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Original article

Comparison of transverse strength and impact strength of a high impact heat cure denture base resin with that of a conventional heat cure denture base resin reinforced with e-glass and polyethylene fibers

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ABSTRACT

To compare the transverse strength and impact strength of a high impact heat cure denture base resin with that of a conventional heat cure denture base resin reinforced with E-glass and polyethylene fibers. To investigate the relative efficacy of addition of E-glass and polyethylene fibers in improving the impact and transverse strength of a commercially available conventional heat cure resin and compare that with high impact heat cure denture base resin. 80 het cure denture base resin blocks samples; 20 of conventional heat cure denture base resin (DPI India), 20 of high impact heat cure denture base resin (Trevalon High Impact, Dentsply International, Germany), 20 of E-glass fiber(India chemicals limited, Ahmadabad, India) reinforced heat cure denture base resin and 20 of polyethylene (India chemicals limited, Ahmadabad, India) reinforced heat cure denture base resin respectively) were tested with Lloyd's instrument material (Milano, Italy Model No. LR 100K) for transverse strength and Charpy digital impact tester (Milano, Italy Model No. IZOD 44) for impact strength. There was significant increase in transverse and impact strength values of conventional heat cure denture base resin reinforced with E-glass and polyethylene fibers. However transverse strength of high impact heat cure denture base resin was still higher than conventional heat cure denture base resin reinforced with E-glass and polyethylene fibers.

1. Introduction

The commonest material used for the construction of conventional denture base is poly methyl methacrylate (PMMA), introduced in dentistry in 1943. They are resilient plastics formed by polymerization of methyl methacrylate molecules. The advantages of PMMA include excellent esthetics, accuracy of fit and minimum expense. The material has certain disadvantages like low transverse and impact strength, less color stability and monomer toxicity.1

To overcome the less strength of PMMA, various materials like metallic wire, carbon fibers, silk fibers polyethylene fibers and glass fibers have been incorporated. Polymer strengthening by fiber reinforcement is based on the principle that a relatively soft ductile polymer matrix is fully capable of transferring an applied load to fibers via shear forces at the interface. The fibers will be the main load bearing constituents while the matrix forms a continuous phase to surround and hold the fibers in place.

There is a conflicting opinion in the literature regarding incorporation of various materials to strengthen the heat cure denture base resin. Keeping in view the disagreeing opinions, this study was conducted to investigate the relative efficacy of addition of E-glass and polyethylene fibers in improving the impact and transverse strength of a commercially available conventional heat cure resin and compared that with high impact heat cure denture base resin.

2. Materials and methodology

A master die was fabricated with industrial iron (Figure1). It was roughly rectangular in shape with two parallel sides. It had three parts namely base, body and lid. The body had a rectangular space of 65mm x 10mm x 3mm. The function of the body and lid was to confine and prevent the escape of molten wax until it solidified.

Modeling wax (No. 2, Hindustan Dental Products Limited) was melted and poured in the die space, until it was in level with the edges of die space. Once it had solidified and cooled to room temperature, the wax pattern was removed carefully from the die space (Figure 2).

Fig. 1. Master Die.

Fig. 2. Wax Blocks.

1. Fabrication of conventional PMMA (DPI, India) samples: The wax patterns ware invested in Type IV die stone (Kalabhai, India) in a compression molding metal denture flask and clamp. Dewaxing was done and potassium alginate in aqueous solution was used as the separating medium to coat the surfaces of mold cavity. The polymer and monomer were mixed according to manufacturer's instructions in a ratio of 3:1. The polymer was weighed in an electronic weighing machine and monomer was measured in a calibrated tube. Material was packed in dough stage; flasks were subjected to curing cycle in a curing bath after 30 minutes of bench curing. After curing, careful separation of the samples was done. 20 such samples were made (Figure 3). After checking the dimensional accuracy, the samples were polished with 600-grit dry carborundum paper.

2. Fabrication of High Impact PMMA (Travalon High Impact, Dentsply International, Germany) samples: The monomer and polymer were mixed according to the instructions of manufacturer. Similar method as described earlier was used for polymerization. 20 such samples were made.
3. Fabrication of conventional reinforced heat cure denture base resin (DPI India) reinforced with E-glass fibers (India chemicals limited, Ahmadabad, India): The E-glass fibers were supplied by the manufacturer in cut fiber form. The fibers were weighed in an electronic weighing machine. The weighed fibers were incorporated in a ratio of 2:1:1 with 2 parts of polymer, one part of fiber and one part of monomer. The monomer and polymer were mixed and measured fibers were incorporated in the dough stage and mixed by hand manipulation. After mixing similar method for polymerization as described earlier was used. 20 such samples were made.
4. Fabrication of conventional reinforced heat cure denture base resin (DPI India) reinforced with polyethylene fibers (India chemicals limited, Ahmadabad, India): The polyethylene fibers were supplied by the manufacturer in cut fiber form. The fibers were weighed in an electronic weighing machine. The weighed fibers were incorporated in a ratio of 2:1:1 with 2 parts of polymer, one part of fiber and one part of monomer. The monomer and polymer were mixed and measured fibers were incorporated in the dough stage and mixed by hand manipulation. After mixing similar method for polymerization as described earlier was used. 20 such samples were made.

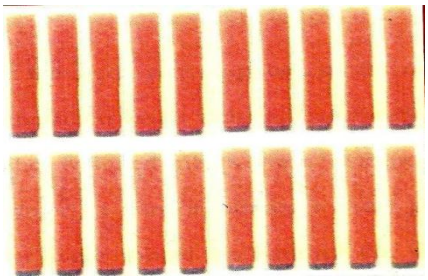


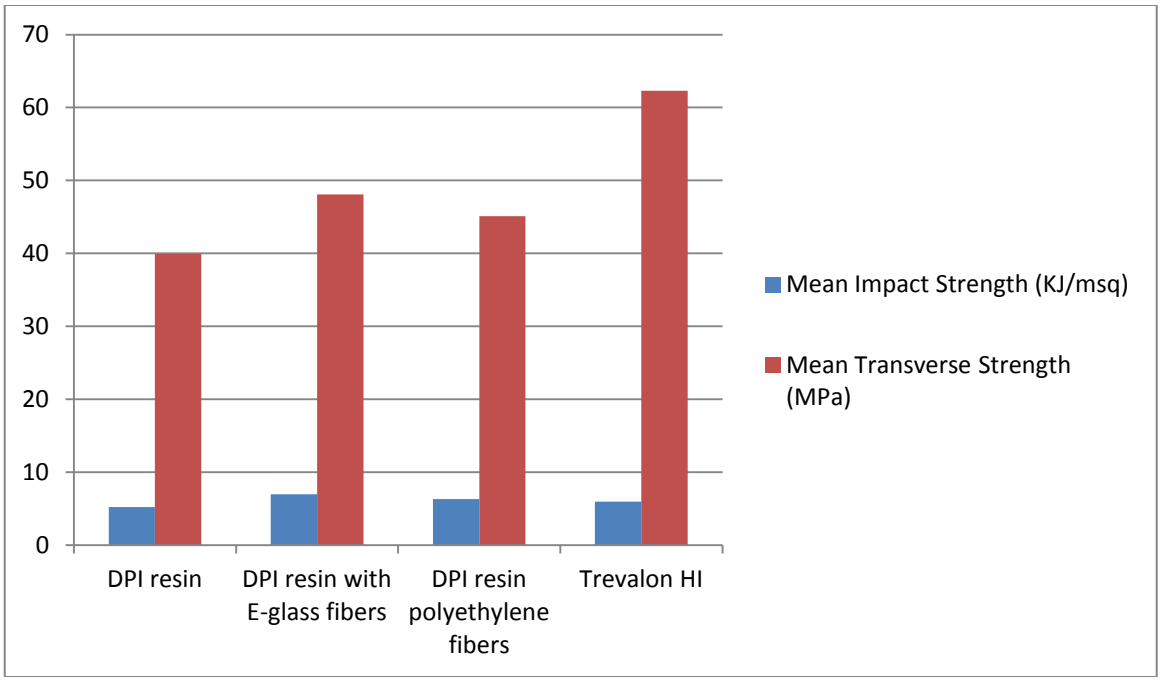
Fig. 3. Resin Samples.

3. Results

Eighty (80) samples were prepared; forty (40) were intended for evaluation of transverse strength and forty (40) were intended for evaluation of impact strength. The results obtained using Lloyd instrument and Charpy digital impact tester were tabulated, statistically analyzed and interpreted as shown in Table 1and Graph 1. Results revealed that there was significant increase in the transverse and impact strength values of conventional heat cure denture base resin (DPI) reinforced with E-glass fibers and polyethylene fibers. Conventional heat cure denture base resin (DPI India) reinforced with E-glass fibers exhibited maximum values of transverse strength as compared to conventional heat cure denture base resin (DPI India) reinforced with polyethylene fibers. However the transverse strength values of high impact heat cure denture base resin (Trevalon HI) were still higher than conventional cure denture base resin (DPI India) reinforced with fibers. The impact strength values of conventional heat cure denture base resin (DPI India) reinforced with E-glass fibers was greater as compared to conventional heat cure denture base resin (DPI India) reinforced with E-glass fibers. When impact strength of conventional heat cure denture base resin (DPI India) reinforced with fibers was compared with high impact heat cure denture base resin (Trevalon HI), the conventional heat cure denture base resin showed increase in impact strength values.

Table 1
Mean impact and transverse strength of conventional DPI resin, DPI resin reinforced with E-glass fibers, DPI resin reinforced with polyethylene fibers and Trevalon HI.

Strength	**Conventional DPI resin**	**DPI resin reinforced with E-glass fibers**	**DPI resin reinforced with polyethylene fibers**	**Trevalon HI**
Impact Strength (Mean)	5.2KJ/m^2	6.992KJ/m^2	6.32KJ/m^2	5.98KJ/m^2
Transverse Strength (Mean)	39.9MPa	48.1MPa	45.1MPa	62.35MPa



Graph 1. Mean impact and transverse strength of conventional DPI resin, DPI resin reinforced with E-glass fibers, DPI resin reinforced with polyethylene fibers and Trevalon HI.

4. Discussion

Removable prostheses are susceptible to high impact extra oral forces, such as being accidently dropped. As a result, stress concentration is generated and denture base acrylic resin can initiate cracks or propagate existing ones, thereby influencing the failure rate. To compensate for these problems, the ability of the material to withstand crack propagation is an important factor affecting denture performance. It is customary to repair a fractured denture base until more definitive treatment can be rendered. Although heat polymerized repairs are desirable, they are seldom performed due to extended lab work. The high polymerization temperature increases the risk of distortion of parent denture base.3 Therefore; most of the denture base repairs are made using an autopolymerizing PMMA resin for reasons of lower cost and greater expediency.

However, the mean transverse strength of heat polymerized denture base PMMA repaired with autopolymerizing PMMA resin has been reported to be only 57% of the original material before fracture4. Fracture of the denture base resin can be reduced by either increasing the strength of PMMA or repair material.5 Many methods to increase the strength of PMMA denture base have been attempted6. They include copolymerization, cross linking and reinforcement with strengtheners.7, 8 In the present study the effect of incorporation of E-glass fibers and polyethylene fibers on impact and transverse strength of PMMA was evaluated.

Impact strength of conventional PMMA substantially increased on incorporation of both types of fibers which was greater than that of high impact PMMA. However transverse strength although showed an increase as compared to conventional PMMA; but were less than that of high impact PMMA. Probably hand mixing of fibers could have caused a homogenous mix. Hence the resultant transverse strength could not be high.

5. Conclusion

Impact strength of conventional heat cure denture base resin was significantly improved by E-glass fibers (from 5.2KJ/m2 to 6.992KJ/m2) and polyethylene fibers (from 5.2KJ/m2 to 6.32KJ/m2); which were greater than mean impact strength (5.98KJ/m2) of high impact denture base resin.

Transverse strength of conventional heat cure denture base resin was significantly improved by E-glass fibers (from 39.9MPa to 48.1MPa) and polyethylene fibers (from 39.9MPa to 45.1MPa); which were less than mean transverse strength (62.35MPa) of high impact denture base resin.

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