made in the same place for all specimens, a pencil mark was made on the base of each specimen. Two readings were recorded, and the final value of surface roughness for each specimen was the average of two readings. After processing, all the specimens were kept in distilled water containers in an incubator at 37°C for 24 hours. The first evaluation of surface roughness was done after 24 hours (The readings were considered as a baseline value). The second and third evaluation of surface roughness was obtained after 1 and 3 weeks respectively. All testing of final specimens for shore A hardness test. After finishing of acrylic disk soft liner, the shore A durometer was used to measure soft liner hardness. The testing value was taken as an average of different reading that were taken directly from the scale reading of durometer by using pointed dibbing tool, where the pointed dibbing tool penetrate the material surface because of the pressure on the instrument where the dibbing tool head touching quite the surface of the samples then the hardness values were recorded. After that the specimens were removed placed in room temperature for one hour, and then weighted with digital electronic balance. This cycle was repeated until constant weight was determined. This was considered to be the initial weight (W1).The specimens were immersed in distilled water for 7 days at 37c ±2c. After this period of time, each disc was removed from the water with tweezers, wiped with clean, dry hand towel until free from visible moisture, waved in the air for 15 seconds and weighed one minute after removal from the water. This weight represents (W2).

Measurements were calculated were made according to the following formulae.
{Sorption (mg/cm2) = w2-w1 /surface area}

Thermocycler was used in this study it composed of cold and hot water bath chambers, Heater, thermostat and thermometer to regulate and measure the temperature of hot water; refrigerator, thermostat and thermometer to control the temperature of cold water.[29]

Thermocycling was carried out by soaking the specimens alternatively into (5ºC and 55ºC) ±2ºC water bath chambers with 60 seconds dwelling time at each temperature.[30] then subject to the testing procedure.

RESULT

Table (2): Comparisons between control groups and reinforcement specimens of surface roughness without thermal treatment.

Groups	Without	
	P-value	**Sig**
ZrO_2 0.5%	0.091	NS
ZrO_2 1%	0.048	S
ZrO_2 1.5%	0.000	HS
TiO_2 0.5%	0.108	NS
TiO_2 1%	0.041	S
TiO_2 1.5%	0.033	S

P<0.05 Significant **P>0.05 Non significantP<0.001 High significant**

Table (3): Comparisons between control groups and reinforcement specimens of surface roughness with and without thermal treatment.

Groups	Roughness		Groups	Roughness	
	P-value	**Sig**		**P-value**	**Sig**
Control group	0.124	NS	Control group	0.124	NS
ZrO_2 0.5%	0.094	NS	TiO_2 0.5%	0.097	NS
ZrO_2 1%	0.089	NS	TiO_2 1%	0.102	NS
ZrO_2 1.5%	0.043	S	TiO_2 1.5%	0.041	S

***P<0.05 Significant **P>0.05 Non significant**

Table (4): Comparisons between control groups and reinforcement specimens of surface roughness with thermal treatment.

Groups	With	
	P-value	**Sig**
ZrO_2 0.5%	0.125	NS
ZrO_2 1%	0.042	S
ZrO_2 1.5%	0.034	S
TiO_2 0.5%	0.109	NS
TiO_2 1%	0.048	S
TiO_2 1.5%	0.039	S

***P<0.05 Significant **P>0.05 Non significant**

Table (5): Comparisons between control groups and reinforcement specimens of hardness without thermal treatment.

Groups	Without	
	P-value	Sig
ZrO_2 0.5%	0.041	S
ZrO_2 1%	0.027	S
ZrO_2 1.5%	0.000	HS
TiO_2 0.5%	0.008	S
TiO_2 1%	0.000	HS
TiO_2 1.5%	0.000	HS

***P<0.05 Significant **P>0.05 Non significant ***P<0.001 High significant**

Table (6): Comparisons between control groups and reinforcement specimens of hardness with and without thermal treatment.

Groups	Hardness		Groups	Hardness	
	P-value	Sig		P-value	Sig
Control group	0.197	NS	Control group	0.197	NS
ZrO_2 0.5%	0.040	S	TiO_2 0.5%	0.028	S
ZrO_2 1%	0.042	S	TiO_2 1%	0.042	S
ZrO_2 1.5%	0.049	S	TiO_2 1.5%	0.000	HS

***P<0.05 Significant **P>0.05 Non significant ***P<0.001 High significant**

Table (7): Comparisons between control groups and reinforcement specimens of hardness with thermal treatment.

Groups	With	
	P-value	Sig
ZrO_2 0.5%	0.433	NS
ZrO_2 1%	0.013	S
ZrO_2 1.5%	0.000	HS
TiO_2 0.5%	0.261	NS
TiO_2 1%	0.019	S
TiO_2 1.5%	0.000	HS

P<0.05 Significant **P>0.05 Non significant ***P<0.001 High significant.

Table (8): Comparisons between control groups and reinforcement specimens of water sorption without thermal treatment.

Groups	Without	
	P-value	Sig
ZrO_2 0.5%	0.144	NS
ZrO_2 1%	0.047	S
ZrO_2 1.5%	0.038	S
TiO_2 0.5%	0.040	S
TiO_2 1%	0.038	S
TiO_2 1.5%	0.045	S

***P<0.05 Significant **P>0.05 Non significant**

Table (9): Comparisons between control groups and reinforcement specimens of water sorption with and without thermal treatment.

Groups	water sorption		Groups	water sorption	
	P-value	Sig		P-value	Sig
Control group	0.091	NS	Control group	0.112	NS
ZrO_2 0.5%	0.142	NS	TiO_2 0.5%	0.093	NS
ZrO_2 1%	0.236	NS	TiO_2 1%	0.041	S
ZrO_2 1.5%	0.278	NS	TiO_2 1.5%	0.038	S

***P<0.05 Significant **P>0.05 Non significant ***P<0.001 High significant**

Table (10): Comparisons between control groups and reinforcement specimens of water sorption with thermal treatment.

Groups	With	
	P-value	Sig
ZrO_2 0.5%	0.062	NS
ZrO_2 1%	0.049	S
ZrO_2 1.5%	0.047	S
TiO_2 0.5%	0.049	NS
TiO_2 1%	0.040	S
TiO_2 1.5%	0.039	S

***P<0.05 Significant **P>0.05 Non significant**

DISCUSSION

The physical and mechanical properties of soft liners are influenced by several factors, Ageing is one factor that has an effect on the characteristics of polymer.[31] Therefore, it is important to be able to assess the resistance of denture liners to aging, this could be by in vitro simulated an aging treatment.[32] The present study was conducted to evaluate in vitro the effect of reinforcement materials by using two types (Zirconium oxide and Titanium oxide Nano particles) with three percentage (0.5,1,1.5 wt.%) and thermo cycling treatment on some properties (hardness, roughness and water sorption) of soft liner material.

Surface Roughness

The surface roughness of denture material is important, because it affects the oral health of tissue in direct contact with denture.[33-34] Most microorganisms present intra orally, particularly those responsible for caries, periodontal disease, and denture stomatitis, can only surive in the mouth, if they adhere to a non-shedding oral surface and begin to form colonies.[35] In this study profilometer device was used to estimate the estimate the effect of adding Nano filler on surface geometry of the specimens because this device appears to be an excellent device to evaluate surface roughness by giving a quantitative measurement that can be evaluated and compared statistically.[36]

Surface Roughness without thermal cycling treatment: The result of this study in Table (2) show surface roughness of specimens were added ZrO_2 decrease rather than control group this result may be due to that the surface roughness test is concerned with outer surface and not with inner surface using Zirconium oxide Nano particle which are very small size and they were well dispersed in the polymer matrix moreover, so only very small amount of Nano particle concerned on the surface.[37] But the result in Table (2)show increase the surface roughness of specimens were added TiO_2 rather than control group this finding can be explained by the incorporation of Nano particle causes these particles to agglomerate and aggregate. The agglomerated compounds can act as stress concentrating center in the matrix and adversely affect mechanical properties of the polymerized material.[38]

Surface Roughness with thermal cycling treatment: The effect aging process thermal cycling on soft liner showed decrease of control group after treatment in Table (3) and this result can explained by the fact irregularity of temperature lead to partial removal of the residual monomer and lead to more smoothing in outer surface of specimen.[39] While in Table (3) ZrO_2 after thermal cycling treatment increase in the surface roughness values of all percentage when compare with ZrO_2 without thermal cycling treatment could have been expected after specimens had been submitted to the experimental conditions because water absorption and solubility result in a variety of chemical and physical processes, such as the release of substances that did not react[24] and the formation of byproducts by hydrolytic degradation, affecting the structure as well as the biocompatibility of the polymeric materials.[40-41-42] But when compare the added Zirconium oxide Nano particle after thermal cycle treatment with control groups with thermal cycle treatment show in Table (4) decrease in surface roughness this finding expected the hot water may also have accelerated the release of degradation products and unreacted monomer molecules, promoted further free-radical polymerization reactions and increased the degree of conversion.[24] But the specimens were added TiO_2 and after treatment the result decrease rather than specimens without treatment show in Table (3) this result may due in addition, residual monomer molecules acting as plasticizers may have been released during the treatment.[43-24] While when compare the added Titanium oxide Nano particle after thermal cycle treatment with control groups with thermal cycle treatment show in Table (4) that result increase in surface roughness this finding expected the filler particles located at the surface of materials would debond and the grooves created would promote the increase in the roughness.[25]

Hardness test Hardness is meant by the resistance of material to plastic deformation typically measured under indentation load.[46] Hardness is an important property for resilient material and should remain constant for a long period so that the materials can efficiently fulfill their function. The ideal hardness or softness for providing a greater comfort to the patient can be obtained with the use of soft materials, but they still have many properties along with unstable use. Hardness defined as the resistance of material to plastic deformation typically measured under an indentation load.[44] In the present study shore (A) device use to evaluate hardness test.

Hardness test without thermal cycling treatment From the result in Table (5) of hardness test the added ZrO_2 Nano particle was increase rather than control group that result may explain which are very small size and they were well dispersed in the resin matrix moreover, so only very small amount of Nano particle concerned on the surface[37], this study agreement with.[45] when it was incorporated into polymer increased the hardness of polymer Nano composite. The increased in hardness could be related to good distribution of Nano filler into the resin matrix and the accumulation of Zirconium silicate Nano particle which is hard material in the polymer matrix. The 1.5% wt Nano ZrSiO4showed more increase in hardness than 1% wt due to more accumulation of Nano filler into the resin matrix.[46] While results in Table (5) were added TiO_2 Nano particle shown increase hardness rather than control group this result may be due to the reduction in the crystallite size may be interpreted as a result of increasing binding sites induced by increasing ion energy.[47] And as the crystallite size decreases the number of grain boundaries increases inversely, therefore the dislocation motions by crystallite boundaries may cause an increase in the hardness with smaller crystallite size.[48]

Hardness test with thermal cycling treatment The effect of thermal cycling treatment on control group was increase in hardness this result show in Table (6) that due to thermal cycling promoted leaching of plasticizer in soft liner, plasticizer loss is due to a threefold sequence of event occurring at the same time: (1) ethanol loss, (2) water sorption, and (3) plasticizer loss that lead to increase in hardness.[49] With regard to the organic matrix, hardness depends on the density and structure of the polymer formed[50], and the degree of conversion after the polymerization.[51] The effect treatment on specimen were added ZrO_2

increase in hardness more than reinforced specimens without thermal cycling treated this result in Table (6) and (7) this finding may which are very small size and they were well dispersed in the resin matrix moreover, so only very small amount of Nano particle concerned on the surface.[37] While in Table (6) reinforced specimens with TiO_2 showed decrease in hardness more than the added TiO_2 without thermal cycle treatment this finding can be explain by the reduction in the inter chain interaction due to effect of shrinkage and expansion of thermal cycling treatment.[42] But in Table (7) when compared with control groups with thermal cycling treatment increase in hardness may be good dispersion of the Nanoparticles into the resin matrix filled the inter-polymeric chain spaces, which shows the importance of the additive content of the Nano particles.[52]

Water sorption test Sorption of the materials represent the amount of water adsorbed on the surface and absorbed into the body of the material during fabrication or while the restoration is in service.[53] The sorption of water is important phenomena of plastic denture base because of its relation to dimensional changes of acrylic denture base.[54] Sorption of the material represented the amount of water absorption on the surface and to the body of the material. The sorption of the acrylic resin materials is facilitates by its polarity. The mechanism which be responsible for the ingress of water is diffusion which be defined as the migration of one substance through a space or within a second substance in which water will penetrate acrylic resin mass and occupy a position between polymer chains.[55]

Water sorption test without thermal cycling treatment In Table (8) show the increase of water sorption values observed for soft liner were added ZrO_2, TiO_2 with deferent concentration occurred may be related to leaching out of water-soluble ingredients, residual monomer, plasticizer, and during water immersion; as a result there will be more micro porosity filed by water lead to increase of water sorption.[56-57]

Water sorption test with thermal cycling treatment In Table (9)and(10) the result observe compare between all groups before and after thermal cycling treatment increase in water sorption of control group and specimen were added (ZrO_2, TiO_2) Nano particle after thermal cycling treatment that may be explain by the lack of plasticizer component that leaving empty space and /or gaps for water to get in or when the amount of pores found are increases may result in more fluid gain through it which causes molecules to be separated that leads to more absorption of fluids.[58]

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