

FRACTURE STRENGTH OF PALATAL DENTURE BASE CONSTRUCTED FROM DIFFERENT ACRYLIC DENTURE BASE MATERIALS

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Abstract

Background: Acrylic resins constitute about 90% of polymeric materials used in prosthetic dentistry. However, they are not devoid of drawbacks. Their weakness includes poor resistance to fracture and abrasion, as well as changes in volume and shape during fabrication and use.

Objectives: The aim of this study is to evaluate and compare the mechanical strength in fracture force test of maxillary palatal denture bases, fabricated from different acrylic resins.

Materials and Methods: Twenty five maxillary edentulous stone casts were constructed from a standard silicon model of maxillary edentulous jaw. Five palatal denture bases were made from each of the following materials; conventional heat cure acrylic (Control Group), rapid cure acrylic, high impact acrylic and Biostar pure acrylic, according to the manufacturer's instructions. The fracture force test was carried out on a universal testing machine (GUNT HAMBURG) at a crosshead speed of 10mm/min. The results were analyzed using ANOVA and *t*- test to determine the significant differences between tested groups at a significant level ($P < 0.05$).

Results: The high impact acrylic resin showed the highest fracture force value, while the Biostar pure acrylic resin showed the lowest value as compared with other tested materials. The results revealed highly significant differences between the high impact acrylic and conventional heat cure acrylic ($P < 0.001$), and other tested denture base materials ($P < 0.05$). Also, rapid heat cure acrylic resin showed significantly higher fracture force value than those obtained by both conventional heat cure acrylic resin and Biostar pure acrylic resin ($P < 0.05$), ($P < 0.001$) respectively. Finally, significantly lower fracture force value was obtained by the Biostar acrylic resin as compared to the conventional heat cure acrylic ($P \leq 0.05$) and other tested denture base materials ($P < 0.001$).

Conclusions: Under the limitation of this study for those patients who fracture their dentures on regular basis, it is possible to consider a high impact and rapid cure acrylic resins denture base, which shows a higher degree of resistance to fracture in comparison with conventional heat cure acrylic resin. However, this is unlike the Biostar pure acrylic resins that showed undesirable results as compared with conventional heat cure acrylic and other tested denture base materials.

Keywords: denture base, Acrylic resin, Fracture force.

Introduction

Acrylic-based resins are intensively used in dental practice as denture base materials. However, its resistance to impact and its fatigue failure are somewhat poor. Thus, fracture of acrylic resin denture bases is a continuing problem in prosthodontics (Yesil et al., 2006). Consequently, there are many predisposing clinical factors for denture fractures. For instance, biting and mastication forces have a deforming effect during function, and any factor that increases the deformation of the base and changes the stress distribution may lead to denture fracture (Gurbuz et al., 2010). Moreover, the fracture of dentures may be related to the mechanical properties of the acrylic resin or may be due to multiplicity of factors leading to failure of the denture base material (Jagger and Jagger, 2002)

In many situations, fractures occur in the midline of the denture base, and the location of fracture occurs more often in maxillary dentures than in mandibular dentures (Abdulla, 2012 and Cilingir et al., 2013). A recent survey of denture base fractures in removable dentures indicated that the ratio of maxillary to mandibular fractures was generally 2/1 based on repairs performed by commercial dental laboratories (Aljmoor, 2013).

In order to produce stronger denture base materials which are resistant to fracture, different approaches have been proposed such as modifying the chemical composition of denture base materials by adding a rubber compound. This would lead to obtaining the high impact resin or reinforced with reinforcing fibers (Nakamura et al., 2007; Alkordy & Alsaadi, 2014). Also many different processing techniques have been proposed to improve and simplify the polymerization technique and reduce denture production time (Gurbuz et al., 2010). Furthermore, information about the mechanical properties of acrylic materials could help in the understanding and improvement of denture fractures. Therefore, the purpose of this study is to evaluate and compare the mechanical strength in fracture force test of maxillary palatal denture bases fabricated from high impact heat cure acrylic resin, rapid heat cure acrylic resin, and Biostar pure acrylic resin with conventional heat cure acrylic resin as a control group.

Materials and Methods

To simulate the clinical situation, a standard model of maxillary edentulous jaw was used in this study for samples construction. An edentulous maxillary silicon mold was poured with type III dental stone (Zhermack, Italy) using 30 ml:100g water / powder ratio according to the manufacturer's instruction, and twenty five casts were constructed. In order to provide the standardization of denture base thickness, a uniform denture base pattern was made from base plate wax (Cavex Modeling Wax, Netherlands) on each stone cast with 2.5 mm thickness. Five palatal denture bases were made from each of following materials; conventional heat cure acrylic (control group), rapid cure acrylic, high impact acrylic and Biostar pure acrylic, according to their manufacturer instructions (Table 1). The thickness of the dentures bases (2.5mm) was measured using a digital caliper (LEZACO, ART.2771, China). Differences in the dimensions were carefully eliminated by trimming the denture bases to predetermined dimensions. The specimens were stored in distilled water at room temperature (25 ± 0.5) °C for 4 weeks prior to testing (Figure 1).

The fracture force test was carried out on a universal testing machine (GUNT HAMBURG) (Figure 2) at a crosshead speed of 10mm/min. The palatal denture bases were fractured by a force of 5,000N. Acrylic denture bases were placed on the sub-table of the machine with the tissue surface of the bases facing upward (Figure 3). The compression load was applied on the midline of the denture bases until catastrophic fracture occurred. The results were analyzed using ANOVA and *t*-test to determine the significant differences between tested groups at a significant level ($P < 0.05$).

Results

The mean, standard deviation, and ANOVA results for fracture force test are presented in Table 2. Highly significant differences were found between the tested materials ($P < 0.001$). The *t*-test results between each two tested denture base materials were depicted in Table 3. Hence, it is clear that the high impact strength acrylic resin material showed the highest mean in fracture force (1.898 KN) followed by rapid cured acrylic resin and conventional heat cure acrylic; while the Biostar pure acrylic showed the lowest mean (0.5680 KN). The results revealed highly significant differences between the high impact acrylic and conventional heat cure acrylic ($P < 0.001$), and other tested denture base materials ($P < 0.05$). The rapid heat cure acrylic resin showed significantly higher fracture force value than both conventional heat cure acrylic resin and Biostar pure acrylic resin ($P < 0.05$), ($P < 0.001$) respectively. Finally, significantly lower fracture force mean value was noticed for the Biostar acrylic resin as compared to the

conventional heat cure acrylic ($P<0.05$), and other tested denture base materials ($P<0.001$).

Discussion

To compare the performance of different denture base resins, various mechanical tests can be performed. In the present study, the force exerted in compression test was designed to simulate clinical condition of upper denture. This is because most fracture occurs in the midline, and this is in agreement with Morris et al. (1985); Yesil et al. (2006) and Hedzelek et al. (2006) studies. They stated that downward force applied to the midline of denture tissue surface became equal to the force applied in the upward direction of the teeth on both sides. Furthermore, they also concluded that this test was sufficient in upper dentures. Hence, the results from this test may be clinically more relevant.

The results obtained also showed that the high impact acrylic resin has the highest fracture force mean value with highly significant differences as compared with conventional heat cure acrylic (control group), rapid cure acrylic, and Biostar pure acrylic ($P<0.001$). These findings could be explained in correlation with the composition of high impact strength acrylic resins. These resins are formulated with rubber reinforcing agent, such as a fine dispersion reinforced with butadiene-styrene rubber. The rubber particles are grafted to methyl methacrylate matrix. The rubbery inclusion stop cracks that develops, showing a high degree of resistance to fracture as a consequence. However, they also cause lowering of the flexural modulus and long term fatigue failure due to excessive flexure (Craig and Power, 2002 and Noort, 2002). This finding is in agreement with the results of Alkordy and Alsaadi (2014) who concluded that the high-impact acrylic resin is a suitable denture base material for patients who are suffering from repeated fracture of the maxillary complete acrylic denture.

The rapid heat cure acrylic resin showed significantly higher fracture force value than both conventional heat cure acrylic resin and Biostar pure acrylic resin ($P<0.05$). This finding shows that the rapid heat cure acrylic resin is hybrid acrylic with both chemical and heat activated initiators that allow rapid polymerization without porosity that might be expected. Furthermore, it polymerizes in boiling water immediately after being packed in flask for 20 minutes (Craig and Power, 2002; Tandon et al., 2010). Several studies confirmed that the heat cure acrylic resin have a significant residual monomer levels from 1% to 3% when they are processed in less than one hour in boiling water (Jerolimov et al., 1989; Harrison and Huggett, 1992; Barbosa et al., 2007 and AL-Taie, 2008). The higher levels of residual monomer have a deleterious effect on the mechanical properties of cured denture base. This could affect the flexural strength because of a plasticizing

effect that reduces the interchange forces. The amount of monomer used must be kept as low as possible, but it must be sufficient to have two important effects. First, it must soften the hard polymer grains and so, reduces the molding pressure. Secondly, there must be sufficient monomer to glue the polymer particles together in solid mass (Craig and Power, 2002). Despite the difference in the mechanical test, this finding is consistent with that of Sedda et al. (2007) who found that the fast polymerization cycle for heat-cured acrylic resin proved to increase the flexural strength.

On the other hand, the results obtained for Biostar pure acrylic resin showed the lowest fracture force mean value, with highly significant difference as compared with other tested materials ($P < 0.001$). Although, Biostar acrylic is pure Polymethylmethacrylate (PMMA) and monomer free, but due to the high and rapid temperature (80°C) applied during processing, it makes the Biostar acrylic resin a stiffer material with lower flexibility. Therefore, the Biostar fractured easily under load as compared to other tested denture base materials.

Conclusion

Based on the limitation of this study, the followings conclusions have been drawn:

- For those patients who complain from repeated fracture of upper dentures, it is possible to consider a high impact resin denture base that shows a higher degree of resistance to fracture in comparison with conventional heat cure acrylic resin.
- The rapid heat cure acrylic resin showed a considerable mean of fracture force compared with conventional heat cure acrylic resin.
- Biostar pure acrylic had the lowest mean of fracture force, and this material is not suitable when compared with conventional heat cure acrylic and other denture base materials.

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Table -1: Types of acrylic resin denture base materials used in this study.

Materials	Manufacturer	Powder/ liquid Ratio	Curing Cycle
High impact heat cure acrylic resin	Vertex dental-Netherlands.	21g powder/ 10ml liquid	Heat processed at 70 °C for 90minutes, then 100 °C for 30 minutes.
Conventional heat cure acrylic resin	Meadway-UK.	1 part liquid to 2.34 parts powder by weight	Heat processed at 70 °C for 90minutes, then 100 °C for 30minutes
Rapid heat cure acrylic resin	Vertex dental-Netherlands.	23g powder/ 10ml liquid	Heat processed directly at 100°C, then left to boil for 20 minutes.
Biostar pure acrylic resin	Biocryl "C"- Scheu Dental GmbH-Germany.	Pure PMMA plate - monomer free. Size: 3 x 125 mm clear color, code 217.	The denture base was prepared using a Biostar machine. The cast was placed on the Biostar platform and dipped in the Biostar beads just below the borders; the code of the Biostar plate is entered; the plate was softened and pressed on the cast (heat and press for 80 sec, and cool for 300sec); then the cast with the plate was removed from the machine; cutting, trimming and finishing were done using Biostar burs.

Table-2: Mean, Standard Deviation, and ANOVA of fracture force test values in KN of tested denture base materials.

Materials	Mean \pm SD	df	F	P- Value	Significance
Conventional heat cure acrylic	0.8460 \pm 0.10738	4	23.692	0.001	H.S.
High impact heat cure acrylic	1.8980 \pm 0.39079				
Rapid heat cure acrylic	1.3160 \pm 0.13885				
Biostar pure acrylic	0.5680 \pm 0.18047				

Table-3: *t*- test results of fracture force values between different denture base materials.

Materials	Mean \pm SD		<i>t</i>	df	P-values	Significance
Conventional heat cure acrylic	0.8460	0.1073 8	-5.804	8	0.001	H.S.
High impact acrylic	1.8980	0.3907 9				
Conventional heat cure acrylic	0.8460	0.1073 8	-5.987	8	0.004	S
Rapid cure acrylic	1.3160	0.1388 5				
Conventional heat cure acrylic	0.8460	0.1073 8	2.960	8	0.018	S
Biostar pure acrylic	0.5680	0.1804 7				
High impact acrylic	1.8980	0.3907 9	3.138	8	0.014	S
Rapid cure acrylic	1.3160	0.1388 5				
High impact acrylic	1.8980	0.3907 9	6.909	8	0.001	H.S
Biostar pure acrylic	0.5680	0.1804 7				
Rapid cure acrylic	1.3160	0.1388 5	7.345	8	0.001	H.S
Biostar pure acrylic	0.5680	0.1804 7				

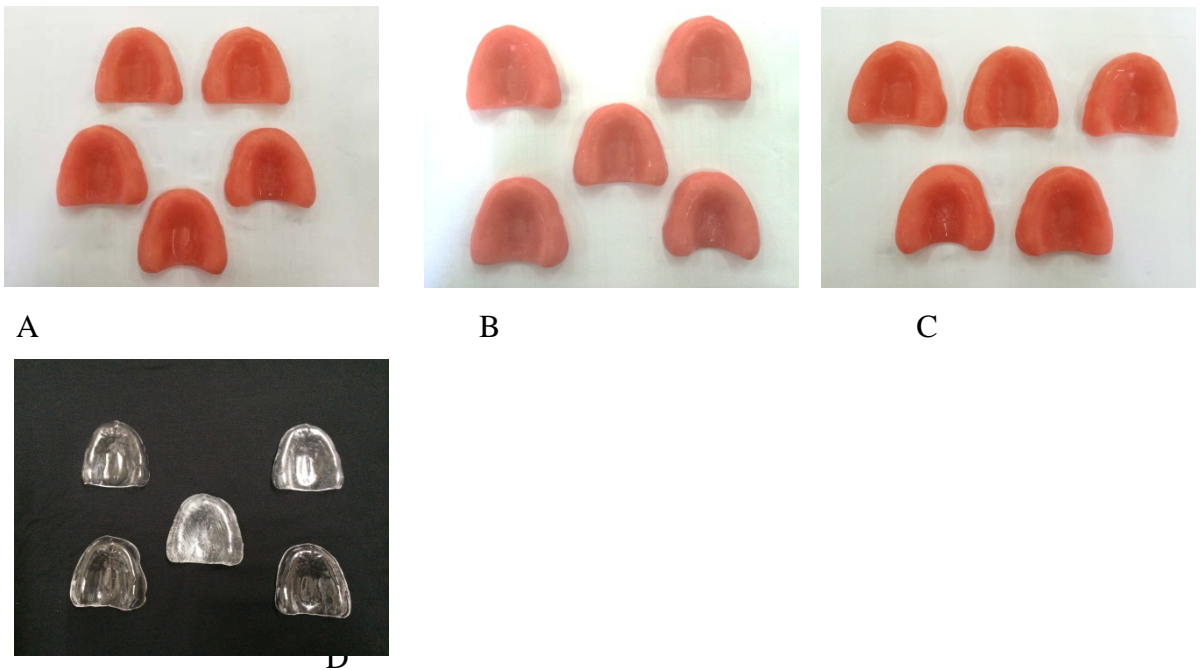


Figure-1: Samples constructed in the study; A-Conventional heat cure acrylic (Control Group), B-High impact acrylic, C-Rapid cure acrylic , D-Biostar pure acrylic.

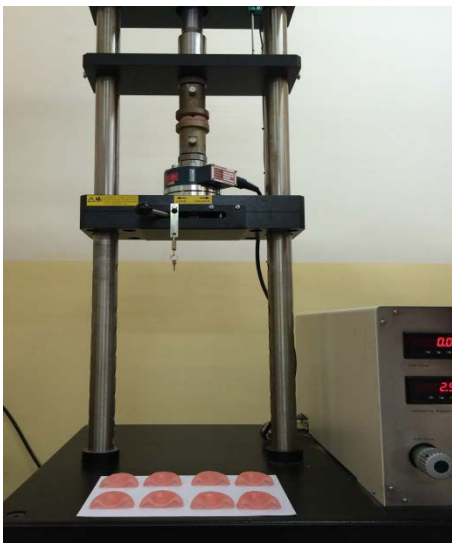


Figure-2: Testing machine.



Figure-3: A sample on testing machine table.