Original Article

Flexural strength of denture base resin with different powder to liquid ratios: An *In vitro* study

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ABSTRACT

Background: Polymethyl methacrylate (PMMA) has been the most commonly used material for construction of dentures since many decades. Although it has many advantages like good esthetics, accurate fit, stability in the oral environment, however lack of strength of material results in fracture. **Objective:** To evaluate the flexural strength of a heat-cured denture base resins with different powder/liquid (P/L) ratios. **Methods:** 150 acrylic samples were made using high impact denture base resin (Travelon Hi). The samples were divided into five groups based on different powder/liquid ratios (g/ml) with 30 samples in each group. The P/L ratio in Group 1 (2.2:1) was the manufacturer's recommended ratio and was used as control. In Group 2, the ratio was 2.7:1, in Group 3, the ratio was 3.2:1, in Group 4, the ratio was 1.9:1, and Group 5 the ratio was 1.6:1. The samples were tested for flexural strength. **Results:** The values of flexural strength decreased significantly as the P/L ratio was increased or decreased from the control group with standard deviation 4.50, 4.15, 4.11, 4.15 and 5.59 respectively for the various groups. **Conclusion:** For high impact resins, the manufacturer's recommended polymer/monomer mixing ratio should be used to obtain the appropriate strength of the material.

Key words: *Flexural strength, hardness and impact strength, high impact denture base resin*

Polymethyl methacrylate (PMMA) has been the most commonly used material for construction of dentures since the 1940s due to many advantages, like good esthetics, accurate fit, stability in the oral environment, etc[1]. However, limitation such as low strength of acrylic resin may lead to denture fracture. Acrylic resins have shown to flex in function to a much greater degree. Many modifications in the conventional denture base resin were introduced to improve its strength and to overcome disastrous eventualities. Chemical modification of acrylic resin by addition of rubber in the form of butadiene styrene has been successful in terms of improving the impact strength [2].

Although numerous studies have been conducted in the past evaluating the effect of powder to liquid ratio (P/L ratio), showed that the mixing ratio has an effect on the strength of unreinforced polymerized material. However, very less information is known about its effect on reinforced PMMA resin. Similarly, several studies have been conducted to evaluate the flexural strength, hardness, and impact strength of different denture base resins using various methods. However, less information is available on

evaluating the effect of varying polymer/monomer ratios on mechanical properties. Therefore, the present study was undertaken to evaluate the flexural strength of heat-cured high-impact denture base resins with different polymer/ monomer ratios,with a null hypothesis that a lower or a higher than the recommended P/L ratio decreases the strength properties of high-impact denture base resin.

MATERIAL AND METHODS

This study was carried out to evaluate the effect of five different polymer/monomer ratios on the flexural strength of heat-polymerized high-impact (reinforced) PMMA resin – Travelon Hi at Yamuna Dental College and Hospital, Yamunanagar. 150 acrylic samples were prepared using high impact denture base resin (Travelon Hi) and were divided into five groups based on different powder/liquid ratios (g/ml) with 30 samples in each group. The P/L ratio in Group 1 (Ratio - 2.2:1 or 25 g/11 ml) was the manufacturer's recommended ratio and was used as control. In Group 2, the ratio was 2.7:1 or 30 g/11 ml, in Group 3, the ratio was 3.2:1 or 35 g/11 ml, in Group 4, the ratio was 1.9:1 or 25 g/13 ml, and in Group 5, the ratio was 1.6:1 or 25 g/15 ml.

Figure 1: Universal testing machine.

The acrylic samples were fabricated using the following technique. A silicone mold was fabricated with five compartments, each measuring 65.5 mm × 10.5 mm × 3.5 mm in length, breadth, and thickness, respectively. Molten modeling wax was flowed in each compartment to obtain rectangular wax patterns. These wax patterns were retrieved, flasked, and dewaxing was done to create mold space for acrylic samples. The appropriate amount of powder and liquid were mixed according to the five ratios to be used in the study for each particular group and packed into the mold space obtained after dewaxing. Curing was done using short curing cycle to achieve rectangular acrylic samples. The acrylic samples thus obtained were then finished and polished to obtain rectangular acrylic samples (dimensions 65 mm × 10 mm × 3 mm in length, breadth, and thickness respectively) [according to ISO 1567 specifications]. The samples were tested for flexural strength using Universal Testing Machine (Figure 1) and the data collected was entered into the MS Excel spreadsheet, coded appropriately and analysed.

RESULTS

Table 1 and Figure 2 depict the comparison of flexural strength values (N/mm ^{2}) within five groups with different powder/liquid ratios using ANOVA test. The mean flexural strength of the control group (group 1) acrylic sample was 128.39±4.50N/mm^2. The values of the flexural strength decreased significantly as the ratio was increased or decreased from the control group. The results were statistically significant ($p<0.001$).

Table 1: Flexural strength of the various groups.

Groups	Flexural Strength (N/mm^2)	
	Mean	Standard Deviation
1	128.394	4.50
2	120.39	4.15
3	109.30	4.11
4	106.72	4.15
5	100.66	5.59
F: 60.442, P: (P< 0.001)		

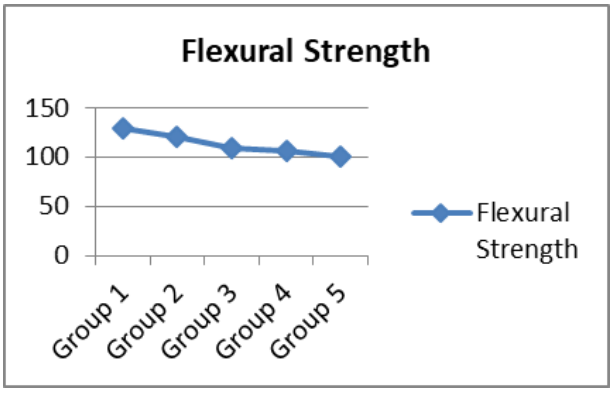

Figure 2: Graphical presentation of the variation in flexural strength.

DISCUSSION

Despite excellent properties of acrylic resins, there are certain limitations of acrylic resins in terms of strength.

Therefore, there is a need for improvement in the composition of the resin. Over the years various modifications were attempted to improve the mechanical properties of PMMA, such as chemical modification of PMMA through the incorporation of butadiene styrene to produce graft copolymer (high-impact denture base resins) [3]. In our study, resin used was Trevalon-Hi. Results showed that with increase in powder (P/L ratio 2.7:1; Group 2) there was a decrease in flexural strength with additional increase in powder content (P/L ratio 3.2:1; Group 3), there was a further decrease in the flexural strength. It can be explained on the basis of the fact that proportions with higher powder (polymer) content can promote a dry mixture due to lack of liquid (monomer), resulting in a material mass with disabilities to convert monomer into polymer as stated by Lopes et al [4].

Similarly, with increase in liquid (monomer) (P/L ratio 1.9:1; Group 4), there was a decrease in the flexural strength which further declined significantly as the liquid content was further increased (P/L ratio 1.6:1, Group 5). This could be explained on the basis that higher monomer content in the mixture results in the greater the amount of residual monomer as found in a study done by Kedjarune et al [5]. The residual monomer degrades the mechanical properties of the material and makes the material more brittle, thus the flexural strength decreases [2, 6]. The residual monomer has the potential for cytotoxicity and it also acts as plasticizer, which reduces the strength by a decrease in interchange forces, making deformation to occur more easily under load as suggested by Nisar et al [7] and Al-Kadi et al [8].

In addition, further increase in the liquid (monomer) content (P/L ratio 1.6:1; Group 5) beyond limits, results in greater amounts of residual monomer, and when subjected to curing change into gas form as the boiling temperature of methyl methacrylate is close to the boiling temperature of water. This produces bubbles in the polymer matrix. This type of gas formation will also be enhanced by exothermic heat production during polymerization. These gas bubbles in the polymer matrix results in voids, thereby increasing the porosity and developing high internal stresses as suggested by Dogan et al [9]. Previous studies have suggested that change in the P/L ratio influences the mechanical properties of unreinforced autopolymerizing resin materials [11-13]. However, little is known about its effect on reinforced heat polymerized PMMA resin. Results of our study suggest that the polymer/monomer ratio had no significant effect on the flexural strength which is in accordance with the study done by Jerolimov et al [10].

With the results of the study, we can accept the null hypothesis that a lower or a higher than the recommended P/L ratio decreases the strength properties of high impact denture base resin. However, the present study utilized only a specific shape of samples and complex shapes such as complete dentures were not used, the mechanism of fracture associated with them in the oral environment could not be simulated and can be considered as a study limitation. Since the samples were stored in water, they tend to absorb water which leads to increase in weight of the samples and causes dimensional changes. However, in the present study, weight of the samples and dimensional changes were not taken into account. Hence, there is a scope for further studies keeping these things into consideration. Furthermore, the effect of different ratios on the mechanical properties of high-impact denture base resin samples of the complex shape of complete denture after cyclic loading could be investigated in the future.

CONCLUSION

From the observation of results, it was thus concluded that for reinforced resins or for high impact resins, the manufacturer's recommended polymer/monomer mixing ratio should be used to obtain the appropriate strength of the material. Varying the polymer/monomer ratios can deteriorate the strength of the material leading to its failure, which ultimately causes hindrance in its success rate. Thus, proper care should be taken for accurate proportioning of the polymer and monomer.

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