How to Cite:
Dubey, S., Perti, S., Shetty, G., Shakeel, S. K., Gouthami, K., & Rajesh, D. (2022). Comparison analysis of poly ether ketone and poly methyl metha acrylate used in prosthodontia for dentures: Original research. *International Journal of Health Sciences*, *6*(S5), 10221–10227.
https://doi.org/10.53730/ijhs.v6nS5.12143

Comparison analysis of poly ether ketone and poly methyl metha acrylate used in prosthodontia for dentures: Original research

Dr. Samiksha Dubey
MDS, Prosthodontist, JRF Periodontology, KGMU, Lucknow, Uttar Pradesh, India.
Corresponding Author email: drsamikshadubey@gmail.com

Dr. Sonali Perti
Professor, Department of Prosthodontics, Kalinga Institute of Dental Sciences,Campus 15 Rd, KIIT-Deemed to be University, Patia, Bhubaneswar, Odisha India.
Email: sonaliperti7@gmail.com

Dr. Ganaraj Shetty
Department of Prosthodontics and crown & bridge, Nitte(Deemed to be university) AB Shetty memorial institute of dental sciences, Deralakatte Mangalore.
Email: drganarajshetty@nitte.edu.in

Dr Shakeel S K
Lecturer / Specialist Prosthodontics, College Of Dentistry, Gulf Medical University, Jurf, Ajman. UAE.
Email: dr.Shakeel@gmu.ac.ae

Dr. K. Gouthami
MDS, Oral Medicine and Radiology, Private Practitioner, Pushpa dental clinic, New GSR complex, surajgunj chowraha, Itarsi, Madya Pradesh.
Email: gouthamikarankot@gmail.com

Dr. Damarasingu Rajesh
OMFS, PhD Scholar, Dept of OMFS, Narsinhbhai Patel Dental College and Hospital, Sankalchand Patel University, Visnagar, Gujarat.
Email: rajeshoralsurgeon@gmail.com

***Abstract*---**Introduction- Several materials have been introduced in dentistry for dentures for over last century. Poly Ether Ether Ketone (PEEK) has adequate flexural strength as a denture base and thereby prolonging its clinical longevity and also overcoming the most common reason for failure of Poly Methyl Metha Acrylate (PMMA) denture base that frequently results in the fracture. Aim- The aim and objective of

Manuscript submitted: 9 April 2022, Manuscript revised: 18 June 2022, Accepted for publication: 27 July 2022

the present study is to evaluate and compare the flexural strength and hardness of heat-cured PMMA denture base with PEEK. Material and methods- The sample size comprised of 60 samples of PMMA and PEEK which were prepared and divided into two groups i.e.; group I and group II respectively, of 30 each. Both the groups were further divided into subgroups consisting of 15 samples of PMMA and PEEK. The flexural strength was test in group I specimens by universal testing machine (UTM), and group II samples was subjected to hardness test using Vickers microhardness tester. The values were analysed statistically. The unpaired t-test was done for comparison of flexural strength and hardness of PEEK and PMMA. Result-The flexural strength of PEEK was 185 MPa, while that of PMMA was 85 MPa. The hardness of PEEK and PMMA was 25 VHN and 20 VHN, respectively. Conclusion-In the present study it was concluded that PEEK can be a denture base material with superior properties as compared to the PMMA. However, further researches are needed to be carried out.

***Keywords*---**Denture base, polyetheretherketone (PEEK), polymethylmethacrylate (PMMA).

Introduction

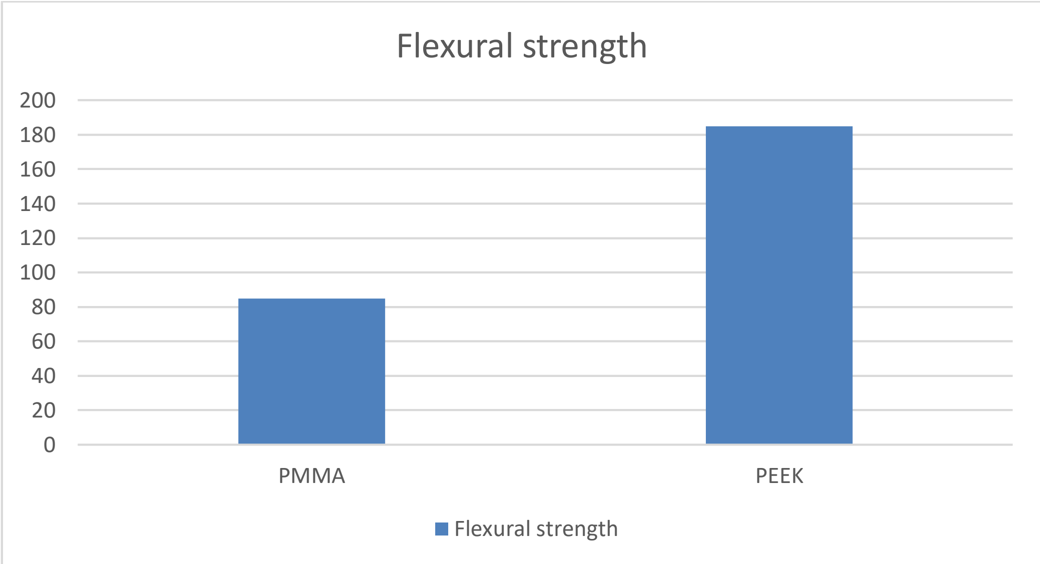
INTRODUCTION: Tooth loss as a result of illness or accidents has been proved to be troublesome throughout the ages in mankind, thereby adapting to the available contemporary materials for the dental applications was necessary in order to restore the function and appearance. With the advancement in civilization, there has been a continuous development in both the quantity as well as the quality of materials in an attempt to obtain a material that is easy to manipulate, biocompatible and control so as to make a prosthesis that is esthetically pleasing and also functionally effective. As it is said that a sound foundation is essential for a strong building, in the same way, a favourable denture base is required for fabricating a successful denture. Multiple materials with newer properties that have been put to use.[1] In the timeline of denture base, it is seen that the introduction of PMMA denture base can be considered as a milestone.[2] However, the use of resins as denture base materials was initiated in 1990 by Dr. Leo Bakeland by using a phenol formaldehyde resin. Due to its outstanding esthetics, relining, easy processing and repair techniques, PMMA is still considered the most predominant denture base material. Thereby, the combination of these desirable properties makes it the material of choice and that is being widely used.[3] It has been observed that when this material is used as a denture base material, it is not perfect for everything,[4] especially its mechanical properties. Thus, in order to overcome the limitations of PMMA, an advanced material i.e., PEEK has been introduced, which is synthetically produced polymeric material that consists of a molecular chain of aromatic compound and it is interconnected by ketone and ether functional groups. PEEK was introduced initially in the automobile and aerospace industries; but in 1999, PEEK was introduced to the field of dentistry. The evaluation of clinical longevity of any denture base material is determined by its polymerization shrinkage, water absorption ability, dimensional stability as well as the polishing ability. It has been that PEEK absorbs lesser water than PMMA, even if it is immersed for 10 days at 120°C. PEEK does not exhibit shrinkage during processing in PEEK, whereas around 7% of volumetric shrinkage and 2% of linear shrinkage is seen in PMMA. Thereby, it has been said that PEEK remains chemically inert.[5] However, information about its flexural strength and hardness as compared to heat cured PMMA is less. Basically, the flexural strength is the resiliency of material under the static loading.[6, 7] Therefore, the aim of this study is evaluation and comparison of the flexural strength and hardness of the heat-cured PMMA and PEEK.

Materials and Methods

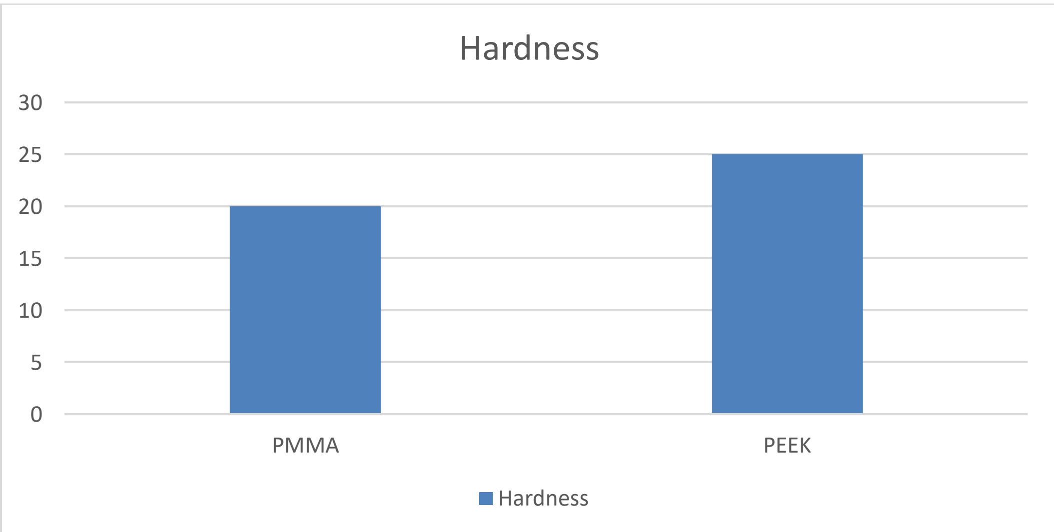
The present study was done for 2 years in the Department of Prosthodontics and Crown and Bridge. The heat-activated PMMA, (Dentsply) and PEEK, (Roechling), materials were used in this study along with Vickers microhardness tester. The sample size was of 60 specimens, out of which 30 were PMMA and 30 were PEEK. The dimensions of PMMA specimens and wax patterns were prepared followed by its processing according to the manufacturer's instructions. The final finishing and polishing of the specimens were done using silicon carbide paper and pumice powder. PEEK specimens were cut from biomedical grade PEEK sheets in the laboratory. The final dimension of samples was verified by using a vernier callipers. The inclusion of the sample specimens was made on the basis of correct dimensions and without any porosities. The final 60 specimens were divided into group I of 30 PEEK specimens and group II of 30 PMMA specimens. Group I specimens were further subdivided into sub category i.e., IA and IB of 15 PEEK and PMMA specimens, respectively. Group II specimens were also further divided into IIA of 15 PEEK and IIB of 15 PMMA specimens (Table 1). All of the specimens were immersed in artificial saliva at 37°C for 30 days in a water bath. The flexural strength was tested in group I specimens by universal testing machine (UTM), and group II samples was subjected to hardness test using Vickers microhardness tester. The group I specimen was centered on the device with the loading wedge which was set to travel at a crosshead speed of 5 mm/minute with a 500 kgf load cell, engaging the center of the upper surface of the specimen. The specimens were loaded. The subcategory IIA specimens fractured after load application, while subcategory IIB specimens showed significant bending. A sharp point or an abrasive particle was used to measure the hardness in group II specimens by applying a force to form the indentation. In the present study, the Vickers microhardness test was done. In Vickers microhardness test, a square-based pyramid indenter is used for applying 300 g of load for 15 seconds. The indentation was observed under the built-in microscope and hardness was calculated digitally on the basis of lengths of the diagonals. The VHN for the respective specimen was determined by mean of the three values obtained. The values obtained for each specimen of both the subgroups were tabulated. Table 2 illustrates the flexural strength and VHN of the subgroups. The readings were subjected to statistical analysis. For comparison of the two means, unpaired *t*-test was done. The significance level for the statistical tests utilized in the study was at $p < 0.05$.

Results

The mean flexural strength of PMMA (subcategory IB) was 85 Mpa, whereas the mean flexural strength of PEEK (subcategory IA) was 185 Mpa. Mean VHN of PMMA (subcategory IIB) was 20, while that of PEEK (subcategory IIA) was 25. VHN of the two subcategories showed a significant difference with the *p* value <0.001. Graph 1 shows the flexural of PMMA and PEEK specimens and Graph 2 shows the hardness exhibited by the PEEK specimens as compared to the PMMA specimens.



Graph 1- showing flexural strength of PMMA and PEEK specimens



Graph 2- showing hardness of PMMA and PEEK specimens

Discussion

However, the acrylic resins were introduced in dentistry in 1937 following which various other materials have also been introduced in the material science, but none of them closely mimics the oral soft tissue as it does. The time since its introduction, it is routinely and also successfully being used for fabrication of full and partial prosthesis owing to its outstanding properties.[8] The studies done by Phoenix,[9] Meng, and Latta[10] suggested that PMMA is the most popularly used material for removable prosthodontics, but because of its low strength, it results in the failure of the prosthesis. The failures can result intraorally because of excess bite force, inadequate occlusion, trauma, unsatisfactory fit and extraorally due to falling of denture.[11] Studies done by Beyli and Von Fraunhofer,[12] factors such as intensification of stress, higher rates of ridge resorption, deep incisal notches, sharp changes in the denture base contours, and processing changes result in the fracture of the denture bases. To overcome these inherent disadvantages, several methods have been suggested to strengthen the acrylic resin. The studies done by Kurtz,[13] Zhang et al.[14] suggested that PEEK, which was being used in industries, has a potential for biomedical applications also. According to the observation of Brillhart and Botsis[15] and Sobieraj and Rimnac,[16] properties such as biocompatibility, solvent resistance, and also the modulus of elasticity which is same as that of the bone make PEEK a good candidate for medical and dental applications. Thereby, PEEK can be thought to be a novel material to substitute PMMA, but few studies have been done to assess the mechanical behavior of PEEK when it has to be utilized as a denture base material. Zappini et al.[17] did a study to assess the strength of five types of heat-activated denture base resins and concluded that although the strength of the denture base depends on the impact, it is not an ideal test for the prediction of the clinical function. Alhareb compared the VHN values of unfilled PMMA with that of PMMA reinforced with NBR or ceramic fillers. According to him, he concluded that the VHN values did not significantly increase after the addition of the fillers. Fraunhofer and Suchatlampong and Braun et al. compared the VHN for differently activated PMMA. It was found that the hardness values were greater for heat-activated PMMA than that of the other available differently activated PMMA. Thereby, an attempt was made in the present study to compare the VHN values of PMMA and PEEK. The mean flexural strength of PMMA, was 85 MPa. Hence, the mean flexural strength of PMMA is in accordance with the previous researches done. The mean hardness of PEEK specimens, was found to be 25. Goyal et al. evaluated PEEK using Vickers microhardness tester and reported it to be 24 kgf. The mean values of VHN for PEEK are similar to the previous studies. In the present study, the difference in the values of flexural strength of PMMA and PEEK was found to be highly significant ($p < 0.001$). The mean flexural strength of PEEK (185 MPa) was found to be greater than PMMA (85 MPa). A comparison was also done between the VHN of PEEK and PMMA, and a very high significant difference appeared between them. The VHN of PEEK (25) was evaluated to be greater than PMMA (20). The results obtained are in agreement with the study done by Muhsin et al. in which the flexural strength of the PEEK material was superior to that of the PMMA material. Another important mechanical property of hardness was compared in addition to the flexural strength in this study, and it was observed that PEEK is significantly superior to PMMA with respect to hardness

Conclusion

PEEK is superior in the mechanical properties like flexural strength and hardness values to that of PMMA, however further studies are required in order to evaluate and also to compare the other properties of these materials. Thereby, the prosthesis fabricated with PEEK as a substructure may have a great impact on its prognosis and therefore might also enhance the patient acceptability. Hence, this research is important as it introduce the new material that can be successfully used clinically so that the drawbacks can be limited.

References

1. Anusavice KJ. Phillips science of dental materials. 11th ed. W.B Saunders; 2003. p. 78–98.
2. Beyli MS, Fraunhofer JA. An analysis of causes of fracture of acrylic resin dentures. J Prosthet Dent 1981;46(3):238–241.
3. Brillhart M, Botsis J. Fatigue crack growth analysis in PEEK. Int J Fatigue 1996;16(2):134–140.
4. Heimer S, Schmidlin PR, Roos M, et al. Surface properties of polyetheretherketone after different laboratory and chairside polishing protocols. J Prosthet Dent 2017;117(3):419–425.
5. Jagger RG. Effect of the curing cycle on some properties of a polymethylmethacrylate denture base material. J Oral Rehabil 1978;5(2):151–157.
6. Jani, J. R., Bajamal, A. H., Utomo, S. A., Parenrengi, M. A., Fauzi, A. A., Utomo, B., & Dwihapsari, Y. (2021). Correlation between magnetic resonance imaging (MRI) and dynamic mechanical analysis (DMA) in assessing consistency of brain tumor. International Journal of Health & Medical Sciences, 4(2), 260-266. https://doi.org/10.31295/ijhms.v4n2.1737
7. Khindria SK, Mittal S, Sukhija U. Evolution of denture base materials.J Indian Prosthodont Soc 2009;9(2):64–69. DOI: 10.4103/0972- 4052.55246.
8. Kurtz SM. An overview of PEEK biomaterials. In: PEEK Biomaterials Handbook, Elsevier; 2012. p. 1–7.
9. Meng TR, Latta MA. Physical properties of four acrylic denture base resins. J Contemp Dent Pract 2005;6(4):93–100.
10. Nejatian T, Johnson A, Noort RV. Reinforcement for denture base resin. Int J Adv Sci 2006;4:124–129.
11. Peyton FA. History of resins in dentistry. Dent Clin North Am 1975;19(2):211–222.
12. Phoenix RD. Denture base materials. Dent Clin North Am 1996;40(1):113–120.
13. Sobieraj MC, Rimnac. Fracture, fatigue, and notch behavior of PEEK.In: PEEK biomaterials handbook. Elsevier; 2012. p. 61–73.
14. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Get vaccinated when it is your turn and follow the local guidelines. International Journal of Health Sciences, 5(3), x-xv. https://doi.org/10.53730/ijhs.v5n3.2938
15. Tandon R. Denture base materials: from past to future. Indian J Dent Sci 2010;2:33–39 .

16. Uzun G, Hersek N, Tincer T. Effect of five woven fiber reinforcements on the impact and transverse strength of a denture base resin. J Prosthet Dent 1999;81(5):616–620.
17. Yazdanie N, Mahood M. Carbon fiber acrylic resin composite: an investigation of transverse strength. J Prosthet Dent 1985;54(4):543–547.
18. Zappini G, Kammann A, Wachter W. Comparison of fracture tests of denture base materials. J Prosthet Dent 2003;90(6):578–585.
19. Zhang Z, Breidt C, Chang L, et al. Wear of PEEK composites related to their mechanical performances. Tribol Int 2004;37(3):271–277.