

Effect of different denture cleanser solutions on some mechanical and physical properties of nylon and acrylic denture base materials

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ABSTRACT

Background: Thermoplastic non-metal clasp denture became recently the most attractive option for patients due to its esthetic outcome and many other advantages. The chemical immersed denture cleanser is the most widely used method by the patients to maintain clean and healthy denture, but the use of such cleanser may have harmful effect on the denture base materials. This study aimed to evaluate some physical and mechanical properties of one of the thermoplastic denture base materials which is (nylon) compared with those belong to conventional heat cured acrylic and to observe the effect of two prepared denture cleansers (4% oxalic acid, 4% tartaric acid) in addition to one commercial denture cleanser (Lacalut dent) on the indentation hardness, flexural strength, flexibility, surface roughness and color stability of nylon and conventional heat cured acrylic.

Materials and method: Two hundred and sixty specimens (130 nylon and 130 acrylic) were prepared, 60 specimens (30 nylon, 30 acrylic) were used to test each of the properties mentioned above except an 80 specimens were used (40 nylon, 40 acrylic) to test flexural strength and flexibility.

Results: The result obtained in the present study showed high significant difference between nylon and conventional heat cured acrylic in four properties which were: indentation hardness, flexural strength, flexibility and color stability, with no difference in the surface roughness. Furthermore oxalic acid and tartaric acid cleansers significantly decrease the indentation hardness and flexural strength of conventional heat cured acrylic while Lacalut dent didn't significantly affect those properties of acrylic, also all the three cleansers didn't affect the indentation hardness and flexural strength of nylon. Oxalic acid and tartaric acid cleansers significantly decreased the flexibility of nylon while Lacalut dent didn't significantly change this property. All the three cleanser had no effect on the flexibility of acrylic. All the three cleanser had no effect on the surface roughness or color stability of nylon and acrylic.

Conclusions: It can be concluded that nylon had better flexibility and translucency than conventional heat cured acrylic while conventional heat cured acrylic had better indentation hardness and flexural strength than nylon. Regarding surface roughness the two polymers show no significant difference between them.

There were an adverse effect of the prepared denture cleansers which contain isopropyl alcohol on indentation hardness and flexural strength of conventional heat cured acrylic, it decreased both those properties, so it is advised not to use solution containing alcohol as acrylic denture cleanser also it is advised not to use it with nylon denture because it decreased its flexibility. Lacalut dent which is an oxygenating commercial denture cleanser, had no adverse effects on both polymers used in the study, so it can be used safely with them.

Key words: nylon, denture base material, denture cleanser solutions. (J Bagh Coll Dentistry 2011; 23(sp. issue):19-24).

INTRODUCTION

Favorable denture base material is needed for fabricating long lasting and biologically acceptable dentures⁽¹⁾. Acrylic "polymethyl methacrylate"(PMMA) is one of the most widely used denture base material with numerous advantages⁽²⁾, but PMMA has poor mechanical properties like fracture due to unsatisfactory transverse strength, impact strength or fatigue resistance⁽³⁾, allergic reactions to PMMA are also reported⁽⁴⁾. Studies has been done to improve the mechanical properties of (PMMA), and in recent years nylon polymer gained attractive attention as a denture base material because of many advantages, as:

favorable esthetic outcome (non metal clasp), toxicological safety to patients allergic to metals and resin monomer⁽⁵⁾, higher elasticity than conventional heat polymerizing resins and sufficient strength for use as denture base material⁽⁶⁾. Yet, cleaning of the denture remains an important procedure, otherwise the denture becomes unsanitary and an undesirable effects is expected like bad breath, unpleasant staining and biofilm, calculus accumulation on the denture which can lead to periodontal disease and recurrent caries in the abutment teeth, occasionally denture stomatitis and angular cheilitis⁽⁷⁾.

Denture cleansers are popular method used by denture wearers for cleaning but cleanser may have harmful effect on the plastic or metal component of the denture, so the dentist must be able to recommend a denture cleanser that is

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effective, non deteriorative to denture material and safe for patient use (8)

MATERIAL AND METHOD

Metal (iron) pattern was constructed with the following dimensions:

1. Bar shape patterns having (65 mm× 10mm ×2.5 mm) length, width and thickness respectively were made for shore D hardness, flexural strength, flexibility(Three point bending test) and surface roughness (Ahmed N 2010).
2. Disc shape patterns for color stability 50 mm in diameter and 0.5 mm in thickness (ADA No 12 1999).

The material used in the study listed in table 1. The conventional flasking technique for complete denture was followed during the mould preparation. Smaller metal flask with clamp compatible with the injection device was used for nylon, figure 1. For nylon samples preparation a wax sprue were made on top of the metal pattern after the stone in the lower flask half had been set, Figure 2 , then separating media was applied , then after the setting of the stone in the upper half, wax elimination in a boiling water was done Figure 3 .



Figure1: Nylon flask in the clamp



Figure 2: Wax sprue on top of metal pattern

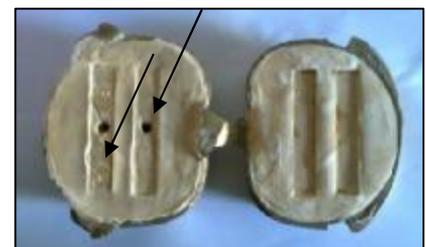


Figure 3: The opened flask after wax elimination

Table 1: Materials used in the study

Material	Manufacturer
Heat cured acrylic resin (polymer and monomer.)	DENTSPLY , Stellon QC-20, Englad
Nylon denture base material capsules	Unite, Diosoft international corporation ,USA
Oxalic Acid powder	BDH England
Tartaric acid powder	E. Merk, Darmstadt
LACALUT dent ,Commercial denture cleanser	Dr. Theiss Naturwaren. Homburg/ Germany
Dental stone type IV	Italy.
Isopropyl alcohol	E. Merk, Darmstadt



Figure 4: Plastic injection machine

Then after a night drying the flask was screwed in its specially design clamp tightly and

placed in hot oven at 75 °C for 12 minutes, mean while the nylon capsule was placed in the cylindrical sleeve and heated till 282 °C and after the ring alarmed the nylon was ready for injection into the mould ensuring that the nylon clamp in its place at the stage of injection device. Figure 4. Deflasking after bench cooling was done to get nylon sample ready for finishing and polishing. All these steps were carried out according to manufacturer recommendation, even the finishing and polishing which were started by the separation of the samples from the sprue by a tungsten carbide bur.

A rubber point was used then to complete the polishing and the excess material that accumulated at the angles of the specimens were removed using sharp blade . The final glossy surfaces were obtained by polishing with polishing rouge and wool brush on dental lathe with continuous intermittent soaking in cold water to prevent surface melting. 260 samples were prepared ,60 samples (30 nylon and 30 acrylic) for each tested property except 80 samples were prepared for flexural strength and flexibility tests (Three points bending test).

4 gm of oxalic acid + 50 ml of isopropyl alcohol + 50 ml distilled water → 100 ml of oxalic acid powder denture cleanser solution

4 gm of tartaric acid + 50 ml of isopropyl alcohol + 50 ml distilled water → 100ml of tartaric acid powder denture cleanser solution

Experiment procedure

All the physical and mechanical tests were done before and after soaking in the denture cleanser solutions. The 1st measurement (before soaking) was done after 48 hours storage in distilled water in incubator at 37 °C, then the 2nd measurement was done after soaking in the denture cleansing solutions for 7 days period (15 minutes soaking, twice daily with 4 hours between each soak), the specimens were kept in incubator at 37 °C all the time between each soaking till the 8th day when the 2nd measurement was done.

Physical and mechanical tests

- Hardness test : Was done by Shore D hardness tester to measure the indentation hardness
- Three points bending test (flexural strength, flexibility): Was done by computerized electronic Instron universal testing machine. The load at deflection of the nylon specimens and acrylic

Preparation of cleanser solutions

A. Commercial denture cleanser

The solution was prepared according to manufacturers recommendation by dissolving one tablet in 100 ml warm water(40°C).

B. Prepared denture cleanser

Denture cleanser solution was prepared by dissolving each of the oxalic acid , tartaric acid in isopropyl alcohol ,which was used due to its antiseptic effect⁽⁹⁾+ equivalent volume of distilled water .

As follow:

specimens was recorded; the nylon specimens reached to irreversible yield and not fractured while acrylic specimens was fractured. The load deflection curve was drawn by the machine .Two properties had been measured by this test :

1. The flexural strength was calculated using the following equation:

$$F_s = 3PL/2bd^2$$

F_s = flexural strength (N/mm²) or (MP)

P = load at yield (0.2 offset was selected to determine the yield)

L = Span distance between the two supports (50mm)

B= Width of the specimen (10 mm)

D= thickness of the specimen (2.5 mm)

2. The flexibility represent the percent deformation (straight) at proportional limit, it was determined by drawing a straight line from the proportional limit down to corresponding strain at load deflection curve, figure 5and 6.

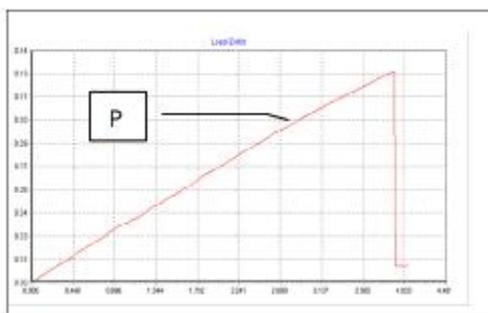


Figure 5: Load deflection curve (acrylic)

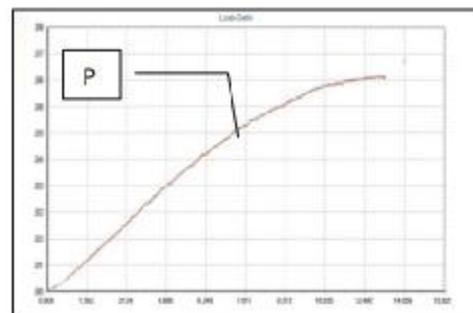


Figure 6: Load deflection curve (nylon)

P: Proportional limit

- Surface roughness test: Was done by Profilometer device
- Color stability test: The spectrophotometer was used to perform this test by measuring the light absorption of each specimen at two wave lengths 400 nm and 500 nm.

RESULTS AND DISCUSSION

1. Indentation hardness test :One way analysis of variance test (ANOVA) showed a statistically high significant difference between heat cure acrylic and nylon,t-test showed high significant difference between nylon and heat cured acrylic hardness for pre soaking subgroups ,also high significant difference between nylon and acrylic hardness for post soaking subgroups whatever the denture cleanse and the higher measurements was for acrylic , this difference in hardness between these two polymers was because of the differences between these two polymers in the process of polymerization. Nylon polymerized by condensation polymerization leading to the formation of an aliphatic polymer without cross linking polymer chain while conventional heat cured acrylic polymerized by addition(free radical) polymerization leading to the formation of a partial cross linked aliphatic polymer chains giving the acrylic this higher hardness⁽¹⁰⁾. T-test showed that no significant

difference between pre and post soaking indentation hardness for nylon but for heat cured acrylic significant difference between pre and post soaking in oxalic acid and between pre and post soaking in tartaric acid but no significant difference between pre and post soaking in lacialut dent table 3. In this study the diffusion of water and isopropyl alcohol which was used in the preparation of oxalic and tartaric acid cleanser solutions lead to this softening of acrylic surface which is a polymer with side groups chains leading to more water diffusion to the acrylic while nylon is more packed and less intermolecular spaces polymer, the polymer chains are not contain side groups so less water diffusion. Nylon is a highly chemical-resistant material due to its high degree of crystallinity while acrylic is amorphous leading to less water and alcohol absorption for nylon⁽¹¹⁾, so this may

explain the non significant effect of oxalic and tartaric acid cleanser or Lacialut dent solutions on nylon . Lacialut dent is an oxygenating cleanser which had no significant effect on acrylic hardness because no alcohol is present in its composition and the effect of water molecule penetration to polymer is mild to cause significant differences on acrylic indentation hardness.

Table 3: t-test between same subgroups within different material (Nylon &Acrylic)

Material		Nylon		P-Value	Sig	Acrylic		P-Value	Sig
		Mean	SD			Mean	SD		
Oxalic acid	presoaking	65.102	1.631	0.889	NS	74.39	0.962	0.031	S
	postsoakin	65.104	0.704			72.98	0.389		
Tartaric acid	presoaking	63.90	0.895	0.49	NS	74.7	0.425	0.02	S
	postsoakin	64.19	0.956			73.34	0.544		
Lacialut dent	presoaking	64.63	1.012	0.560	NS	73.89	0.784	0.07	NS
	postsoakin	63.86	0.669			74.77	0.811		

2. Flexural strength (three point bending test): One way analysis of variance test (ANOVA) showed a statistically high significant difference between nylon groups and heat cure acrylic groups . t-test showed high significant difference between nylon and heat cured acrylic flexural strength between presoaking groups, also high significant difference between nylon and acrylic flexural strength for post soaking subgroups whatever the denture cleanser the higher measurements was for acrylic .The difference in flexural strength between two polymers can be explained in relation to the strength and number of primary bonds between the atoms and secondary (hydrogen bonds)

between adjacent chains,the weaker the bond the weaker the material⁽¹²⁾. Farther more nylon polymerization during synthesis difference than acrylic, acrylic partial cross linked polymer while nylon is not⁽¹³⁾. T-test also indicated that no significant difference in flexural strength between pre soaking and post soaking for nylon groups but significant difference presented for heat cured acrylic between pre soaking group and post oxalic and between presoaking and post tartaric group table 4,this may be due to that the chemical agents used in this study are aqueous-based solutions with alcohol , alcohol – based

disinfectant decrease the flexural strength of heat cured acrylic because it act as solvent that causes crazing making them more prone to fracture around crazing **line**⁽¹³⁾. stated that solution contain alcohol should not be used for cleaning or storing denture because it cause crazing in certain denture **plastics**⁽¹⁴⁾. Nylon is more packed and

less intermolecular spaces polymer so it may cause less water sorption and highly chemical-resistant material due to its high degree of crystallinity leading to less water and alcohol effect and this explain that no significant effect of oxalic and tartaric acid or lacialut dent cleanser solution on flexural strength.

Table 4: T-test of flexural strength between same subgroups within different material (Nylon&Acrylic)

Material	Nylon		P-Value	Sig	Acrylic		P-Value	Sig
	Mean	SD			Mean	SD		
Control +Postsoakin in oxalic acid	69.3	1.24	0.40	NS	128.42	1.88	0.019	S
	67.57	2.13			125.03	1.88		
Control + Postsoakin in Tartaric acid	69.3	1.24	0.21	NS	128.42	1.88	0.013	S
	68.28	2.20			124.1	2.12		
Control + Postsoak in Lacialut dent	69.3	1.24	0.45	NS	128.42	1.88	0.40	NS
	68.74	2.08			127.39	1,81		

3. Flexibility (three point bending test) : One way analysis of variance test (ANOVA) showed a statistically high significant difference between nylon groups and heat cure acrylic groups .T-test showed high significant difference between nylon and heat cured acrylic flexibility between control groups ,also high significant difference between nylon and acrylic flexibility for post soaking subgroups whatever the denture cleanser the higher measurements were for nylon ,this difference in flexibility between these two polymers can be related to the strength and number of the secondary bonds (hydrogen bonds) between polymer **chains**⁽¹²⁾.The weak nylon secondary bonds allow these chains to slid past one another at much lower stresses within polymer mass , in addition to that acrylic is

polymerized with partial cross linking so it is more rigid than nylon. T-test indicated that significant difference presented between nylon presoaking in oxalic group and post soaking also significant difference presented between nylon presoaking in tartaric group and post soaking . No significant difference presented between other nylon groups or between acrylic groups , these two cleanser reduced the flexibility of nylon and this may be due to that the alcohol constituent of these two cleansers enhance the leaching out of plasticizer and soluble component which lead to decrease in nylon flexibility .No significant decrease in acrylic samples flexibility may be due to that acrylic contains less or no plasticizer and soluble component that released to cause an effect. Table 5

Table 5: T-test of flexibility between same subgroups within different material (Nylon Acrylic)

Material	Nylon		P-Value	Sig	Acrylic		P-Value	Sig
	Mean	SD			Mean	SD		
Control + postsoak in Oxalic acid	7.47	0.141	0.046	S	3.86	0.069	1.00	NS
	7.33	0.149			3.78	0.078		
Control + postsoak in Tartaric acid	7.47	0.141	0.017	S	3.86	0.069	0.999	NS
	7.21	0.264			3.77	0.11		
Control + postsoak in Lacialut dent	7.47	0.141	0.26	NS	3.86	0.069	1.00	NS
	7.37	0,23			3.74	0.08		

4. Surface roughness test: One way analysis of variance test (ANOVA) showed a statistically no significant difference between heat cure acrylic and nylon .T -test indicated also no significant difference between pre and post soaking for nylon groups and no significant difference between pre

and post soaking for heat cured acrylic groups, also t –test , indicated no significant difference between nylon and heat cured acrylic both between post soaking sub groups and between pre soaking sub groups for all cleanser groups.

5. Color stability: One way analysis of variance test (ANOVA) showed a statistically high significant difference between heat cure acrylic and nylon at 400nm and high significant difference at 500 nm. T-test showed high significant difference between nylon and heat cured acrylic for pre soaking subgroups, also high significant difference between nylon and acrylic for post soaking subgroups whatever the denture cleanser, acrylic absorb more light than nylon,

this is due to that the unstauration is more in the PMMA polymer than polyamide (nylon polymer) at both 400 nm and 500 nm wave length. The three cleansers had no significant effect on nylon or acrylic color, this may be due to that all the denture cleanser solutions used in the study had no chemical reactivity to cause color changes in both polymers due to the low concentration of those solutions. Table 6 and table 7.

Table 6: t-test of color stability between different subgroups (pre & posoaking) within same material at 400 nm wave length.

Material		Nylon		P-Value	Sig	Acrylic		P-Value	Sig
		Mean	SD			Mean	SD		
Oxalic acid	Presoaking	0.9083	0.0348	0.47	NS	1.8320	0.1489	0.19	NS
	postsoakin	0.9249	0.0620			1.9144	0.1165		
Tartaric acid	presoaking	0.9398	0.0497	0.29	NS	1.878	0.1304	0.07	NS
	postsoakin	0.9615	0.0395			1.9426	0.0867		
Lacalut dent	presoaking	0.9290	0.0553	0.88	NS	1.9428	0.0875	0.22	NS
	postsoakin	0.9252	0.0566			1.8991	0.0630		

Table 7: t-test of color stability between different subgroups (pre & posoaking) within same material at 500 nm wave length.

Material		Nylon		P-Value	Sig	Acrylic		P-Value	Sig
		Mean	SD			Mean	SD		
Oxalic acid	Presoaking	0.8736	0.0369	0.82	NS	1.5892	0.1537	0.24	NS
	postsoakin	0.8702	0.0290			1.6693	0.1425		
Tartaric acid	presoaking	0.8727	0.0359	0.56	NS	1.674	0.0715	0.08	NS
	postsoakin	0.8839	0.0479			1.7548	0.0754		
Lacalut dent	presoaking	0.8928	0.0435	0.95	NS	1.8306	0.1439	0.45	NS
	postsoakin	0.8942	0.0615			1.7774	0.1645		

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