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Original Research Article

A Research Study To Compare The Flexural Strength And Impact Strength Of Different Heat Cure And Chemical Cure Acrylic Resins Under Various Conditions

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ABSTRACT

Flexural strength and impact strength of acrylic resins play an important role in success of prosthesis and many approaches have been made to improve the fracture resistance of acrylic resins by strengthening them. Purpose of the study was to assess and compare the strength of high impact denture base resin material with conventional heat and chemical-polymerized polymethyl methacrylate (PMMA) resin materials under dry and wet storage conditions. Sixty specimens of standard dimensions were prepared (20 specimens of each resin); 10 each were placed in dry conditions and 10 each were placed in wet conditions. All 60 specimens were then subjected to a 3-point bending test for the calculation of flexural strength and Notched IZOD impact tester for the calculation of impact strength. Statistical analysis was carried out using One Way Analysis of Variance and Multiple Comparison Test. The mean flexural strength and impact strength of Trevelon HI denture base resin material when tested under dry conditions was high as compared to DPI heat and chemical cure resins. All the specimens stored under wet conditions showed decrease in flexural strength in comparison to those stored in dry conditions.

Keywords: Denture base material, Flexural strength, Impact Strength.

INTRODUCTION

The material most commonly used in the fabrication of many types of dental prostheses, including complete or removable partial denture, interim prostheses, and implant-supported prostheses is poly methyl methacrylate. Polymers play an important role in the spectrum of dental materials. Although the various properties of acrylic resins have their own limitations, particularly in terms of flexural strength and impact strength. There have been many research studies undergone in an attempt to improve the mechanical properties of poly methyl methacrylate. [1] Reinforcement of different resin materials was done commonly with different materials. [2,3] Many additives like fibers, beads, carbon, [4,5] polyethylene, [6,7] glass [8-11] have been added to acrylic resins in an attempt to improve its mechanical properties. To avoid fractures, metal inserts in the form of wires, meshes and plates have also been incorporated into denture resin bases. [12-13] These additives help to improve toughness and impact resistance, and also help to prevent crack propagation. These products are referred as "high impact" and manufacturers claim them to have improved strengthening properties. [1,14,15] These materials are often expensive when compared to conventional resin materials.

The purpose of this study was to determine the impact strength and flexural strength of high impact denture base resin with conventional heat cure denture base resins and chemical cure acrylic resins.

MATERIALS AND METHODS

The materials used in the study were two types of heat cure denture acrylic resins viz. Trevelon HI and DPI heat cure denture base acrylic resin and DPI chemical cure acrylic resin. All the above selected acrylic resins were evaluated and compared for their flexural strength and impact strengths. Conventional heat cure denture base resin was used as a control.

Sample preparation:

Acrylic bar samples were made from metallic dies for testing denture base resins in accordance to ADA Specifications. [16]

Strip for Flexural strength: 65x10x3mm

Strip for Impact strength: 80x12.7x3.17mm

After the metallic die samples were fabricated, the mould space was made in denture flasks using compression molding technique. Small amount of wax (Modeling Wax, Hindustan Dental Products, Hyderabad India Ltd.) was filled into both ends of the metal strip to facilitate its removal. A thin layer of petroleum jelly (Bioline®) was applied on the strips and was invested in the denture flask, embedding half of the thickness of the strip into plaster investment. After the plaster was set, a coat of separating medium was applied. The second pour was made with dental plaster and the flask was held in compression till the final set of dental plaster. After the material was set completely, the flask was opened and the preformed strips were retrieved from the plaster. Later the steps that followed were similar to one used for processing conventional complete denture.

DPI Heat Cure Polymer (P:L Ratio of 15 g: 5 ml), DPI Chemical Cure polymer (P:L Ratio of 15 g: 5 ml), Trevelon HI Heat Cure Polymer (P:L Ratio of 15 g: 5 ml) was taken in, manipulated and packed into the mold in dough stage. Care was taken to avoid porosities due to entrapment of air bubbles. Trial closure was performed. Curing was done using a short curing cycle where the temperature was slowly raised to 73ºC and held for 120 min followed by boiling at 100ºC for 60 min. Test samples were labeled on each end before testing as HC1 to HC20 for DPI heat cure conventional resin: CC1 to CC20 for chemical cure conventional resin, HI1 to HI20 for Trevelon HI heat cure resin. 60 resin samples were prepared.

Finishing and polishing of samples:

After investing the samples were retrieved, finished and polished with sandpaper and pumice. Minimal finishing and polishing was required and care was taken to maintain low heat during the procedure. Now the samples were divided into two groups:

Group 1 consisted of specimens to be tested in dry conditions.

Group2 consisted of specimens to be tested after immersing it in artificial salivary substitute at 37^0C.

The testing for flexural strength was done using three-point bend test on Universal Instron testing machine while impact strength was tested using IZOD Impact tester.

a) Evaluation of Flexural Strength

The specimens were tested for flexural strength with a three-point-bending test using INSTRON universal testing machine at a crosshead speed of 2 mm/min and span length of 50 mm. The load was applied centrally on the bar specimen until fracture occurred. The amount of deflection and the load at fracture were noted.

The flexural strength was calculated using the formula:

Flexural strength = 3/2 x pl/bd 2 where

p - is the peak load

l - is the span length

b - is the sample width and

d - is the sample thickness

b) Evaluation of Impact Strength

For impact strength the samples were tested using a Notched IZOD impact tester. The specimens were clamped at one end and a swinging pendulum of 0.5 J was used to break the unnotched specimens. The absorbed energy by the specimen was noted. The impact strength was calculated using the formula:

Impact strength = E / b x d where

E - is the absorbed energy

b - is the sample width and

d - is the sample thickness

The values for comparison of flexural strength and impact strength of various heat cure resins and chemical cure resins was evaluated using One Way Analysis of Variance and multiple comparison test.

RESULTS

The results obtained are given in Table 1 and 2

Table 1: Mean Impact Strength (KJ/m2) of the three materials tested.

Materials	Dry	Artificial saliva
DPI heat cure	1.66 ± 0.60	1.48 ± 0.03
DPI cold cure	1.32 ± 0.36	1.25 ± 0.28
Trevalon HI heat cure	2.60 ± 0.35	3.23 ± 0.23

Table 2: Mean Flexural Strength (MPa) of the three materials tested.

Materials	Dry	Artificial saliva
DPI heat cure	62.05 ± 2.16	59.29 ± 1.08
DPI cold cure	58.45 ± 2.59	54.67 ± 1.7
Trevalon HI heat cure	119.53 ± 2.45	111.63 ± 1.87

DISCUSSION

In removable prosthodontics fracture of acrylic resins is frequently encountered problem despite numerous attempts made to rectify its causes. Upper denture fracture is more common with a ratio of 2:1 as compared to the lower dentures. Two types of failures are commonly analyzed with respect to fracture viz.: (1) Outside the mouth, caused by impact forces, i.e., a high stress rate and (2) Inside the mouth, usually in function, which is probably a fatigue phenomenon, i.e., low and repetitive stress rate. Inside the mouth, generally repetitive stress like flexural stress occurs most commonly over a period of time. This type of fracture is typically seen in midline of maxillary dentures than in mandibular dentures. Acrylic resins have shown to flex in function to a much greater degree than would be expected. [15-17] Therefore to overcome such disastrous eventualities many modifications in the conventional denture base resin to improve its strength were introduced [7-10]

Many such attempts led to modification of the acrylic resins including plasticization, copolymerization, cross linking and reinforcement to improve the specific properties of the polymer. [8] One such attempt led to the chemical modification of acrylic resin through the incorporation of rubber in the form of butadiene styrene has been successful in terms of improving the impact strength. [18,19] However, the incorporation of rubber has not been entirely successful in that it can have detrimental effects on the modulus of elasticity and hence the rigidity of the denture base. Various mechanical tests are done to test the fracture resistance, the common among them are the flexural strength and impact strength. This study compared the impact strength and flexural strengths of high impact denture base acrylic resin with a conventional heat-cured and chemical cured acrylic resin. The samples obtained in this study are similar to one adopted by Jhon J et aI [20,15]

The transverse (flexural strength) of a material is a measure of stiffness and resistance to fracture. [14] Flexural strength tests were undertaken as these were considered relevant to the loading characteristics of a denture base in a clinical situation. Sample dimensions were taken as per ADA specification No 12 [16] where in a three point bend test was carried out using IINSTRON universal testing machine with predictability. Reinforced resins require higher forces to fracture them and hence have better transverse strength.

Impact Strength:

There are basically two types of tests for impact strength that is Charpy and IZOD tests. In this study IZOD impact tester is utilized. Impact tests are influenced by loading conditions and specimen geometry, such as the dimensions of the sample and the presence and configuration of notches and hence can give different values. [14,15]

Flexural Strength:

Flexural strength was tested to get an understanding of how denture base resins hold up under function. There were significant differences in the acrylic resin denture base materials tested. Trevelon HI heat cure resin material has higher impact strength and flexural strength, compared to DPI heat cure acrylic resin and DPI chemical cure acrylic resin. But on the other hand, statistically, there was no significant difference in impact strength as well as flexural strength of DPI heat cure acrylic resin and DPI chemical cure acrylic resin. These higher properties are indicative of the needed strength and durability of resins used for denture prostheses.

It was noted that when these specimens were stored in artificial saliva the strength decreased as they release residual monomer during immersion for a week.

This would cause them to become more brittle and accentuate the difference between the conventional resins and the high impact denture base resins. Clinically a resin material exhibiting a lower flexural strength may be more prone to fracture during function as a denture base, than would a resin with higher flexural strength.

This potential for fracture may increase due to water sorption, further decreasing their strength. The present data justifies the observation that the polymers behave differently in air and after immersion in artificial saliva.

From the above discussion of results as well as the statistical analysis it is evident that after immersion in liquid medium the denture base resins were more prone to fracture than when they are tested dry.

CONCLUSION

The overall success of denture base resins does not only depend on the mechanical behavior but also on the design and fabrication, the action of residual stresses and on the conditions of loading. Hence the interpretation of laboratory results obtained to produce comparative data on different materials may differ.

Mechanical properties are also depended on factors like different powder/liquid ratios, homogenous copolymer beads, differences in water uptake.

Within the limitations of this study, results showed high flexural strength and impact strength of reinforced denture base resins in dry conditions as compared to the conventional heat and chemical cure denture base resins in wet conditions.

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