Research Article

Effect of the Incorporation of Cerium Oxide and PEEK Composite on Mechanical Properties and Denture Base Adaptation of PMMA Resin

Mariam Mohammed Aadi[1], Firas Abdulameer Farhan[1*], Eshamsul Sulaiman[2]

1 Department of Prosthodontics, College of Dentistry, University of Baghdad, Bab Al-Muadham campus of the University of Baghdad, 1417, Baghdad, Iraq.
2 Department of Restorative Dentistry, Faculty of Dentistry, University of Malaya, 50603 Kuala Lumpur, Malaysia.
* Corresponding author: firas.farhan@codental.uobaghdad.edu.iq

Received date: 20-05-2025
Accepted date: 19-08-2025
Published date: 15-06-2026

Article DOI

Abstract: Background: Polymethyl methacrylate (PMMA) resin is extensively utilized in prosthodontics and orthodontics, particularly in fabricating artificial teeth, provisional crowns, denture bases, and orthodontic retainers. Aims: This study aimed to evaluate the effects of incorporating cerium oxide and polyether ether ketone nanoparticle (CP) composite into PMMA resin on transverse strength, impact strength, surface hardness, and denture base adaptation. Materials and Methods: A total of 120 PMMA specimens were divided into three groups based on the concentration of CP composite added to PMMA resin, with each group consisting of 40 specimens: a control group without fillers, group (A) containing 1% wt. of composite filler with a ratio of 30% cerium oxide and 70% polyether ether ketone, and group (B) comprising 3% wt. of composite with a ratio of 50% ceria, and 50% polyether ether ketone, as determined by the pilot study. Each group was tested for transverse strength, impact strength, surface hardness, and denture base adaptation, with 10 specimens for each test. The tested specimens were examined using Fourier transform infrared spectroscopy (FTIR), and field emission scanning electron microscopy (FE–SEM). The resulting data were statistically analyzed using SPSS at a significance level of $P \leq 0.05$. Results: Group B showed a significant statistical increase in transverse and impact strength compared with the other groups. Surface hardness and denture adaptation increased significantly in group A. FTIR analysis revealed transmission peaks and heightened intensity after the addition of the CP composite into the PMMA. The FE–SEM images showed a well-distributed nano CP composite within the PMMA matrix for all experimental groups, with increased agglomeration observed in group B (3%). Conclusion: The incorporation of 3% wt. CP into PMMA resin significantly improved transverse and impact strength compared with 1% wt. and the control. The surface hardness and denture base adaptation improved when 1% wt. CP was incorporated into the PMMA resin compared with the other tested groups.

Keywords: Cerium oxide, polyether ether ketone, polymethyl methacrylate resin

Introduction

Polymethyl methacrylate (PMMA) is extensively used as a denture basis in the fabrication of complete and partial dentures. It is considered a primary choice of denture base material because of its biocompatibility in the dental environment, low manufacturing cost, and favorable color matching with gums [1, 2]. However, clinical trial studies showed that 68% of the PMMA denture base is susceptible to breakage during use within the first 3 years. Researchers have conducted several studies to improve the mechanical properties and clinical applications of PMMA by modifying it with metal oxides and fibers [3, 4].

Recently, nanotechnology has produced a modified material exhibiting enhanced mechanical and physical features. By incorporating nanoparticles into PMMA materials, composite materials with unique mechanical and physical properties can be created that are not possible with the base material alone. Furthermore, hybrid reinforcement with two or three additives may yield denture base material with superior characteristics than a single additive [5, 6]. Each additional reinforcement enhances a certain material quality [7]. Natural fibers have several advantages over synthetic fibers, including renewability, reduced wear on processing equipment, light weight and cost-effectiveness, favorable mechanical properties, and environmental sustainability [8].

Some natural fibers utilized as reinforcements include oil palm empty fruit cluster fiber and ramie fiber [9]. Researchers have proposed the use of metal oxides as fillers, and they are applicable across various fields, including health and industry [10]. Cerium oxide nanoparticles (CeO_2 NPs) have recently attracted considerable interest because of their remarkable biological properties, including antibacterial, anti-inflammatory, and antioxidant activities [11]. The integration of CeO_2 NPs into diverse polymer-based scaffolds designed for wound healing applications has led to accelerated wound healing due to the presence of CeO_2 NPs [12, 13].

In dentistry, CeO_2 NPs have been used in the modification of dental materials, such as cerium oxide-based glass restorations, cerium oxide-based pit and fissure sealants, cerium oxide filler-based resin composite, dental adhesives containing cerium dioxide particles, cerium oxide-based glass ceramics, and cerium oxide-based mineral trioxide aggregate (MTA). Cerium oxide, recognized for its potent antioxidant properties, protects osteoblasts from oxidative stress by restoring the intracellular antioxidant defense system [14]. In a study conducted by Isam et al., CeO_2 NPs were added into soft liner denture base material at concentrations of 2% and 3% wt. They found that increased hardness is correlated with an increased amount of filler [15].

Polyetheretherketone (PEEK) is categorized as a semi-crystalline thermoplastic biomaterial within the polymer class of poly aryl ether ketones (PAEKs). This category involves high-performance thermoplastic resins characterized by aromatic chains interconnected by ketone and ether groups [16]. Its tensile properties closely resemble those of bone, enamel, and dentin, making it suitable for use as a dental restorative material [17]. It functions as an implant material, fixed crown, removable denture, and fixed prosthesis [18–20]. Most PEEK and its derivatives are supported by in vitro studies or short-term in vivo research [21]. Researchers Chen SG and Yang J have utilized a combination of nano-fillers, surface-modified titanium dioxide (TiO_2), and micro-fillers of PEEK [22].

This study aimed to evaluate the effects of incorporating ceria and PEEK NPs in two ratios (30/70 and 50/5) on transverse strength, impact strength, surface hardness, and the adaptability of denture bases. The study hypothesized that the 50/50 formulation would exhibit superior mechanical properties compared with the 30/70 formulation and conventional PMMA

Materials and Methods

Preparation of PEEK NP Powder

PEEK powder (VER3TIX / the UK) with an average particle size of 12–13 μm was ground using a planetary ball mill to produce nano-sized particles. PEEK powder was placed inside a specialized container containing stainless steel balls in a 1:3 ratio (powder to balls) by weight. The grinding process lasted for 2 h. After sieving, the resulting powder exhibited a smooth texture with an average particle size of 83–85 nm.

Preparation of Cerium Oxide and PEEK NP Composite

Cerium oxide powder (HONGWUNEW MATERIA/China) with a purity of 99.9% and an average particle size of 30–50 nm was mixed with PEEK powder to produce a cerium oxide/PEEK (CP) composite by using a ball milling machine at 300 rpm for 20 min. The mixing parameters were selected according to the pilot study.

Preparation and Grouping of Specimens

A total of 120 PMMA specimens were prepared and divided into three groups based on the concentration of CP composite incorporated into PMMA resin, with each group consisting of 40 specimens: a control group without CP, group (A) containing 1% wt. CP with a ratio of 30% CeO_2 and 70% PEEK, and group (B) comprising 3% wt. CP with a ratio of 50% CeO_2 and 50% PEEK. These ratios were selected according to our pilot study. Each group was tested for transverse strength, impact strength, surface hardness, and denture base adaptation, with 10 specimens for each test.

A plastic pattern with different dimensions was prepared based on the designated test. Each pattern was placed in hard putty laboratory silicone and positioned into a plastic container to form a specimen mold [23]. The lower half of the flask was filled with type IV dental stone following the manufacturer's mixing instructions. The upper half of the flask was then secured over the lower half and filled with a new stone mixture, which was allowed to set. Finally, the two halves of the flask were separated, and the plastic patterns were removed to receive and pack PMMA specimens.

PMMA powder (PROCRYLA, Germany), with or without CP NPs depending on the group, was mixed with a monomer according to the manufacturer's instructions for the powder/monomer ratio. The final specimens were polished and completed by a uniform procedure. Each PMMA specimen was immersed in distilled water for 2 days prior to the test to reduce the residual monomer.

Mechanical Tests

Transverse Strength Test

Thirty specimens were prepared with dimensions of 65 mm in length, 10 mm in width, and 2.5 mm in thickness. The test was conducted according to ISO specifications (No. 20795-1, 2013) using a universal testing machine at a constant displacement rate (5 mm/min) until fracture of the specimen.

Surface Hardness

Thirty specimens were fabricated with dimensions of 65 mm in length, 10 mm in width, and 2.5 mm in thickness. The surface hardness test was conducted using Shore D hardness according to the standard test methods ASTM D2240 and ISO 868:2003.

Impact Strength Test

According to ISO 179-1:2000, the acrylic specimens for the impact strength test were fabricated with dimensions of 80 mm in length, l0 mm in width, and 4 mm in thickness. The impact strength test was conducted utilizing Charpy's impact testing apparatus.

Denture Adaptation Test

A plastic transparent bio-art sheet (Plastvac P7 Dental Vacuum Forming Machine, Brazil) and a maxillary stone cast were used to prepare the denture base pattern for the fabrication of 30 maxillary denture base specimens, categorized based on the percentage of CP filler addition into the control, group A (1%), and group B (3%), with 10 specimens in each group. The transparent denture pattern was flasked to produce PMMA denture bases following the procedure used to fabricate complete denture bases (Figure 1A).
The fitting surface of the specimens was scanned, sprayed, flipped to resemble a cast surface, and saved as a stereolithography (STL) file. The maxillary stone cast was also sprayed and scanned, and the STL file was selected as reference data in Figures 1B and 1C.

The STL file of the fitting surface of the PMMA specimens was designated as empirical data. The files were automatically aligned by selecting the “best-fit alignment” icon in Geomagic software (Exocad, version 3.2) to evaluate adaptation (Figure 1D). The gap between the denture base and stone cast was assessed at five points: one on the right (point A) and one on the left side (point B) of the maxillary tuberosity, one at the midline near the posterior border of the denture base (point C), one on the hard palate at the middle of the maxilla (point D), and one on the incisive papilla (point E) (Figure 1E).

The resulting data were statistically analyzed using the Statistical Package for Social Science (SPSS version 25, Inc., USA), with significance set at P≤0.05.

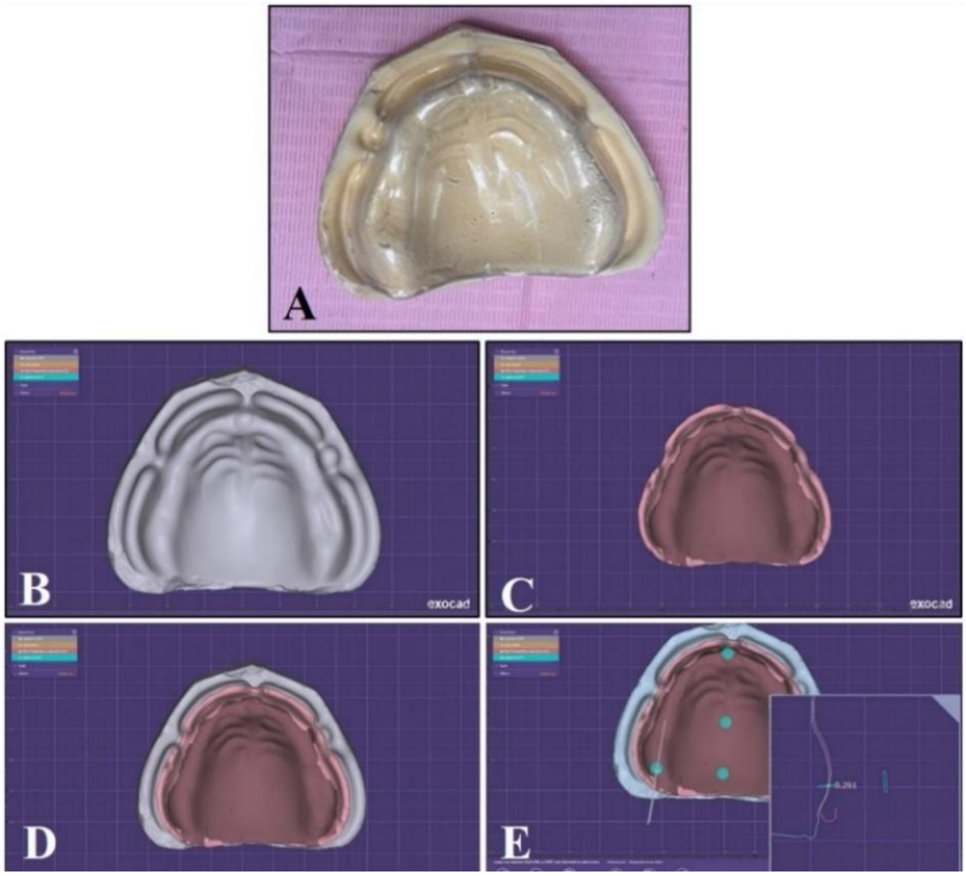

Figure 1: Denture adaptation test A: A plastic transparent bio-art sheet and a maxillary stone cast, B: STL file of the master cast, C: the STL file of the specimens, D: Fitting of the PMMA specimen on the cast and E: measuring the gap between the PMMA specimen reference points and the fitting surface of the cast.

Results

Descriptive statistics, including mean values of transverse strength, indicated that group B possessed the highest value among the other groups. One-way ANOVA showed a significant difference at P≤0.05 among all groups (Table 1).

Table 1: Descriptive analysis and one-way ANOVA test of transverse strength (N\mm2)

Groups	N	Mean	±SD	F	P value
Control	10	93.86	3.13		
A	10	105.6	5.12	33.88	0.0001
B	10	108.43	4.10		

Sig. P value < 0.05

The descriptive analysis of impact strength revealed that the mean values for groups A and B were nearly identical and exceeded those of the control group. One-way ANOVA test revealed a significant difference across all tested groups, as shown in Table 2.

Table 2: Descriptive statistics analysis and one-way ANOVA test of impact strength (Kj\m2)

Group	N	Mean	± SD	F	P value
Control	10	9.37	1.28		
A	10	11.38	0.94	11.76	0.0001
B	10	11.45	1.00		

Sig. P value < 0.05

The mean value and ANOVA test of surface hardness demonstrated that group A surpassed group B and the control, revealing significant differences among the groups (Table 3).

Table 3: Descriptive analysis and ANOVA test of the hardness test of all experimental groups

Groups	N	Mean	± SD	F	P value
Control	10	84.89	1.44		
A	10	87.31	1.06	11.289	0.0001
B	10	86.90	1.11		

Sig. P value < 0.05

The descriptive statistics of denture base adaptation represent the gap between the denture base and the stone cast at five points. The mean values for the selected five points indicated that group A had the lowest gap compared with the other groups. The Welch test was chosen for the comparison of the tested groups, as shown in Table 4.

Table 4: Descriptive statistics and Welch test of denture base adaptation in (μm)

Groups	N	Mean	± SD	Statistic	df1	df2	P value
Control	10	0.213	0.031				
A	10	0.164	0.022	58.34	2	7.23	0.0001
B	10	0.490	0.060				

Sig. P value < 0.05

Fourier transform infrared (FTIR) spectroscopy analysis

The FTIR analysis results of PMMA before and after the addition of CeO_2 /PEEK mixture showed transmission peaks and increased intensity after the addition of CP fillers. The FTIR peaks demonstrated the initiation and completion of polymerization.

Field emission scanning electron microscopy (FE-SEM)

The FE-SEM images showed particle sizes and distribution of nano CP composite within the PMMA matrix for all experimental groups, with increased agglomeration observed in group B (3%) (Figure 2).

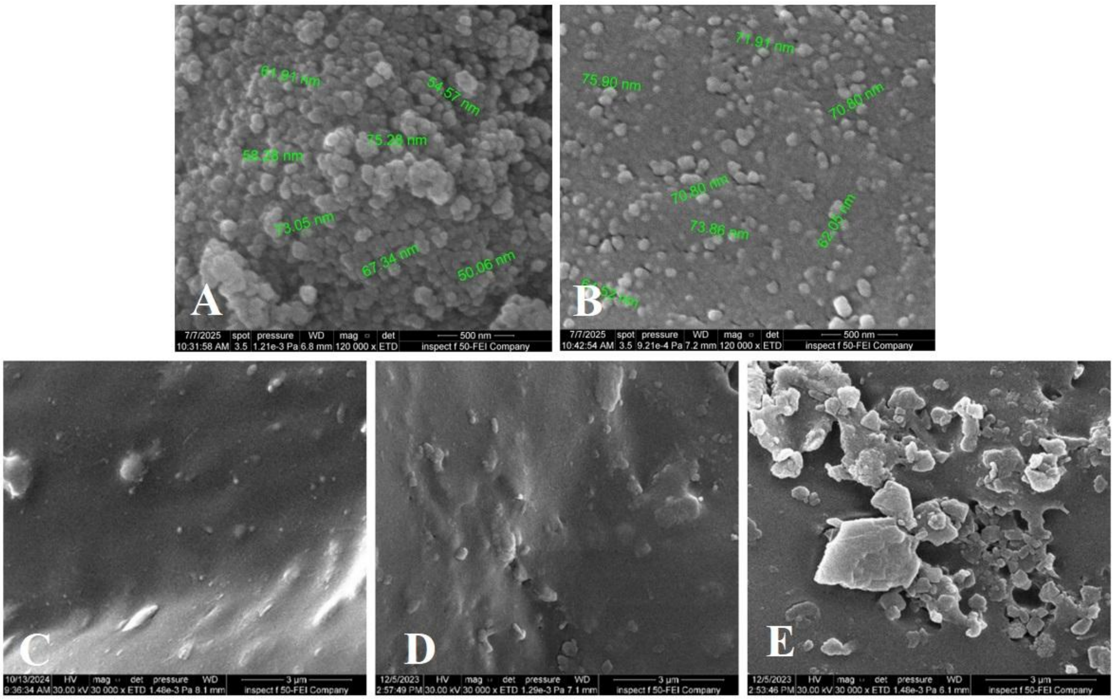

Figure 2: FE-SEM image of PMMA specimens at 30 kV magnification, A: Cerium oxide NP size, B: PEEK NP size, C: Control group, D: Group A (1%CP), and E: Group B (3%CP)

Discussion

PMMA resin is widely regarded as one of the most popular materials for denture bases in the restoration of partial and complete edentulous patients because of its ease of processing and reparability. However, it has disadvantages, such as poor impact strength, low wear resistance, and abrasion [23-25]. Several researchers have attempted to enhance the mechanical properties of PMMA resin by reinforcing it with fibers or particles. The current study evaluated the transverse strength, impact strength, surface hardness and adaptation of denture bases of PMMA base resin after adding 1% and 3% CP mixture. Recently, nanotechnology has been utilized in dentistry, and numerous studies have been conducted to define its potential benefits and applications [26].

The flexural test evaluates the strength of a bar supported at both ends [27]. In the current study, the transverse strength of the reinforced groups increased after the addition of the CP mixture. The observed results could be due to the effective connectivity among CP nano-sized particles within the PMMA matrix. The enhancement in transverse strength may also result from the transfer of stress from a flexible polymer to the high modulus, stiff, and rigid filler particles. The results of the study were in agreement with the findings of Barapatre et al. in 2022 [28], who revealed that the flexural strength of PMMA resin reinforced with PEEK/zirconia NPs significantly increased compared with other groups. They concluded that the hybrid PEEK and zirconia-reinforced resin can be utilized in the treatment of patients with high occlusal forces and those who complain of recurrent denture fractures.

The mean values of the reinforced groups (1% and 3% CP) demonstrated a highly significant increase in impact strength compared with the control group. The incorporation of 3% CP resulted in a notable increase in the mean impact strength values. The enhancement in impact strength observed in the present study may be attributed to the elevated concentration of PEEK NPs. PEEK is known for its resilience to stress concentrations and has exhibited superior impact strength than PMMA resin [29]. Denture bases exhibiting high impact resistance are suitable for patients prone to dropping their dentures, especially those with physical or cognitive disabilities. Improved mechanical properties, including enhanced strength and fracture resistance, may reduce the frequency of denture breakage, lower replacement costs, and contribute to better long-term patient satisfaction and quality of life. These enhancements could ultimately improve the durability and reliability of removable prostheses in clinical settings. These results are consistent with those reported by Gad et al., who demonstrated that the incorporation of nano-zirconium dioxide (ZrO_2) and glass fibers into PMMA significantly increases the impact strength relative to unreinforced control samples. By contrast, Alwan Erhim et al. (2024) reported a reduction in impact strength with increasing concentrations of NP fillers in denture base materials, indicating that the type and proportion of nanofillers significantly influence mechanical performance [30].

The addition of 1 wt% CP filler led to an increase in mean surface hardness, whereas the 3 wt% CP group exhibited the lowest value among the tested groups. The reduction in hardness at increased filler content may result from the elevated proportion of CeO_2 NPs in group B (50% CeO_2 + 50% PEEK), potentially compromising the mechanical integrity of the PMMA matrix. These findings were in agreement with those of Amrah et al. (2020) [31], who reported that incorporating recycled PMMA into heat-cured acrylic resin at varying concentrations results in increased surface hardness. Additionally, an increase in PEEK fiber content has been shown to enhance surface hardness [32]. This result was consistent with the findings of Stuart and Briscoe [33], who concluded that the presence of highly crystalline polymers contributes to enhanced hardness of polymer composites.

PMMA acrylic resin denture bases have a strong tendency to shrink after polymerization. Research has shown that expert fillers are incorporated into PMMA materials to reduce dimensional instability. Good denture adaptation results from accurate dimensional stability, significantly enhancing denture retention and patient comfort, reducing speech-related problems, and ensuring proper occlusion. In the present study, CP NPs were integrated into PMMA resin to enhance denture fit. The denture fit improved after adding 1% CP, especially at point (B); this may be related to an increase in the thermal conductivity of the acrylic resin with added fillers and the degree of polymerization, primarily driven by heat dissipation and thermal conductivity. Consequently, the denture base contracts due to further polymerization shrinkage [33] or may become brittle, which compromises the fit of the denture. A previous study proposed by Basima M and Aljafery A (2015) revealed that the addition of a ZrO_2-Al_2O_3 NP mixture into heat-cured acrylic resin denture base material results in a gap between the denture base and the cast [34]. They suggested that this gap is from the inclusion of NPs [35,36], which improves the thermal conductivity of acrylic resin, considerably influencing polymerization via thermal conductivity and heat dissipation [37].

The incorporation of a cerium oxide and PEEK nanocomposite into PMMA resin exhibited promising improvements in material properties; however, several limitations should be considered to provide a balanced interpretation of the results. One major concern is the potential for nanoparticle agglomeration, particularly at elevated concentrations of 3%, which may result in uneven dispersion within the resin matrix. This inconsistency may adversely affect the mechanical integrity. Additionally, the limited sample size in this study may restrict the statistical power and generalizability of the findings. Moreover, the current study failed to incorporate long-term simulations of the oral environment, such as thermal cycling or mechanical fatigue, which are critical for assessing the durability and biocompatibility of dental materials under realistic settings. Future research should address these aspects through extended in vitro and in vivo studies to comprehensively evaluate the clinical relevance of PMMA modified with cerium oxide/PEEK nanocomposites (38).

Conclusion

This study concluded that the incorporation of 3% wt. CP into PMMA resin significantly improved transverse and impact strength compared with 1% wt. and the control. The surface hardness and denture base adaptation improved when 1% wt. CP was incorporated into the PMMA resin compared with the other tested groups.

Conflict of interest

No potential conflict of interest was reported by the authors in this study.

Author contributions

All authors approved the final version of the manuscript and are responsible for all aspects of the work.

Acknowledgement and funding

This study received no funding or grants from the government or commercial sectors.

References

1. Karci M, Demir N, Yazman S. Evaluation of flexural strength of different denture base materials reinforced with different nanoparticles. J Prosthodont. 2019;28(5):572-9. https://doi.org/10.1111/jopr.12974

2. Sahin O, Koroglu A, Dede DÖ, Yilmaz B. Effect of surface sealant agents on the surface roughness and color stability of denture base materials. J Prosthet Dent. 2016;116(4):610-6. https://doi.org/10.1016/j.prosdent.2016.03.007

3. Gad MM, Al-Thobity AM, Rahoma A, Abualsaud R, Al-Harbi FA, Akhtar S. Reinforcement of PMMA denture base material with a mixture of ZrO2 nanoparticles and glass fibers. Int J Dent. 2019; 2019:11. https://doi.org/10.1155/2019/2489393

4. Al-jmoor CA. The prevalence of fracture in acrylic removable dentures in Sulaimania City. Sulaimani Dent J. 2014;1(1):29-35. http://dx.doi.org/10.17656/sdj.10015

5. Al-Sammraaie MF, Fatalla AA. The effect of ZrO2 NPs addition on denture adaptation and diametral compressive strength of 3D printed denture base resin Nanomed Res J. 2023, 8(4):345–355. http://doi.org/10.22034/nmrj.2023.04.003

6. Elmadani A, Radović I, Tomić NZ, Petrović M, Stojanović DB, Heinemann RJ, et al. Hybrid denture acrylic composites with nanozirconia and electrospun polystyrene fibers. PLOS One. 2019;14(12): e0226528. https://doi.org/10.1371/journal.pone.0226528

7. Lazouzi G, Vuksanović MM, Tomić NZ, Mitrić M, Petrović M, Radojević V, et al. Optimized preparation of alumina based fillers for tuning composite properties. Ceram Int 2018;44(7):7442-9. http://doi.org/10.1016/j.ceramint.2018.01.083

8. Tomar P, Gope P, Chauhan S. Influence of fiber Reinforcement on properties of PMMA. Int. J. Mech. Therm. Eng. 2023;4(1):23-7. http://dx.doi.org/10.22271/27078043

9. Fadhel HM, Safi NI. Evaluating the effect of the addition of Nano-cellulose fibers on certain properties of heat-cured acrylic resin denture base material. F1000Research. 2024; 13:529. https://doi.org/10.12688/f1000research.147446.1

10. Hussein NA, Ali NA. Synthesis and characterization of Ni2O3 as a phase of nickel oxide nanomaterial. Iraqi J Sci. 2022;63(11):4733-9. https://doi.org/10.24996/ijs.2022.63.11.12

11. Zhang M, Zhang C, Zhai X, Luo F, Du Y, Yan C. Antibacterial mechanism and activity of cerium oxide nanoparticles. Sci China Mater. 2019;62(11):1727-39. https://doi.org/10.1007/s40843-019-9471-7

12. Nosrati H, Heydari M, Khodaei M. Cerium oxide nanoparticles: synthesis methods and applications in wound healing. Mater Today Bio. 2023; 23:100823. https://doi.org/10.1016/j.mtbio.2023.100823

13. Younis A, Chu D, Li S. Cerium oxide nanostructures and their applications. Functional Nanomaterials: InTech; 2016. p. 53-68. http://dx.doi.org/doi:%2010.5772/65937

14. Abd El Aziz PM. Applications of Cerium Oxide Nanoparticles in Dentistry: A Review Article. ERURJ. 2025;4(2):2581-94. https://doi.org/10.21608/erurj.2025.333537.1202

15. Isam MA, Mahmood WS. Impact of cerium oxide nanoparticles incorporation on shear bond strength and surface hardness of acrylic-based soft lining material. J. Emerg. Med. Trauma Acute Care. 2024;2024(8):4. https://doi.org/10.5339/jemtac.2024.midc.4

16. Abd El-Fattah A, Youssef H, Gepreel MAH, Abbas R, Kandil S. Surface morphology and mechanical properties of polyether ether ketone (PEEK) nanocomposites reinforced by nano-sized silica (SiO2) for prosthodontics and restorative dentistry. Polymers. 2021;13(17):3006. https://doi.org/10.3390/polym13173006

17. Parate KP, Naranje N, Vishnani R, Paul P. Polyetheretherketone material in dentistry. Cureus. 2023;15(10). https://doi.org/10.7759/cureus.46485

18. Papathanasiou I, Kamposiora P, Papavasiliou G, Ferrari M. The use of PEEK in digital prosthodontics: A narrative review. BMC Oral Health. 2020; 20:217. https://doi.org/10.1186/s12903-020-01202-7

19. Manolea HO, Obădan F, Popescu SM, Rîcă R, Mărășescu P, Iliescu AA, et al., editors. Current options of making implant supported prosthetic restorations to mitigate the impact of occlusal forces. Defect and Diffusion Forum; 2017: Trans Tech Publications, Ltd. http://dx.doi.org/10.4028/www.scientific.net/DDF.376.66

20. Schmidlin PR, Stawarczyk B, Wieland M, Attin T, Hämmerle CH, Fischer J. Effect of different surface pre-treatments and luting materials on shear bond strength to PEEK. Dent Mater. 2010;26(6):553-9. https://doi.org/10.1016/j.dental.2010.02.003

21. Zhang Y, Zhang W, Yang M, Li M, Zhou L, Liu Y, et al. Comprehensive review of polyetheretherketone use in dentistry. J. Prosthodont. Res. 2025;69(2):215-32. https://doi.org/10.2186/jpr.JPR_D_24_00142

22. Chen S, Yang J, Jia Y, Lu B, Reinforced P. 3D Printing PMMA Composite Resin for Dental Denture Base Applications. Nanomaterials. 2019; 9(7):1049. https://doi.org/10.3390/nano9071049

23. Neppelenbroek KH, Pavarina AC, Vergani CE, Giampaolo ET. Hardness of heat-polymerized acrylic resins after disinfection and long-term water immersion. J Prosthet Dent. 2005;93(2):171-6. https://doi.org/10.1016/j.prosdent.2004.10.020

24. McCabe JF, Walls AW. Applied dental materials: John Wiley & Sons; 2013.

25. Sakaguchi RL, Powers JM. Craig's Restorative Dental Materials-E-Book: Craig's Restorative Dental Materials-E-Book: Elsevier Health Sciences; 2011.

26. Adhikari R, Michler GH. Polymer nanocomposites characterization by microscopy. J. Macromol. Sci., Part C: Polymer Reviews. 2009;49(3):141-80 https://doi.org/10.1201/b12170-12

27. Abdulrazzaq HT, Ali MM. The effect of glass flakes reinforcement on the surface hardness and surface roughness of heat-cured poly (methyl methacrylate) denture base material. J. Bagh. Coll. Dent. 2015;27(2):6-10.

28. Barapatre D, Somkuwar S, Mishra S, Chowdhary R. The effects of reinforcement with nanoparticles of polyetheretherketone, zirconium oxide and its mixture on flexural strength of PMMA resin. Eur Oral Res. 2022;56(2):61-6. https://doi.org/10.26650/eor.2022904564

29. Muhsin SA, Hatton PV, Johnson A, Sereno N, Wood DJ. Determination of Polyetheretherketone (PEEK) mechanical properties as a denture material. Saudi Dent J. 2019;31(3):382-91. https://doi.org/10.1016/j.sdentj.2019.03.005

30. Alwan Erhim E, Abbood MA, Halbos HT. Assessment of surface hardness and impact strength of denture base resins reinforced with silver–titanium dioxide and silver–zirconium dioxide nanoparticles: In vitro study. Open Eng. 2024;14(1):20240064. https://doi.org/10.1515/eng-2024-0064

31. Al-Jmmal A, Mohammed N, Amer A. Evaluation of some properties of recycled polymethylmethacrylate incorporated to the acrylic resin. Int J Res Pharm Sci. 2020;11(3):2765-71. http://dx.doi.org/10.26452/ijrps.v11i3.2320

32. Asar NV, Albayrak H, Korkmaz T, Turkyilmaz I. Influence of various metal oxides on mechanical and physical properties of heat-cured polymethyl methacrylate denture base resins. J Adv Prosthodont. 2013; 5:241-7. https://doi.org/10.4047/jap.2013.5.3.241

33. Stuart B, Briscoe B. Scratch hardness studies of poly (ether ether ketone). Polymer. 1996;37(17):3819-24. https://doi.org/10.1016/0032-3861(96)00212-1

34. Al-Rais RM, Al-Nakkash WA, Al-Bakri AA-WK. Filler reinforced acrylic denture base material. Part 2-Effect of water sorption on dimensional changes and transverse strength. J Bagh Coll Dent. 2005;17(1):6-10.

35. Ellakwa AE, Morsy MA, El-Sheikh AM. Effect of aluminum oxide addition on the flexural strength and thermal diffusivity of heat-polymerized acrylic resin. J Prosthodont. 2008;17(6):439-44. https://doi.org/10.1111/j.1532-849X.2008.00318.x

36. Basima M, Aljafery A. Effect of addition ZrO_2-Al_2O_3 nanoparticles mixture on some properties and denture base adaptation of heat cured acrylic resin denture base material. J. Bagh. Coll. Dent. 2015;27(3):15-21.

37. Jasim BS, Ismail IJ. The effect of silanized alumina nano-fillers addition on some physical and mechanical properties of heat cured polymethyl methacrylate denture base material. J. Bagh. Coll. Dent. 2014;26(2):18-23.

38. Ellakwa AE, Morsy MA, El-Sheikh AM. Effect of aluminum oxide addition on the flexural strength and thermal diffusivity of heat-polymerized acrylic resin. J Prosthodont. 2008;17(6):439-44. https://doi.org/10.1111/j.1532-849X.2008.00318.x

تأثير دمج أكسيد السيريوم ومركب PEEK على الخواص الميكانيكية وتكيف قاعدة طقم الأسنان لراتنجPMMA

مريم محمد عايد، فراس عبدالامير فرحان، ايشام سول سليمان

ملخص:

الخلفية: يُستخدم راتنج بولي ميثيل ميثاكريلات (PMMA) على نطاق واسع في طب الأسنان التعويضي وتقويم الأسنان، وخاصةً في تصنيع الأسنان الاصطناعية والتيجان المؤقتة وقواعد أطقم الأسنان وأجهزة تثبيت تقويم الأسنان. الأهداف: هدفت هذه الدراسة إلى تقييم آثار دمج مركب أكسيد السيريوم وجسيمات نانوية من بولي إيثر إيثر كيتون (CP) في راتنج PMMA على القوة العرضية وقوة التأثير وصلابة السطح وتكيف قاعدة طقم الأسنان. المواد والطرق: تم تقسيم ما مجموعه 120 عينة من PMMA إلى ثلاث مجموعات بناءً على تركيز مركب CP المضاف إلى راتنج PMMA، حيث تتكون كل مجموعة من 40 عينة: مجموعة ضابطة بدون حشوات، والمجموعة (أ) تحتوي على 1% وزنًا من حشو مركب بنسبة 30% من أكسيد السيريوم و70% من بولي إيثر إيثر كيتون، والمجموعة (ب) تحتوي على 3% وزنًا. من مركب بنسبة 50٪ سيريا، و 50٪ بولي إيثر إيثر كيتون، كما حددته الدراسة التجريبية. تم اختبار كل مجموعة من حيث القوة العرضية، وقوة التأثير، وصلابة السطح، وتكيف قاعدة طقم الأسنان، مع 10 عينات لكل اختبار. تم فحص العينات المختبرة باستخدام مطيافية تحويل فورييه بالأشعة تحت الحمراء (FTIR)، ومجهر مسح إلكتروني بانبعاث المجال (FE-SEM). تم تحليل البيانات الناتجة إحصائيًا باستخدام SPSS عند مستوى دلالة $P \leq 0.05$. النتائج: أظهرت المجموعة ب زيادة إحصائية كبيرة في القوة العرضية وقوة التأثير مقارنة بالمجموعات الأخرى. زادت صلابة السطح وتكيف طقم الأسنان بشكل ملحوظ في المجموعة أ. كشف تحليل FTIR عن قمم النفاذية وزيادة الكثافة بعد إضافة مركب CP إلى PMMA. أظهرت صور FE-SEM مركب CP نانوي موزع جيدًا داخل مصفوفة PMMA لجميع المجموعات التجريبية، مع زيادة التكتل الملحوظ في المجموعة ب (3٪). الاستنتاج: دمج 3٪ وزني. أدى دمج CP في راتنج PMMA إلى تحسين قوة الانحناء والصدمة بشكل ملحوظ مقارنةً بـ 1% وزنيًا والمجموعة الضابطة. كما تحسنت صلابة السطح وتكيف قاعدة طقم الأسنان عند دمج CP بنسبة 1% وزنيًا في راتنج PMMA مقارنةً بالمجموعات الأخرى المختبرة.