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Comparision of the Transverse Strength of Three Different Injection Moulding Denture Base Materials: An Invitro Study

Kaveti Saikrishna[1*] A. Kalyan Chakravarthy[2] NV. Vasudha[3] B.Veerendra[4] Bhanu Chander[5] Avinash[6]

[1]Senior Lecturer, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.
[2]Professor and Head, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.
[3]Assistant Professor, Department of Prosthodontics, GDC Afzal Gunj, Hyderabad, Telangana, India.
[4]Reader, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.
[5]Senior Lecturer, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.
[6]Senior Lecturer, Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.

ABSTRACT

Aim: This in vitro study compared the transverse strength of three different injection moulding denture base Materials.

Materials and Methods: The following denture base resins were examined: Brecrystal, PEEK (BIO XS)(Thermopressed injection-molded) and Ivoclar. Specimens of each material were tested according to the American Society for Testing and Materials standard D790-03 for flexural strength testing of reinforced plastics. The data was analyzed with Scheffe's Post Hoc Test and one-way Anova analysis.

Results: Flexural strength of PEEK (Bio XS) (163.30±1.72) was significantly higher than Brecrystal (113.89±0.95), and Ivocap SR (80.86±0.61).The tested denture base materials fulfilled the requirements regarding flexural strength (>65 MPa).

Conclusion: Within the limitations of this study, Flexural strength of PEEK (Bio XS) was significantly higher than the Brecrystal and Ivoclar. PEEK (Bio XS) showed a higher mean transverse strength value of (163.30±1.72) MPa.

Keywords: Flexural strength, Injection Molding, Thermopress 400.

INTRODUCTION

Polymethylmethacrylate resin has many favourable properties, and is thus well established as a reliable material for use in removable dentures. Its remarkable working characteristics include ease of manipulation, polishability, seamless use with inexpensive equipment, stability in the oral environment and optimum esthetic results. By virtue of these characteristics, this material has been extensively used as a denture base polymer. Conventional acrylic resin denture base polymer does not fulfill all the requirements in terms of optimal mechanical properties due to its brittle nature. Over the years, curing procedures have been modified with a view to improve the physical and mechanical properties of resin materials[1,2]. These advances led to the introduction of injection molding techniques and polymers exhibiting improved impact resistance.

The purpose of this in vitro study was to evaluate the transverse strength of the newly introduced injection moulding denture base materials (Breycrystal,Peek Bio Xs,Ivocap Sr) based on the null hypothesis that there would be no statistically significant difference in the transverse strength of these materials.

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*Correspondence Dr. Kaveti Saikrishna.
Department of Prosthodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India.
Email: kkaveti58@gmail.com

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Transverse strength was selected as the unit of comparison because it is the value that has been reported most commonly in dental literature. The transverse strength is important because it reflects the rigidity of the material, which in turn is important for the integrity of the supporting ridge and tissues, along with the fitting accuracy of the denture. Denture base resin should not deform under loading to permit proper load distribution to the underlying structures[5,7]. The prosthesis may fracture accidentally due to an impact while outside the mouth, or it may crack while in service in the mouth. The latter is generally the result of fatigue failure caused by repeated flexure over a period of time. Transverse strength is also known as flexural strength or modulus of rupture. Transverse strength is a collective measurement of tensile, compressive and shear stresses.

AIMS

The aims of the present study are to evaluate and compare the transverse strength of three different injection moulding denture base materials. (Breycrystal,PEEK(Bio Xs),Ivocap Sr).

MATERIALS AND METHODS

Advances in polymer science have developed new molding and activation techniques, and high strength polymers. The question arises as to whether these resins are also resistant to flexural fatigue. Therefore there is a need for further investigation. Three commercial denture base resins, available in the market were selected for this study. The denture base resins examined were Breycrystal,PEEK(Bio Xs),Ivocap Sr (Thermopressed injection-molded), Each denture base material was tested for flexural strength according to ISO 1567 Standards. Acrylic specimens of dimension 65 × 10 × 3 mm were prepared by a tool manufacturer.

Preparation Of Thermopressed Injection-Molded Samples

A total of 45 rectangular strips samples (65-mm in length, 10-mm in width and 3-mm thick) were fabricated using three different denture base materials. The specimens were divided into three groups, 15 each

Group 1: Samples fabricated using Brecrystal injection moulding material (Bredent GmbH &Co.KG,Germany).

Group 2: Samples fabricated using Bio XS (PEEK) injection moulding material (Bredent GmbH &Co.KG,Germany).

Group 3: Samples fabricated using Ivocap-SR injection moulding material. (Ivoclar co. USA).

All the samples were prepared according to ADA and ISO specification.

(i) Fabrication Of Wax Specimens

To fabricate the Brecrystal ,Bio XS(PEEK) and Ivocap SR samples,initially 45 wax specimens were fabricated. An acrylic sheet of 3mm thickness was cut into specific dimensions (65 x l0 x 3 mm) which act as a die for the test samples. These dies were placed on a glass slab and boxing was done with modeling wax (fig:1). Silicone (Doublident) duplicating material was poured on to the boxed samples and the material is allowed to set for 30 minutes.The acrylic dies were retrived to get a mold of the acrylic specimens (fig:2). Modeling wax was molten and poured into the silicon mold space and allowed to harden. Thus, 45 wax specimens of specific dimensions were obtained (fig:3).

ii) Preparation Of Brecrystal , Bio Xs (Peek) Samples

The wax specimens were invested in dental flasks with dental stone and sprues with modeling wax were attached to the wax specimens. After dewaxing, cartridge was introduced into the mold that was pre heated to 2600C for 15 min using injection pressure of 9.2 bars. The injection process was carried out in the injection unit (Thermopress 400) at a temperature of 260°C.The dental flask was bench cooled for 30 minutes before deflasking and samples were retrieved (fig:5,6).

iii) Preparation Of Ivocap Sr Samples

To fabricate the Ivocap SR samples, wax specimens were invested in dental flasks with dental stone. Sprues were prepared with modeling wax and were attached to the wax specimen invested in dental stone. After dewaxing, resin was introduced into the mold which contains resin in ratio 20gms-30ml.

Pneumatic injection mold is used to press material followed by holding the compartment 30 min in boiling water. After cooling the samples were retrieved (fig:4).

All 45 samples were trimmed and finished to a final dimension of 65 x l0 x 3 mm for evaluation transverse strength .

MEASUREMENT OF TRANSVERSE STRENGTH

Transverse strength is also known as flexural strength or modulus of rupture. Transverse strength is a collective measurement of tensile, compressive and shear stresses.This study evaluated the transverse strength of three injection molded denture base materials.

Testing the samples for Tranverse Strength

Transverse strength is defined as force per unit area at the point of fracture of test sample subjected to flexural loading. According to the American Society for Testing and Materials (ASTM) standard 0790, the samples were tested for transverse strength with a 3- point bending test using Instron Universal testing machine (Model no. Autograph AG 15, Shimadzu, Japan) (fig:7) .

The testing device consists of a central loading plunger and two polished cylindrical supports 3.2 mm in diameter and 10.5 mm long. The distance between the centers of the support is 50 mm. The specimens were centered on the device, the loading wedge was brought down at a crosshead speed of 5 mm/min and the loading continued until fracture occurred. The compressive force was applied perpendicular to the center of the specimens until a deviation of the load-deflection curve and the fracture of specimen occurred (fig:8).

The transverse strength was calculated using the following formula:

$\sigma = 3pl/ 2bd2$

Where,

σ - transverse strength
p - is the applied load (N)
L – is the distance between the supporting wedges(50.00mm)
b - is the width of the sample(mm)
d - is the sample thickness(mm).

According to ISO 1567, the minimum flexural strength of denture base materials of should not be less than 65 MPa.

RESULTS

The results were tabulated and statistically analyzed. Mean and standard deviations were estimated from the sample for each material. Mean values were compared by Scheffe's Post Hoc Test and one-way ANOVA analysis was employed to identify the significant groups at 5% level.

Flexural strength evaluation samples were divided into three groups as follows:

GROUPS	VARIABLE NAME
GROUP I	IVOCAP SR RESIN (Control)
GROUP II	BRECRYSTAL RESIN
GROUP III	BIO XS (PEEK)

Table 1: Minimum, Maximum, Mean and Standard Deviation (SD) values of flexural strength in three study groups and compared using ANOVA One way analysis.

Flexural strength (newton/mm^2)	Min	Max	Mean	Sd	P value
Group i	79.77	81.83	80.86	0.61	0.000
Group ii	112.18	114.95	113.89	0.95	
Group iii	161.34	166.56	163.30	1.72	

Mean comparison of flexural strength between the groups

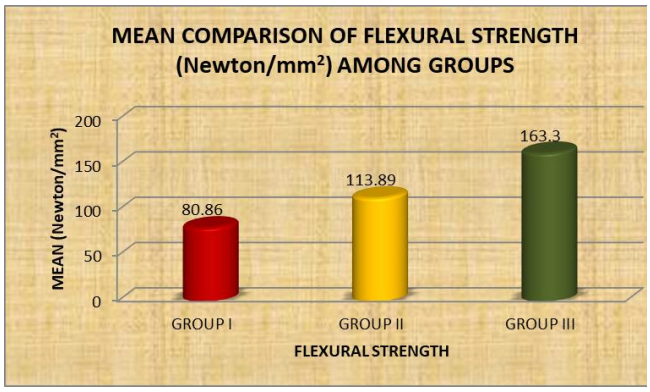
Table 2: Shows the mean comparison of the flexural strength between groups using Scheffe's Post Hoc Test.

GROUPS	(Newton/mm2)		Difference	P value
	MEAN	SD	MEAN±SD	
GROUP I	80.86	0.61	33.03±0.34	0.000 Significant
GROUP II	113.89	0.95		

GROUPS	(Newton/mm2)		Difference	P value
	MEAN	SD	MEAN±SD	
GROUP I	80.86	0.61	82.44±1.11	0.000 Significant
GROUP III	163.30	1.72		

GROUPS	(Newton/mm2)		Difference	P value
	MEAN	SD	MEAN±SD	
GROUP II	113.89	0.95	49.41±0.77	0.000 Significant
GROUP III	163.30	1.72		

Statistical Analysis: Scheffe's test. Statistically significant if P<0.05



Graph 1: Mean comparison of flexural strength.

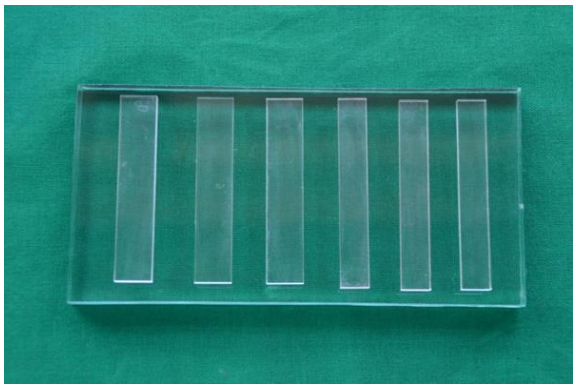


Fig 1: Acrylic specimens assembly on glass slab.

DISCUSSION

Fracture of the dentures occurs quite frequently because of the fatigue and chemical degradation of the base material. Fracture of the denture base may cause inconvenience to the patients. These fractured denture portions can pose a significant health hazard if inhaled[11].To overcome these problems many modifications in the material and processing methods were introduced to improve its strength. Modification of the acrylic resin designed to improve specific properties such as plasticization copolymerization, cross linking and reinforcement. In 1942, Pryor introduced the injection-molding technique to overcome the adverse effects of compression molding[19]. Grunewald et al investigated Pryor's technique and reported significant advantages over the conventional

Fig 2: Silicone mold (Doublident).

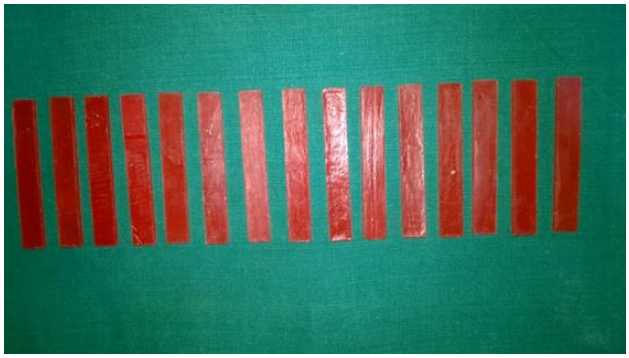


Fig 3: Retrived Wax specimens.

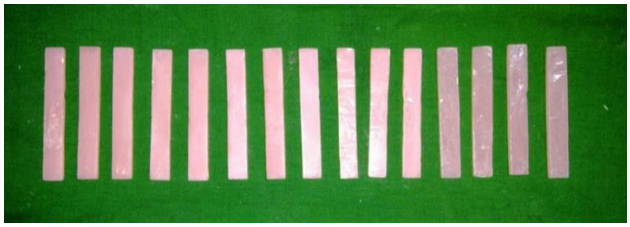


Fig 4: Ivocap SR samples (control group).

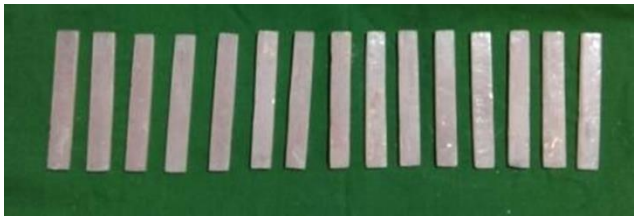


Fig 5: Brecrystal resin samples.

method[23]. Ganzarolli et al demonstrated higher flexural strength for the injection-molding technique(122.8) compared to the conventional method(69.8)[21] . Hamanaka re-ported that all the injection-molded thermoplastic resins had significantly higher impact strengths compared to the conventional PMMA. Gary C. Anderson et al

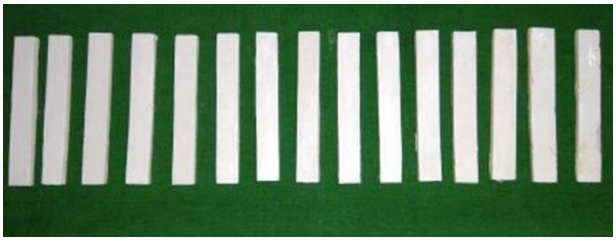


Fig 6: Bio XS (PEEK) resin samples.

Fig 7: Universal lnstron testing machine (Model no. Autograph AG 15,Shimadzu, Japan)

Fig 8: Sample testing of Flexural strength.

examined polymerization shrinkage of poly(methyl methacrylate) denture base resin when processed by two techniques, a conventional compression packing (72.09) and an injection processing technique (102.08). injection-processed resin

exhibited significantly less polymerization shrinkage than the compression processed resin[28].

The present study compared mean transverse strength recorded for thermopressed injection-molded samples. The null hypothesis that there would be no statistically significant difference in the transverse strength of the three tested denture base materials was rejected. This present study demonstrated significant difference between the mean transverse strengths of the three groups.

The mean and standard deviations values of Flexural strength of Ivocap SR (80.86±0.61), Brecrystal (113.89±0.95), and Bio XS (PEEK) (163.30±1.72),were statistically compared using Anova One way analysis. The analysis revealed that there is statistically significant difference (P<0.00) in the flexural strength of the samples (Ivocap SR, Brecrystal , Bio XS (PEEK)) all the three groups.(Table-I)

Flexural Strength value is found to be greater for Bio XS (PEEK), than Brecrystal and Ivocap SR. The mean and standard deviations values were evaluated among the groups using Scheffe's Post Hoc Test. Among the (control group) Ivocap SR (80.86 N/mm2),and Brecrystal (113.89 N/mm2), Brecrystal showed greater flexural strength value.Among the (control group) Ivocap SR (80.86 N/mm2) and Bio XS (PEEK) (163.30 N/mm2),Bio XS (PEEK) showed greater flexural strength value. Among the Brecrystal (113.89N/mm2) and Bio XS (PEEK) (163.30 N/mm2) .Bio XS (PEEK) showed greater flexural strength value. (Table-II)

As per the stastical analysis, it was observed that Bio XS (PEEK) shows greater flexural strength than Brecrystal and Ivocap SR.(graph -I)

As the Bio XS (PEEK) has significant Flexural strength but the colour of the Bio XS is not resin colour. Only Flexural strength was evaluated. It would have been better if Impact strength ,dimensional stability, elastic modulus and surface changes also have been evaluated. The use of a simple rectangular-shaped specimen rather than a complex denture design should have been used in this study. Further studies are needed to evaluate other mechanical properties as well as to determine the potential benefits that methylmethacrylate-free materials can offer to prosthodontics treatment.

CONCLUSION

The present In-Vitro study is conducted to evaluate transverse strength of three different injection moulding denture base resins. Transverse strength of three injection moulding denture base samples were evaluated. Results of these tests were subjected to statistical analysis by using ANOVA One way analysis and Scheffe's Post Hoc Test. With in the limitations of this study , the following conclusions were drawn.

1. Among Ivocap SR(control group) and Bio XS (PEEK),the latter has shown greater transverse strength with significant difference.

2. Among Ivocap SR(control group) and Brecrystal, the latter has shown greater transverse strength with significant difference.

3. Among Brecrystal and Bio XS (PEEK), the latter has shown greater transverse strength with significant difference.

4. Among all the three groups the transverse strength of Bio XS (PEEK) is greater followed by the Brecrystal and Ivocap SR with significant difference.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Jagger, D. C., Jagger, R.G., Allen, S.M., Harrison, A. An investigation intothe transverse and impact strength of "high strength" denture base acrylic resins.J Oral Rehabilitation2002;29: 263-267.

2. Price, C. A. A history of dental polymers.Aust Prosthodont J 1994;8: 47-54.

3. Greener, E. H., Harcourt, J. K., Lautenschlager, E. P. (1972). Materials Science in Dentistry. Baltimore: Williams and Wilkins Pub. Co.

4. Barsoum, W. M., Eder, J. & Asgar, K.Evaluating the accuracy of fit of aluminum-cast denture bases and acrylic resin bases with a surface meter. J Am Dent Assoc.1968;76, 82-88.

5. Zissis, A., Huggett, R. & Harrison, A. Measurement methods used for the determination of dimensional accuracy and stability of denture base materials. J Dent.1991;19: 199-206.

6. Ganzarolli, S. M., de Mello, J. A., Shinkai, R. S. & Del Bel Cury, A.Internal adaptation and some physical properties of methacrylate-based denture baseresins polymerized by different techniques.J Biomed Mater Res B Appl Biomater .2007; 82:169-173.

7. Parvizi, A., Lindquist, T., Schneider, R., Williamson, D., Boyer, D. & Dawson, D.V.Comparison of the dimensional accuracy of injection-molded denture basematerials to that of conventional pressure-pack acrylic resin.J Prosthodont 2004; 13: 83-89

8. Johnson, J. A. & Jones, D.W.The mechanical properties of PMMA and its copolymers with ethyl methacrylate and butyl methacrylate J Mater Sci1994;29, 870-876.

9. Anusavice, K. J. (2003). Phillips' Science of Dental Materials 11th edition Elsevier Health Sciences.

10. Combe, E. C. (1992). Notes on dental Materials. 6th edn. London: Churchill Livingstone.

11. Eugene W.Skinner. Acrylic Denture Base Materials and Their PhysicalProperties and Manipulations. Journal of Prosthetic Dentistry. 1951; 1:161-167.

12. John A. Cornell, John L. Tucker. Physical properties of denture-base materials. J Prosthet Dent 1960;10(3):516-524.

13. D. C. Smith. Recent developments and prospects in dental polymers. J Prosthet Dent 1962;12(6):1066-1078.

14. Johnston E P, Jack. Nicholls. Flexure fatigue of ten commonly used denture base resins. J Prosthet Dent 1981;46(5):478-483.

15. Vallitu PK, lasilaVP. Reinforcement of acrylic denture base material with metal or fiber strengtheners. J oral rehabil.1992; 19:225-220.

16. Gregory L. Polyzois, Alkibades J Zissis. The Effect of Glutaraldehyde and Microwave Disinfection on Some Properties of Acrylic Denture Resin. Int J Prosthodont 1995;8:I50-154

17. Sergio S. Nogueira, DDS, Robert E. Ogle, DDS, and Elaine L. Davis, PhD. Comparison of accuracy between compression- and injection-molded complete dentures. Journal of Prosthetic Dentistry.1999; 82: 3: 291-300.

18. D. C. Jagger, A. Harrison. The reinforcement of dentures. Journal of oral rehabilitation 1999 26; 185-194.

19. Fumio Teraoka, DEng, and Junzo Takahashi, DEng. Controlled polymerization system for fabricating precise dentures. Journal of Prosthetic Dentistry.2000; 83: 5: 514-520.

20. Sohail Memon. M, Norsiah Yunus. Some Mechanical Properties of a Highly Cross-Linked, Microwave- Polymerized, Injection-Molded Denture Base Polymer. Int J Prosthodont 2001;14:214–218.

21. Jacob John, Shivaputrappa flexural strength of heat polymerized polymerized polymethyl methacrylate denture resin reinforced with glass, aramid, or nylon fibers. J Prosthet Dent 2001;86:424-7.

22. Sir Hao Foo et al. effect of polyaramid fiber reinforcement on the strength of 3 denture base polymethyl methacrylate resins. J Prosthodont 2001;10:14-153.

23. D. Jagger et al. the effect of the addition of surface treated chopped and continous poly (methyl methacrylate) fibers on some properties of acrylic resin. Journal of oral rehabilitation 2001;28:865-872.

24. Sohail Memon. M, Norsiah Yunus. Some Mechanical Properties of a Highly Cross-Linked, Microwave- Polymerized, Injection-Molded Denture Base Polymer. Int J Prosthodont 2001;14:214–218.

25. Cemal Aydin, Hadan Yilmaz, Alper Caglar. Effect of glass fiber reinforcement on flexural strength

of different denture base resins. Quintessence international 2002;33:457-463.

26. Ali Parvizi, Terry Lindquist. Comparison of the Dimensional Accuracy of Injection-Molded Denture Base Materials to that of Conventional Pressure-Pack Acrylic Resin. Journal of Prosthodontics 2004;13(2):83-89.

27. Rodney D. Phoenix, Michael A. Mansuet, Neal A. Ackerman, Robert E. Jones. Evaluation of mechanical and thermal properties of commonly used denture base resins. Journal of proshodontics, march, 2004:13(2) pp 17-27.

28. Ih Tacir, Jd Kama et al. flexural properties of glass fiber reinforced acrylic resin. Australian Dental Journal 2005;51;1.

29. Pfeiffer P, Natalie. Repair strength of hypoallergenic denture base materials. J Prosthet Dent 2008; 100(4):292-301.

30. Diaz-Arnold AM, Vargasma, Shaull K, Lafffoon JE, Qain F. Flexural and fatigue strengths of denture base resin. J prosthet dent 2008; 100:47-51.