FLEXURAL STRENGTH OF HEAT CURE DENTURE BASE RESIN WITH ADDITION OF ALUMINIUM OXIDE FILLER CURED BY DIFFERENT CURING METHODS

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Abstract:

Background: Flexural strength of denture base resin is considered primary mode of clinical failure.

Aim: This study was done to compare the flexural strength of acrylic resin with or without addition of aluminium oxide filler and processed with two techniques.

Material and method: 10 samples each were processed using normal acrylic resin with conventional water bath technique, modified acrylic resin with 10% and 15% aluminium oxide processed by conventional water bath technique, normal acrylic resin with microwave technique, modified acrylic resin with 10% and 15% aluminium oxide processed with microwave technique. The values obtained were subjected to statistical analysis using ANOVA followed by post hoc Tukey's test.

Result: Mean flexural strength were normal acrylic resin processed with conventional water bath technique is 68.2, Modified acrylic resin with 10% aluminium oxide processed by conventional water bath technique is 78.11, Modified acrylic resin with 15% aluminium oxide processed by conventional water bath technique is 82.95. Normal acrylic resin processed with microwave technique is 79.43. Modified acrylic resin with 10% aluminium oxide processed with microwave technique is 82.21. Modified acrylic resin with 15% Al_2O_3 processed with microwave technique is 85.27.

Conclusion: The specimens of heat-curing acrylic resin reinforced with 10% and 15% aluminium oxide filler provided superior flexural than those with normal acrylic resin. The specimens of heat curing acrylic resin reinforced with aluminium oxide filler showed increase in flexural strength when processed by microwave technique.

Key Words: Flexural strength, Aluminium oxide, denture base resin

Introduction

Synthetic plastics are the single class of materials that have influenced humans from its introduction to dentistry. Plastics also had an enormous impact on dentistry, and they are now used in Prosthodontics as bonding materials, restorative materials, veneering materials and impression materials. Poly methyl methacrylate currently is the material of choice for denture base fabrication.[1] Introduced in 1937 by Dr. Walter Wright, Poly methyl methacrylate continues to be used because of its favorable working characteristics, processing ease, accurate fit, biocompatible, stability in the oral environment, superior esthetics, and use with inexpensive equipment.[2] Despite these excellent properties, there is a need for improvement in the fracture resistance of poly methyl methacrylate. Most fractures of the denture occur inside the mouth during function, primarily because of resin fatigue.[3,4] Since its introduction, there has been a continuous search to modify the processing techniques and working properties to improve the physical and mechanical properties of acrylic resin. Primary mode of clinical failures in denture base resins considered are flexural strength of denture base resin.[5,6] Various methods to enhance strength of acrylic resin have been suggested. These include chemical modification to prepare high impact resin,[7] mechanical reinforcement glass fibers,[8-11] sapphire whiskers,[12,13] aramid fibres,[9,12] carbon fibres,[14-16] metal wires,[17-19] nylon,[9,20] polyethylene fibres[21,22] and zirconia.[23] The processing is usually done by conventional water bath technique.[24,25] Microwave energy is also used to process the resin.[26-29] The controlled microwave energy enables a higher degree of conversion of monomers into polymer chains in the polymerization process, thereby enhancing the physical and biocompatibility characteristics of acrylic resin. This study was undertaken to compare the strength of acrylic resin reinforced with aluminum oxide and when processed by conventional water bath technique and microwave energy.

Materials And Method

A rectangular metal die specimen measuring 65 mm in length, 10 mm in height, and 3 mm (ISO 1567 standard) in thickness were prepared for each acrylic resin according to ADA specification. The impression of the metal die was made using polyvinyl siloxane material. 60 wax samples were prepared (n=10). 30 wax samples were invested in metal flasks for water bath technique and 30 were invested in plastic flasks for microwave curing. (Table I)

For conventional water bath technique the wax samples were invested in metal flasks by type III dental stone. After the final set of the dental stone, the flask was kept for dewaxing for 5 mins in boiling water. Then the flasks were opened and cleaned to remove any trace of wax and to facilitate the application of separating medium. The mold cavities obtained were used for the preparation of acrylic resin test specimens. The control group test specimens were made with conventional heat-polymerized acrylic resin. The acrylic resin used in this study was DPI (Dental Products of India). Three concentrates (5%, 10% and 15% by wt.) of aluminium oxide powder (5 – 22microns) were mixed with polymer of conventional heat polymerized denture base material of group B, C, D, E, F respectively. Alginate separating media was applied on the die stone mold with the help of a brush and dried. The monomer and polymer were mixed according to manufacturer's instructions for all the groups. When the resin had reached dough stage, it was packed into the molds and the flask was kept in bench press unit for bench curing for 30 mins and curing was done according to manufacturer's instructions. Finishing and polishing was carried out using acrylic bur and sandpaper. Specimens were stored in distilled water at 37 C for 7 days before flexural strength test.

For Microwave processing, the wax samples were invested in plastic microwavable flasks. The flasks were kept in microwave oven for 30 seconds for dewaxing. After the dewaxing the flasks was removed and cleaned for remaining wax residue. The flasks were kept for 3 mins at 500W. The specimens were kept for bench cooling overnight before deflasking. The specimen was mounted on the designed part of a Universal Testing Machine. The load was applied on the center of the specimen with a cross-head speed of 0.5 mm/min. The maximum load before fracture was measured.

The flexural strength of the specimens was calculated using the standard relation:

$$S=3LP/2WT2$$

Where: S = Flexural strength.
P = Maximum load before fracture.
L = Distance between supports (50 mm).
W = Width of the specimen (10 mm).
T = Depth (thickness) of the specimen (2.5 mm).

Statistical analysis

The values obtained after this was subjected to statistical analysis using ANOVA followed by post hoc Tukey's test for multiple group comparison and paired 't' test for intra group comparisons.

Results

In this study the comparison of flexural strength was done between unmodified acrylic resin sample and modified acrylic resin with 10% and 15% aluminum oxide powder processed with two different techniques. Table I shows different test groups. Table II shows the mean and standard deviation values of flexural strength for each of the experimented groups. Higher mean flexural strength was observed in Group F followed by Group C and Group E respectively. Lowest mean flexural strength is recorded in Group A. The ANOVA result shows that there is a significant difference between the groups with respect to the mean flexural strength (P0.05).

Discussion

The commonly used resin for denture base is PMMA. It has advantage of low cost, ease of processing, easy repair and light weight. This material has also disadvantages of low strength, brittle and also exhibits large shrinkage during polymerization which leads to inaccuracy in the dimensions of hardened material. Several materials and methods have been used to improve the strength of the acrylic resin. Many studies have been done such as modifying the denture base itself to produce a co-polymerized high impact strength resin or reinforcing it with materials. The ultimate flexural strength (also called transverse strength or modulus of rupture) of a material reflects its potential to resist catastrophic failure under a flexural load. High flexural strength is crucial to denture wearing success, as alveolar resorption is a gradual, irregular process that leaves tissue-borne prostheses unevenly supported. As a foundation, the acrylic resin materials should exhibit a high proportional limit to resist plastic deformation and also exhibit fatigue resistance to endure repeated masticatory loads. 6,9

Recent advances in the processing of dentures had reinforced acrylic resin with Al2O3 ceramic filler.[30] Aluminum oxide, commonly referred to as alumina (Al O), possesses strong ionic interatomic bonding, giving rise to 2 3 its desirable material characteristics. It can exist in several crystalline phases, which all revert to the most stable hexagonal alpha phase at elevated temperatures. This is the phase of particular interest for structural applications. Alpha phase alumina is the strongest and stiffest of the oxide ceramics. Its high hardness, excellent dielectric properties, refractoriness, and good thermal properties make it the material of choice for a wide range of applications .The advantages of the filler is the lower density, thus the light weight of acrylic resin is retained. As the Al2O3 ceramics particles are white, therefore are less likely to alter the finished appearance of the denture base material.[30]

In this study, the acrylic resin (Unmodified and modified with 10% and 15% Al2O3) was processed using conventional water bath technique and microwave energy. Total of six groups were made. The flexural strength between the groups was measured and compared. The results showed that flexural strength had increased with addition of Al2O3. Group A had mean of 96.18, group B had mean of 87.59 group C had a mean of 94.70 and group D had a mean of 83.95. There was a statistical difference when samples of normal acrylic resin were compared with modified acrylic resin. When the processing technique was compared, there was significant difference found between groups processed with conventional water bath technique and microwave energy. The increase of flexural strength of modified acrylic resin may be due to proper distribution of aluminium oxide powder filler particles into the acrylic resin which acts as a potent filler to strengthen resin matrix .

Limitations of the study are untreated filler particles are used and this is an in vitro study. So further studies are needed to enhance bonding of aluminium oxide powder to denture base resin with silane coupling agents. In vitro static load tests differ from the dynamic oral conditions. No cyclic loading in a moist environment was performed.

Conclusion

From the present study, it could be concluded that:

1. The specimens of heat-cure acrylic resin reinforced with 10% and 15% aluminium oxide powder processed by water bath method provided superior flexural strength than those with unmodified acrylic resin.

2. The specimens of heat cure acrylic resin reinforced with 10% and 15% aluminium oxide powder processed by microwave technique showed superior flexural strength than unmodified resin.

Table I:
Different Groups And Description About Each Group

Groups	Description
Group-A	Unmodified heat cure denture base resin processed with water bath technique (Control group)
Group-B	Modified heat cure denture base resin with addition of 10% by wt. aluminium oxide powder processed with water bath technique
Group-C	Modified heat cure denture base resin with addition of 15% by wt. aluminium oxide powder processed with water bath technique
Group-D	Unmodified heat cure denture base resin processed with microwave energy
Group-E	Modified heat cure denture base resin with addition of 10% by wt. aluminium oxide powder processed with microwave energy
Group-F	Modified heat cure denture base resin with addition of 15% by wt. aluminium oxide powder processed with microwave energy

Table II:
Mean Flexural Strength Of Various Groups

Study Groups	Mean	Standard Deviation (SD)	P* Value, sig
Group-A	68.52	3.01	0.002 S
Group-B	78.11	2.04	
Group-C	82.95	2.01	
Group-D	79.43	2.01	
Group-E	82.21	1.04	
Group-F	85.27	1.02	

p <0.05 Significant (S)

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