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ORIGINAL RESEARCH

A Comparative Evaluation of Impact Strength of Conventionally Heat Cured and High Impact Heat Cured Polymethyl Methacrylate Denture Base Resins: An *in vitro* Study

R Narendra, N Simhachalam Reddy, Sashi Deepth Reddy, CR Sashi Purna, M Chandra Shekar, S Balasubramanyam

ABSTRACT

The denture bases made by using polymethyl methacrylates of Acrylic resin family have excellent physical properties, simple to process and easy to reline, rebase and repair. One of the inherent disadvantages of this material is the liability to break during function. The strength assessment of acrylic resins have been made generally by transverse deflection tests.

Aim: To evaluate the impact strength valves of certain brands of commercially available denture base resins and suggest their suitability.

Materials and methods: The denture bases we made using polymethyl methacrylates of acrylic resin family because they have excellent physical properties, simple to process and easy to reline and rebase. Six commercial brands of polymethyl methacrylate, namely Stellon (DPI-India), Acralyn-H (Asian Acrylate, India), Trevalon (Dentsply-England), Lucitone 199 (Dentsply/York division), Acralyn-H (Super Unbreakable), Trevalon HI (Dentsply, Detray division, England) were tested by breaking them using Analog Pendulum (ASTM D 256).

Results: From the entire study the maximum impact strength was reported for Acralyn-H super unbreakable (Asian Acrylates, India) 62.19 joules.

Conclusion: All the analysis led to conclusion that there is basic change in material composition within and among the different groups of denture base resins.

Clinical implications: The complete dentures made using denture base resins with high impact strength valves (e.g. Acralyn-H super unbreakable) will be more durable and can be used by the patient for considerable period of time, i.e. beyond 4 to 5 years.

Keywords: Denture base resins, Impact strength, Unbreakable.

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INTRODUCTION

In 1937, Harold Vernen introduced the use of poly (methyl methacrylate) as a denture base resin. Polymethyl methacrylates belonging to Acrylic resin family have come to stay, because of excellent physical properties, simplicity of processing and easy to reline, rebase and repair.[2,5]

One of the inherent disadvantages of this material is the liability to break during function as a result of fatigue failure in the mouth, or impact failure out of the mouth.[1]

Smith (1967) have investigated polycarbonates was superior to acrylic resing in deflection, impact strength and thermal expansion.[2]

Impact strength is usually measured by the work done in breaking a test piece at high rate of deformation and is an estimate of the toughness of the material.[3]

Various methods of impact strength testing of plastic have been used over the last 60 years; flexural impact, tensile impact, dropping weight impact and repeated blow impact.[4,5]

The purpose of this study is to find out and evaluate the impact strength values of certain brands of commercial available denture base resins.

MATERIALS AND METHODS

Group 1: conventional poly (methyl methacrylate) in powder and liquid form as supplied by DPI—under the brand name of Stellon (standard pack) (Fig. 1).

Group 2: Asian Acrylates, under the brand name of Acralyn-H (standard pack) (Fig. 2).

Group 3: Dentsply Limited, Detray Division, England under the brand name of Trevalon (standard pack) (Fig. 3).

Group 4: Dentsply/York division under the brand name of Lucitone 199 (Fig. 4).

Group 5: Asian Acrylates, under the brand name of Acralyn-H (Super unbreakable) (Fig. 5).

Group 6: Dentsply Limited, Detray division, England under the brand name of Trevalon HI (Fig. 6).

Metal flasks with clamps.

Testing apparatus—Analog pendulum. ASTM D 256 (Fig. 14).

One M—steel bar 63 mm length, 12 mm width and 6 mm of thickness was used to fabricate the mold surface and was coated with a twin layer of petroleum jelly. The upper part of the flask was then placed and filled with stone on a mechanical vibrator (Fig. 7).

The two halves were then separated and the M-steel rods was removed. The mold was then flushed with hot household detergent solution to remove any traces of petroleum jelly and were cleaned in boiling water.

Sixty heat cure poly (methyl methacrylate) specimens were made. Ten specimens were made for each group (Figs 8 to 13).

The flask with acrylic resin was allowed to bench cure for 1 hour. Curing was done by short polymerization cycle method. In 73 ± 1°C water bath for 90 minutes and then transferred to boiling water for 60 minutes.

Apparatus: Impactometer Model 1M.01 with accessories type charpy and notching cutter 'Norm-Kleinstab' for notching of the specimens (Fig. 15).

The test specimens should conform to the dimensions of 63 × 12 × 6 mm (length × width × thickness).

RESULTS

The tests on the six groups described earlier ware conducted as per ISO – R 179 (DIN 53453 or ASTM D-256). Ten specimens were tested in each group and their compatibility was checked statistically. The results are discussed in succeeding paragraphs. It is to be noted that groups 1, 2 and 3 belong to conventional heat cured poly (methyl methacrylate)

Fig. 1: Materials used for the preparation of group 1 specimens

Fig. 2: Materials used for the preparation of group 2 specimens

Fig. 3: Materials used for the preparation of group 3 specimens

Fig. 4: Materials used for the preparation of group 4 specimens

denture base resins while groups 4, 5 and 6 belong to high – impact heat cured poly (methyl methacrylate) denture base resins.

The maximum impact strength obtained among the specimens of group 1 is 9.45 Joules while the minimum nis 9.11 Joules. A comparison of the mean of absolutely calculated of individual results is made with arithmetic mean of the result and it is exceeded by only 0.99%, that is far less than the permissible limit of 10%. Thus, showing results are good agreement in Table 1.

Test results of specimens and their deviation from average value of group 2 are presented in Table 2. The maximum and minimum values of impact strength 11.94 joules and 11.43 joules respectively. The results are in good (*see* Table 2).

Fig. 5: Materials used for the preparation of group 5 specimens

Fig. 6: Materials used for the preparation of group 6 specimens

Fig. 7: Preparation of the mold

Fig. 8: Group 1 specimens

Fig. 9: Group 2 specimens

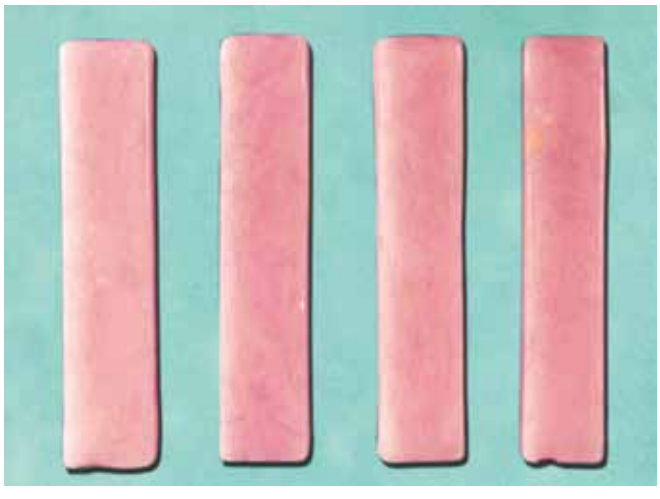

Fig. 10: Group 3 specimens

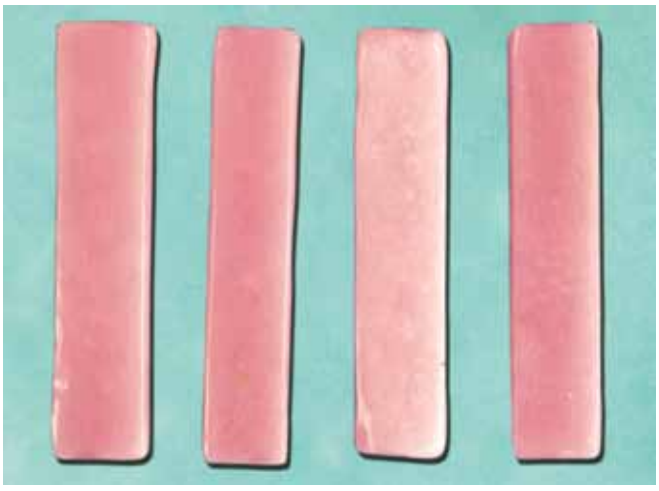

Fig. 11: Group 4 specimens

Fig. 12: Group 5 specimens

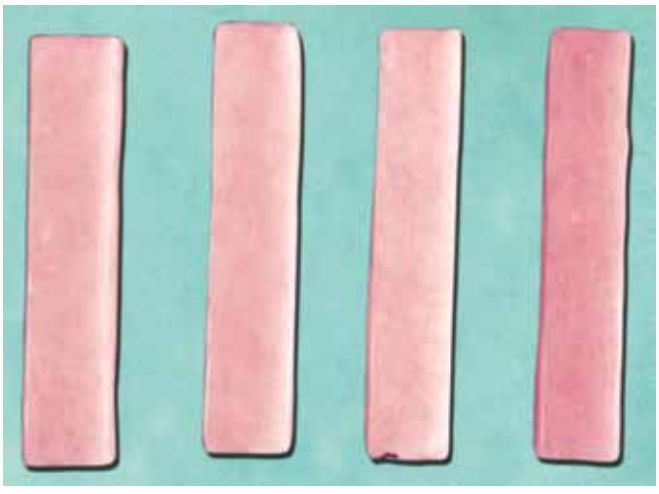

Fig. 13: Group 6 specimens

Fig. 14: Analog pendulum ASTM D256—frontal view

Fig. 15: Specimens of all groups (groups 1-6)

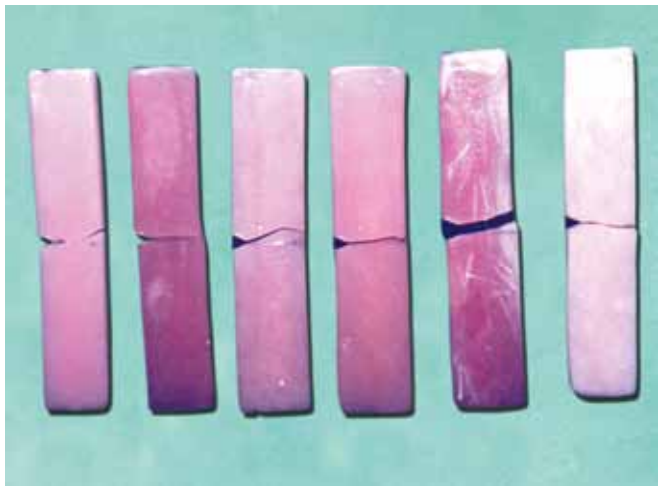

Fig. 16: Fractured resin samples (groups 1-6)

In Table 3, Conventional heat cured poly (methyl methacrylate) denture base resins give a high strength value of 10.78 joules and a low of 10.01 joules. The average value of impact strength is 10.469 joules. In Table 3, the results fall within permissible limits exceeding by only 1.63% from the arithmetic mean strength.

In Table 4, the maximum and minimum impact strength values are 19.27 and 16.82 joules respectively.

Table 1: Impact strength and deviation from mean of group 1 specimens (mean 9.276j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	9.21	–0.066
2.	9.11	–0.166
3.	9.33	0.054
4.	9.17	–0.106
5.	9.29	0.014
6.	9.36	0.084
7.	9.45	0.174
8.	9.24	–0.036
9.	9.19	–0.086
10.	9.41	0.134

Table 2: Impact strength and deviation from Mean of group 2 specimens (mean 11.751j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	11.72	–0.031
2.	11.87	0.119
3.	11.91	0.159
4.	11.94	0.189
5.	11.78	0.029
6.	11.52	–0.231
7.	11.43	–0.321
8.	11.83	0.079
9.	11.71	0.041
10.	11.80	0.049

Table 3: Impact strength and deviation from Mean of group 3 specimens (mean 10.469j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	10.01	–0.459
2.	10.56	0.091
3.	10.23	–0.239
4.	10.36	–0.109
5.	10.42	–0.049
6.	10.78	0.311
7.	10.47	0.001
8.	10.66	0.191
9.	10.51	0.041
10.	10.69	0.221

Table 4: Impact strength and deviation from Mean of group 4 specimens (mean 18.221j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	17.17	–1.051
2.	18.02	–0.201
3.	18.62	0.399
4.	18.33	0.109
5.	17.98	–0.241
6.	16.82	–1.401
7.	19.03	0.809
8.	19.27	1.09
9.	18.84	0.619
10.	18.13	–0.091

Table 5: Impact strength and deviation from Mean of group 5 specimens (mean 57.582j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	54.49	–3.092
2.	62.19	4.608
3.	54.11	–3.472
4.	58.71	1.128
5.	56.67	–0.912
6.	58.00	0.418
7.	59.16	1.578
8.	57.83	0.248
9.	58.77	1.188
10.	55.89	–1.692

Table 6: Impact strength and deviation from Mean of group 6 specimens (mean 30.346j)

Specimen	*Impact strength (Joules)*	*Deviation from mean*
1.	27.94	–2.406
2.	28.70	–1.446
3.	33.72	3.374
4.	29.00	–1.346
5.	29.32	–1.026
6.	31.42	1.074
7.	30.92	0.574
8.	32.14	1.794
9.	28.88	–1.466
10.	31.22	0.874

Once again the arithmetic mean of all absolutely calculated deviation of individual results exceeds by 3.27%, well within the acceptable limit of 10%.

In Table 5, the group 5 of high impact denture base resins with a maximum value of 62.19 joules and a minimum strength of 54.11 joules. The average strength value being 57.582 joules. Variation is only 3.18% in excess of average strength value which is acceptable.

The maximum and minimum strength of 33.72 joules and 27.94 joules respectively, with an average strength of 30.346 joules. The results fall within the stipulated limit of 10% when checked for their repeatability (Table 6). Table 7 presents the mean impact strength with standard deviation and standard error estimated statistically for each group. The error obtained is tolerable.

Finally, a one-way analysis of variance (ANOVA) was attempted to understand the significance of reliability of test results among the six groups and the calculate date are presented in Tables 8, 9 and 10. The analysis was done within the there sets of conventional denture base resins. All the analysis led to the conclusion that there is high significance of variance in the test results. This means that there is a basic change in the material composition within and without the different groups of denture base resins.

DISCUSSION

Historically the search for higher strength polymer denture base materials has taken researchers through many avenues.[6]

The fracture of the denture arises usually out of the mouth and is a high strain rate fracture due to the denture

being dropped on the floor or bent and fractured in cleaning. Only rarely does a complete denture break in the mouth. The advent of modern rubber dispersed phased acrylates suitable for processing in dental flasks and careful consideration by dentists and technicians about denture design has reduced fractures considerably.

The causes of complete denture fractures are:

i. Excessively thin sections
ii. Marked frenal notches especially anteriorly.
iii. Odd dentures on ridges that have continued to resorb.
iv. Open faced (gum fitted) dentures.
v. Where the presence of natural teeth in the opposing jaw presents occlusal problems.

Rubber modified poly (methyl methacrylate) with greater impact strength and fatigue properties than conventional denture base resins has recently been introduced to the profession.[4,8] These butadiene styrene poly [methyl methacrylate] denture base resins are supplied in powder, liquid form. The processing techniques for the reinforced rubber resins is the same as that for conventional heat curing acrylic materials.

Various co-polymers of acrylics are now available with as improved impact strength.[1]

i. MMA and butadiene co-polymerized by emulsion polymerization technique and then coated with MMA over beads. For example, Trevalon H1, HI Core, Lucitone 199 (Figs 4 and 6).
ii. Butadine methacrylate co-polymer without coating, e.g. impact.
iii. A mixture of vinyl chloride, vinyl acetate and MMA, e.g. Vinalane, Luxne 44.
iv. A normal heat cured PMMA with 0.6 presents EGDMA, e.g. Trevalon.

Dentures may be subjected to impact blows in function and perhaps more commonly, accidentally out of the mouth. Small finger notches also occur on the surface of the dentures between the teeth due to defects of trimming and polishing.

Since under impact conditions glassy polymers would show negligible plastic deformation, notching is not necessary to ensure fracture and current practice permits both notched and unnotched specimen to be used (Brown 1981, Harward 1949, Nielsen 1974, Vincent 1962). Instead of testing unnotched specimen ASTMD 256 recommends notched specimen in reverse, so that the notch is in the region of maximum compressive and has minimal effect as specimen fractures.[3]

The improved reproducibility with reverse notch specimens probably resulted from the fact that the fracture path was much more constant always terminating at the notch.

The impact test results showed the very superior impact strength of the high impact denture base resins when compared with conventional denture base polymers.[7]

In one way, ANOVA was used to analyze the total date field. The p-value obtained was <0.05. This indicated the difference in impact strength between the six groups is statistically significant.

SUMMARY AND CONCLUSION

This study evaluates the impact strength of commercially available heat cure resins among which there are conventional

Table 7: Statistical analysis mean impact strength with standard deviation and standard error for each group

Groups	*No. of specimens*	*Mean strength (J)*	*Standard deviation*	*Standard error*
1.	10	9.276	0.015	0.0332
2.	10	11.751	0.156	0.0494
3.	10	10.469	0.218	0.0688
4.	10	18.221	0.741	0.2342
5.	10	57.582	2.279	0.7210
6.	10	30.346	1.752	0.5450

Table 8: One-way ANOVA among the impact test results of conventional denture base resins

Source	*Degree of freedom*	*Sum of squares*	*Mean squares*	*F*	*p*
Between groups	2	30.641	15.3205	499.04	<0.05
Within groups	27	0.8289	0.037		
Total	29	31.4699			

Table 9: One-way anova among the impct test results of high impact denture base resins

Source	*Degree of freedom*	*Sum of squares*	*Mean squares*	*F ratio*	*p ratio*
Between groups	2	8127.0124	4063.5062	1258.48	<0.05
Within groups	27	87.1803	3.2289		
Total	29	8214.1927			

Table 10: One-way among the impact test results of all conventional and high impact denture base resins

Source	*Degree of freedom*	*Sum of squares*	*Mean squares*	*F ratio*	*p ratio*
Between groups	5	6978.440	3489.22	2140.8	<0.05
Within groups	54	88.0092	106298		
Total	59	7066.4492			

heat cure groups 1, 2, 3 and other three are high impact heat cure resins.

Among all the six groups studied, group 5 Acralyn-H (Super unbreakable) demonstrated the maximum impact strength. Therefore, this material suggested as an ideal choice for complete denture fabrication.

REFERENCES

1. Ping Chaing BK. Polymers in the service of prosthetic dentistry. J Dent 1984;12(3):203-214.
2. Fletcher AM. Dental materials: Literature review. J Dent 1990 Feb;18(1):5-23.
3. Price CA. The effect of cross-linking agents on the impact resistence of a linear poly (methyl methacrylate). Denture Base Polymer. J Dent Research 1986 July;65(7):987-992.
4. Winkler S. Denture base resins. Dent Clin North Am 1984;28(2):287-297.
5. Smith DC. Recent developments and prospects in dental polymers. J Prosthet Dent 1962;12:1066-1078.
6. Stafford GD, Huggett R, Mcgregor AR, Graham J. The use of Nylon as a denture base material. J Dent 1986;14:18-22.
7. Jagger DC, Jagger RG, Allen SM. An investigation in to the transverse and impact strength of high strength denture base acrylic resins. J Oral Rehabilitation 2002;29:263-267.
8. Banerjee R, Banerjee S, Prabhudesai PS, Bhide SV. Influence of the processing technique on the flexural strength of denture base resins, an in vitro investigation. Indian J dent Res 2010;21: 391-395.

ABOUT THE AUTHORS

R Narendra

Professor and Head, Department of Prosthodontics, Government Dental College, RIMS, Kadapa, Andhra Pradesh, India

N Simhachalam Reddy (Corresponding Author)

Associate Professor, Department of Prosthodontics, Government Dental College, RIMS, Kadapa, Andhra Pradesh, India, e-mail: drchalam_77@yahoo.co.in

Sashi Deepth Reddy

Associate Professor, Department of Prosthodontics, Government Dental College, RIMS, Kadapa, Andhra Pradesh, India

CR Sashi Purna

Assistant Professor, Department of Prosthodontics, Government Dental College, RIMS, Kadapa, Andhra Pradesh, India

M Chandra Shekar

Professor and Head, Department of Conservative and Endodontics Government Dental College, RIMS, Kadapa, Andhra Pradesh, India

S Balasubramanyam

Professor and Head, Department of Oral and Maxillofacial Surgery Government Dental College, RIMS, Kadapa, Andhra Pradesh, India