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Effect of repeated load on life of the PMMA molar denture

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Abstract
The removal of molar denture was made from PMMA polymer. The alternating load of dental during the process of chewing food therefore it is failure by fatigue. In fatigue failure the crack was initiate then crack propagate. In this paper, the effect of repeated load on life of removable molar denture was study, the PMMA molar was manufacturing then testing to determine mechanical properties by compression fatigue load tester. Also, the mechanical properties of the material were examined as a test of compression and hardness. The force of load is find by special sensor. Finally, the repeated load on removable dental molar can be reduce the life of the dental to less than half.

Keywords: Repeated load; PMMA molar; Compression; Crack; Hardness.

1. Introduction

Polymethylmethacrylate (PMMA) resin is the most extensively used material for the fabrication of dentures because it possesses a combination of favorable characteristics, such as the ease of laboratory manipulation, light weight, inexpensive fabrication, stability in the oral environment, appropriate esthetic and color-matching ability, and lack of toxicity [1]. In linear polymer category, PMMA ploy (methyl methacrylate)] plays major role in fabrication of complete or partial dentures. In addition, denture soft tissues resin cements, pit and fissures sealment also consists of polymer. The PMMA polymer denture is most popular choice of prosthetic device. In complete denture constructed with some precious metal alloy sand base metal alloys in previous days [2]. Acrylic dentures frequently fracture during service due to their poor strength characteristics [3]. Structural modifications to the composition, such as the addition of fillers, could enhance the resin's mechanical properties. The most popular type of prostheses in many countries, can be a method of choice in such cases. The removable dentures made of injection-molded thermoplastic materials, such as acetal (AC) or polyamide (PA), constitute an alternative to widely used polymethyl meth-acrylate (PMMA) dentures [4] The thermoplastic materials have lower modulus of elasticity than the PMMA denture base materials [5] Although the PMMA, PA and AC have been used in clinical practice for several dozen years and were a subject of extensive multidirectional research, to the best of our knowledge, none of the previous studies compared the life of dentures made of these materials. Therefore, the aim of this study was to determine the life molar denture, Figure 1.

In general, the life for polymer materials modified by different techniques as reinforcement with fiber materials or powder material. Thus, at 2012, [6], modified the fatigue life for polymer materials with reinforcement by fiber materials and application its modified materials in socket knee, then, after this, at 2017, [7], modified the fatigue life for rubber materials by using carbon powder materials. At, 2018,

application for polymer materials with different structure after modified the fatigue life by using different reinforcement fiber and powder materials, [8-10].

Figure 1. Removable molar denture.

2. Materials

The molds were used to create wax-up specimens, and specimens were created from PMMA with Silica with different weight fraction (0 %, 2.5%, 5 %, 7.5 %), Groups were prepared with the addition of micro particle of silica in different concentrations by weight to obtain more uniform dispersion of particles with polymer. Prior to the fabrication of acrylic test specimens, the inside and the edges of the mold were polished in order to obtain smooth surfaces.

3. Experimental work

3.1 Compression test

The sample was prepared in semi-cubic dimensions, according to ASTM, as shown in Figure 2, with different weights (0 %, 2.5%, 5 %, 7.5 %) and then perform a compression test by universal test (Tins Olsen), ASTM D1621 is a test method used to determine the compressive properties of rigid cellular materials, particularly expanded plastics. The calculations that can be derived from this method include compressive strength, compressive strain, compressive stress and Modulus of Elasticity.

Figure 2. Compression specimen according ASTM 1621.

3.2 Hardness test

The hardness testing of plastics is most often measured by the Rockwell hardness test or Shore (durometer) hardness test, Rockwell hardness is generally chosen for 'harder' plastics such as nylon, polycarbonate, polystyrene, and acetal where the resiliency or creep of the polymer is less likely to affect the results, in this study Shore D was used to determine the hardness for four groups of weight fraction (0 %, 2.5%, 5 %, 7.5 %), The Shore durometer is a device for measuring the hardness of a material, shown in Figure 3, typically of polymers, elastomers, and rubbers. Higher numbers on the scale indicate a greater resistance to indentation and thus harder materials.

Figure 3. Hardness test by Shore D.

3.3 Dental tests

3.3.1 Bite force sensor

The sensor is just 5/8 inch high and 6 inches long. This makes it easy for a patient to hold it in their hand, insert it in the mouth and apply pressure when instructed by sensor. A subject was asked to position the sensor under their second molar and make three consecutive attempts to bite as hard as they could. This test according standards of references, [11].

3.3.2 Fatigue test of dental

After preparing to manufacture the removable dental molar for groups of composite materials (0, 2.5, 5, 7.5)% wt of Silica, Figure 4, using special device to determine the life of removable molar by applied repeated load was simulating the process of chewing food in humans, as shown in Figure 5.

The machine is turned on and the air pressure is transformation to electrical solenoid then pushed through the pneumatic cylinder, after controlling the force that hits dental molar alternately, the number of strikes is recorded by counter until the failure is reached.

This process was repeated on the molar was manufactured from different weights. Then choose the molar dental that have a higher life than others and determine the best proportion of the weight fraction can be made of dental with the addition of silica.

Figure 4. Removable dental manufacturing method.

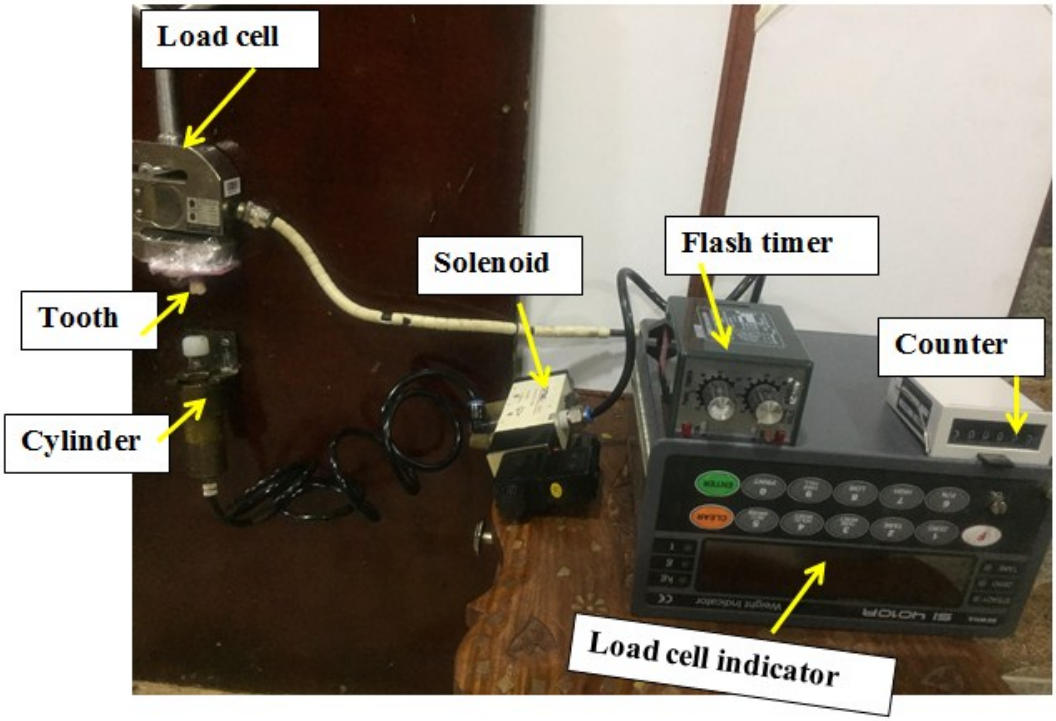

Figure 5. Fatigue dental tester.

4. Results and discussion

4.1 Compression results

After the compressive test was performed for the different groups, the compressive strength, shown in Table 1, was increased by increasing the addition of particles of silica at 2.5 %wt and increased by 5 %wt, but the strength was decreased slightly at 7.5 % wt. This confirms that silica easily initiated the crack propagation, thereby increasing the brittleness of the composites and decreasing their ductility, [12].

Table 1. Results of compression strength for groups.

Group	Weight fraction %	Compression strength (MPa)
A	PMMA	67
B	PMMA + 2.5%wt Sio2	78
C	PMMA + 5%wt Sio2	84
D`	PMMA + 7.5%wt Sio2	73

4.2 Hardness results

This test was performed using durometer hardness tester (shore D hardness). Table 2 shows the values of experimental specimen measuring surface hardness in different concentrations of SiO2 micro filler. The slightly increase of the hardness of the composite at low micro particles concentration (2.5%) would be dominated by network density, while increased hardness of the composite at%5 and 7.5% attributed to the accumulation of the (SiO2)particles in to the acrylic matrix specially on the surface, these results was agreement with reference[13, 14].

Table 2. Hardness shore D for different groups.

Group	Weight fraction %	Hardness Shore D
A	PMMA	71
B	PMMA + 2.5%wt Sio2	76
C	PMMA + 5%wt Sio2	78
D`	PMMA + 7.5%wt Sio2	79

4.3 Life of removable denture molar

By force sensor the maximum applied on molar was 643 N, this load is repeated from zero to 643 N. From the results were obtain by fatigue tester at failure of removable molar denture for different group.

It can be seen that the increase of the particles increase the life of the teeth significantly at the rate of 2.5% wt and at 5% wt, but the hardness is decreasing at 7.5% wt, due to transformation of the material into a ductile material to brittle materials, this transformation which helps to the crack initiation then crack propagation, as shown in Figure 6.

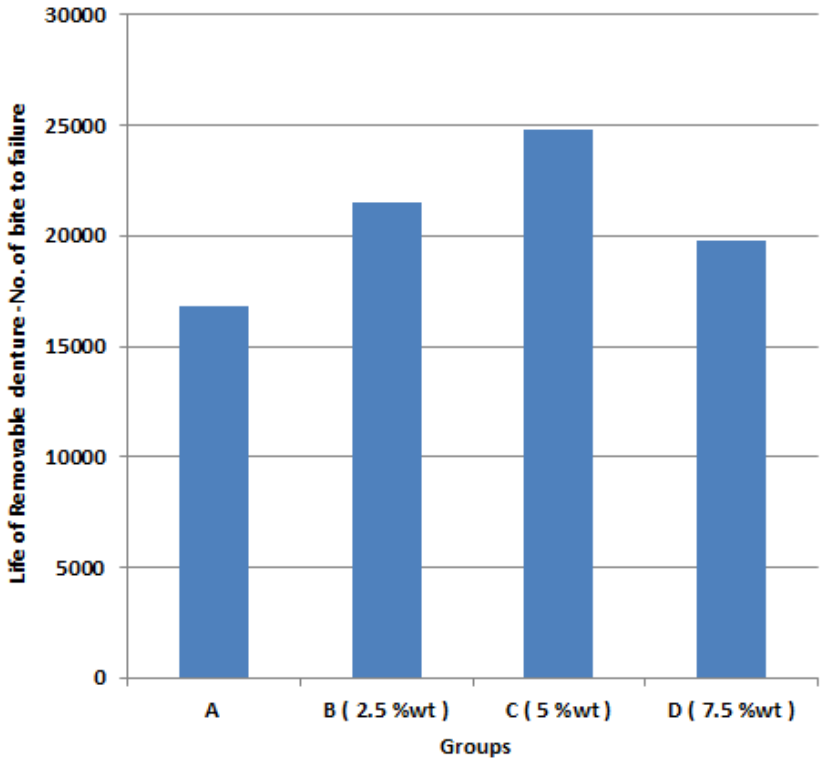

Figure 6. Life of removable molar denture with different weight fraction.

5. Conclusions

Increasing the silica particles to the PMMA by 5% weight fraction, causing an increase in the life of the molar denture by about 50%, and then decrease the life when increasing the weight ratios to 7.5%, this decrease is due to the conversion of the material from ductile to brittle, that causing the growth of crack.

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