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Evaluating some Mechanical and Physical Properties of Vertex Thermosens Denture base Material in Comparison with Heat Cure Acrylicdenture Base Material

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Abstract: ***Background:Thermoplastic materials have been presented to dental use for over 50 years and because of their superior properties the interest in polyamide based materials have increased .New classes of more advanced materials and technologies have developed giving the chance for new applications of thermoplastic resins to be used in the future. The aim of the present study is to compare some of physical and mechanical properties between heat cure acrylic and new denture base material (thermosens). Material and methods: in this study 60 specimens were prepared and divided to three groups according to test (tensile strength, surface roughness and wettability) then each group subdivided in to two groups according to the type of denture base material used (heat cure acrylic(control) and thermosens (experimental) .the results were analyzed by t-test. Result: the result that obtained in this study showed that the tensile strength and surface roughness of thermosens denture base material have higher significant values than that of heat cure acrylic denture base material while the thermosens has lower significant values in wettability than heat cure denture base material. Conclusion: The thermosens denture base material has higher tensile strength and surface roughness while heat cure acrylic denture base material is more wettable.***

Keywords: Thermosens, heat cure acrylic, tensile strength, surface roughness, wettability

1. Introduction

Heat cure acrylic (Poly methylmethacrylate) used in dentistry since 1930 and it became the most reliable material for denture construction because of its favorable properties such as esthetic, easy to repair and reline , low water sorption and toxicity, adequate strength and simple processing techniques.[1] it is a derivative of acrylic acid referred to as acrylic resin. [2]

On the other hand its unfavorable properties such as polymerization shrinkage , low fatigue resistance and impact strength , weak flexural and allergy to its monomer lead to introduction of alternative materials to PMMA such as thermoplastic materials which include : polyamide (nylon plastics) , acetal resin , epoxy resin , polystyrene, polycarbonate resin …etc.are produced during the development of polymer chemistry . All these materials are fitted to the thermoplastic processing.[3,4,5]

Nylon material which is a generic name used for polyamides could be useful in the treatment of patients who demonstrate repeated fracture of dentures and those who have reaction of a proven allergic nature. The main benefit of nylon is its resistance to shock and repeated stressing .[6]

Other new material is the thermosens denture base material which is a thermoplastic material superior to standard polyamide materials and based on a compound mixture of polyamide and pigments, this material doesn't contain residual monomer due to its polyamide bases and produced by injection technique, so it is suitable for people allergic for residual monomer. Its flexibility can be controlled , low shrinkage , homogenous color making it suitable for the construction of complete and partial dentures.[7]

In this study the physico-mechanical properties were made to compare between heat cure acrylic resin denture base material (super-acryl^{R} plus) and Thermosens denture base material (Vertex- dental thermosens) .

2. Material and Methods

60 specimens were prepared in this study that's divided to three main groups according to the tests that used (20 specimens for tensile strength , 20 specimens for surface roughness and 20 specimens for wettability) then subdivided to two subgroups according to type of material (10 specimens for control (heat cure acrylic) and 10specimens for experimental (thermosens)).

First we start to prepare the specimens which need for each test, plastic patterns constructed by cutting plastic plate according to the designed shape and dimension by laser cutting machine.

Preparation of heat cure acrylic and thermosense denture base material specimens

The two denture base materials had same techniques of flasking with few differences in the steps .

For heat cure acrylic denture base material specimens constructed according to the manufacturer'sinstructions by using the conventional flasking technique.

For Thermosens denture base material specimens constructed by using special flask that's used for injection technique which consist of two parts upper and lower half fixed by 4 screws that should be tightened well in use , in the upper half there is a hole at the top which used to pour the second layer of dental stone.

The same procedure that's used for heat cure acrylic specimens preparation by putting separating medium in the mouldand upper and lower half of the flask ,pouring dental stone in the lower half , inserting the mould and leaving it to set.

After setting of dental stone again we put separating medium on the surface of first layer of dental stone and the plastic mould and start to construct the sprues which allow the thermosens denture base material injection procedure, we put 2 types of sprues : major sprues with a diameter of 6-8 mm and minor sprues with 2-4mm which attached to mould then putting the upper half of the flask and fix it to lower by 4 screws , pouring the second layer of dental stone through the hole of upper half.

Wax elimination done by boiling waterthen leave it to cool at room temperature , open the flask , remove the specimen and wash the surface of mould with boiling water to get rid any remnant of wax , leave it again at room temperature to cool.

Now the flasking done by coating the surface with vertex thermo flow separating medium and inserted inside the holes that prepared by wax sprues and leave it to dry then retighten the upper part of flask by 4 screws and reach to injection by vertex thermoject 22 injection machine that's used to construct the thermosens denture base material .

First step preheated the cylinder of machine to $290c^0$ in 8 minutes then thermosens material cartridge was inserted in the cylinder and put the flask in it's position inside the machine, started the machine injection procedure under pressure of 6.5 bar at $290c^0$ which need 18 minutes, when the program finished the flask removed from the machine and leaved to cool for 1 minute, after that the flask opened, the specimens removed finished and polished then the heat cure acrylic and thermosens specimens put in distilled water for 48 hours at 37^0c before testing.

Tensile strength test

For the tensile strength test 20 flat dumbbell shaped specimens were prepared with dimension of 16mm length,3mm width and 2mm thickness[8] (10 control (heat cure acrylic) and 10 experimental (thermosens)).

Tensile strength was measured by Instron universal testing machine (LARYEE, china) at a cross head speed of 5mm/min and 50mm grip to grip distance. Force at failure was recorded in Newton and tensile strength values were calculated by this equation:

Tensile strength= F/A (ASTM 1986)
F = force of failure (newton)
A = minimum cross sectional area (mm^2)

Surface roughness test

Roughness measured by using profilometer device which is suitable for studying the surface roughness of restorations and materials, that supplied with sharp stylus made from diamond to trace the profile irregularities of surface . 20 specimens were poured in plastic mold of 16mm length, 3mm width and 2mm thickness (10 control (heat cure acrylic) and 10 experimental (thermosens)).

The specimens were not polished but only slight remove to the flash were made. A profilometer (Taylor Hobson From TalysurfPGI-840, USA) was used to test the surface roughness of the specimens which placed on stable and fixed base then adjusted the device by making the stylus just touch the specimen surface ,the stylus traversed toward the right direction along the specimen surface of 11mm length at end ,the reading appeared on the digital scale.

Wettability test

Wettability assessed by calculating the contact angle between liquid drop and the solid surface, since the wettability is the measurement of liquid drop spreading property on solid surface.

20 specimens were prepared with dimensions of (8mm*30mm*2mm) width, length and thickness respectively (10 control (heat cure acrylic) and 10 experimental (thermosens)).

A drop of distilled water falling down above the centre of the specimen allowed to dispersed, waiting 5minutes to allow drops to reach equilibrium status and the angle between the surface of the specimens and the drop was calculated by using dino-lite microscope[9]at 45x magnification which placed horizontally and parallel to the floor and the values were calculated.

3. Results

Results gained from the measured data were classified into control group (heat cure acrylic) and experimental group (thermosens)and analyzed by using Spss (Statistical Package for Social Science) version 20 by independent test at 95% confidence level to assess the statistical significance.

Tensile strength:

The result of this test showed that the experimental group had higher tensile strength mean value 52.77 than the control group 38.63 as shown in **table (1).**

t-test showed highly significant difference between the studied groups $p<0.01$.as shown in **table (2).**

Surface roughness:

The result of this test showed that the experimental group had higher surface roughness mean value than the control group as shown in **table (1).**

t-test showed highly significant difference between the studied groups p<0.01.as shown in **table (2).**

Wettability:

The result of this test showed that the experimental group had higher wettability mean value 71.15 than the control group 66.01 as shown in **table (1).**

t-test showed highly significant difference between the studied groups p<0.01.as shown in **table (2).**

Table 1: Descriptive statstic of the tested groups of all tested properties

Properties tested	*category*	*N*	*Mean*	*Std. deviation*	*Std. Error Mean*
Tensile strength(N/mm^2)	Control	10	38.63	2.7677	0.8752
	Experimental	10	52.77	1.3458	0.4256
Surface roughness (µm)	Control	10	1.271	.06336	.02003
	Experimental	10	4.491	.30514	.09649
Wettability (angle)	Control	10	66.01	1.2873	0.4071
	Experimental	10	71.16	0.6493	0.2053

Table 2: Independent sample t-test for the properties used

Tested properties	t	d.f.	Sig (2-tailed)	Mean difference	Std. error difference	95% confidence internal of difference	
						Upper	Lower
Tensile strength	-14.5292	18	0.000	-14.14	0.9722	-12.0952	-16.1846
Surface roughness	-32.666	18	0.000	-3.2193	0.0985	-3.0122	-3.4263
Wettability	-11.2890	18	0.000	-5.147	0.4559	-4.1891	-6.1048

4. Discussion

The most common material that used for complete/ partial dentures construction has been PMMA, in spite of many advantages but it is not the ideal in every respect because of fracture, foul smell and allergy to PMMA could not be avoided [10]. Patient who wear dentures at early age because of various reasons start to search for something better. That is why different types of materials start to use for fabrication of prosthesis.

Tensile strength test:

The ability of denture base materials to withstand force of mastication depend on flexural strength which is useful in comparing between denture base materials because it simulates the stress types that is applied to denture during mastication , and it can be defined as a combination of compressive strength and tensile strength also involve elastic modulus and proportional limit measurements.[11]

For the tensile strength test the result showed high significant difference between heat cure acrylic and thermosens denture base material (thermosens had higher tensile strength than heat cure acrylic) as the thermosens can withstand stress through a considerable degree of deflection.

The causes of this result may be related to the structural formula difference (chemical composition) thermosens is crystalline polymerwhere as heat cure acrylic is amorphous and to polymerization technique.

This result was agreed with the study that says thermoplastic material is more flexible than heat cure acrylic denture base material because it is polyamide which is not only monomer free but unbreakable that comprises the largest engineering plastics that is suited for a wide range of applications[12,13] also our finding supported byYunus et al (2005) [11]and Ammer (2012) [14]but disagree with El-khodary et al (2016)[15]and by Takahashi et al (2012)[16] as they found that the flexural strength of polyamide was higher than that of heat cure acrylic.

Surface roughness test:

The prime objective of prosthesis or restoration is a smooth surface obtaining with fine or no scratches on the surface to prevent biological consequence of plaque accumulation on rough surface [17].

In this study the result showed that there was a high significant difference between thermosens and heat cure acrylic denture base materials. This result may be due to the difference in surface texture between these two materials as a result of the size of the crystals of thermosens which are large and make it difficult to get a smooth surface when compared with heat cure acrylic denture base material , also because the thermosens which is polyamide the surface may be affected by some degree of disintegration of mold surface that was heated to higher degree of temperature compared to heat cure acrylic in addition to the pressure during injection molding for the thermosens [18] .

Our finding was agreed with Mohammed A.A.(2011)[19], Abuzar et al in (2010) [20]and Kawara et al (2014) [21]as they found that the surface of thermosens denture base materials was easily damaged when compared with heat cure acrylic denture base materials.

Wettability test:

The wettability of the surface determined by measuring the magnitude of the contact angle which obtained between the drop and the surface. Good wettability result from small values while large values result in poor wettability [22, 23]. The surface wettability is highly depending on the intrinsic hydrophobicity of materials, the roughness geometry and surface energy which is the interactions between the forces of adhesion and cohesion[24].

The result showed high significant difference between thermosens and heat cure acrylic denture base materials (thermosens had higher values of wettability than heat cure acrylic denture base material),the cause for this result can be attributed to the hydrophobicity property of the thermosens as described in [25] and the surface texture as

we obtained from our study and previous studies by Mohammed A.A. (2011)[19],Abuzar et al in (2010) [20]and Kawara et al (2014) [21]that the thermosens is more rough than heat cure acrylic and the drop of water need smooth surface to spread on it, so the wettability of thermosens was less than the heat cure acrylic denture base material,thermosens had poor adhesiveness and low surface energy and this may be due to acceptance of the surface of heat cure acrylic to hydrogen bond more than the thermosens.[26]

5. Conclusion

Within limitation of this study, we could conclude the following:

1) The vertex thermosens denture base material showed higher tensile strength and surface roughness when compared with heat cure acrylic denture base material.
2) There was highly significant decrease in wettability of the vertex thermosens denture base material.

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