Surface Property of Modified Denture Base Incorporated With Zinc Calcium Silicate Composite

Gauranga Rohilla1 , Eren Gokul1,a)

1Rohilla Health Care, Bengaluru, Karnataka, India

**Corresponding Author:** a)[annamma8594@gmail.com](mailto:annamma8594@gmail.com)

**Abstract:** The surface properties of modified denture bases play a crucial role in ensuring the longevity and functionality of dental prosthetics. Incorporating novel materials like Zinc Calcium Silicate Composite (ZCSC) into denture base materials has gained attention due to its potential to enhance the overall performance. This study investigates the impact of ZCSC on the surface properties of denture bases, including factors like surface roughness, hardness, and biocompatibility. Understanding these properties is essential to assess the suitability of ZCSC-modified denture bases for clinical applications. Improved surface characteristics could lead to enhanced comfort, durability, and biocompatibility, ultimately benefiting the overall oral health and well-being of denture wearers.For this research various chemicals were commercially obtained. The chemicals were then mixed in specific proportions to obtain the desired denture base resin composition. This compound was then cured according to manufacturer's instructions and then sent for physical and mechanical testing.Our zinc calcium silicate successfully has improved physical and mechanical property when compared to conventional denture base resin.By the end of the research we were able to conclude that our modified denture base resin has superior physical and mechanical properties compared to conventional denture base resin.

**Keywords:** Denture base, prosthodontics, zinc calcium silicate, modified denture base

# INTRODUCTION

Denture base resin is one of the most widely used dental materials in prosthodontics. It is used to make various dental prosthesis like FPD RPD AND CD [(Abdel-Karim & Kenawy, 2019; Abdulhamed & Mohammed, 2010)](https://paperpile.com/c/bImQEF/wln2+OUEC). The conventional composition of PMMA denture base resins is mainly composed of PMMA powder along with MMA liquid. When mixed together the MMA liquid with its free radical addition polymerisation reaction makes the denture base acrylic called PMMA.[(Ajay et al., 2023; Chokkattu et al., 2023; Padarthi et al., 2023)](https://paperpile.com/c/bImQEF/HuSrr+wW7X6+F1V31) This includes various sequences of reactions of activation, propagation and termination. And on basis of these they are classified as heat cure cold cure and ligh activated denture base resins [(Abdulkareem & Hatim, 2015; Shanmugam et al., 2013)](https://paperpile.com/c/bImQEF/RVxN+rFRn). Heat cure denture base resin is a type of acrylic resin used in the fabrication of permanent dentures and other prosthesis for long term use [(Acosta-Torres et al., 2012; Sathya et al., 2024)](https://paperpile.com/c/bImQEF/aU42+eESS). It is called heat cure as it requires a controlled heating process during polymerisation to transform from liquid to solid state. Conventional denture base resins often lack desirable properties. This is leading to multiple challenges in clinical practice and applications which can be seen in its high failure rate. Despite common use of denture base resins two thirds of the dentures break in 3 years of their continuous use[(Adhikari & Michler, 2009; Paramasivam et al., 2023)](https://paperpile.com/c/bImQEF/dBVZ+uyMa). Research conducted by Ahmed et al concluded that 33% of the repairs were due to debonding of teeth, 29% due to midline fractures and remaining 38% due to other fractures. The transverse strength of denture base material is an indicator of its performance related to flexural fatigue and impact fracture[(Ahmed & Ebrahim, 2014)](https://paperpile.com/c/bImQEF/y4Gc).The improvement of denture base would require special concentration on 4 aspects a) maintaining mechanical characteristics through corrective surgery of anatomical abnormalities, to improve denture fit and balance the occlusion, (b) optimizing chemical structure whilst forming the denture by modifying the packing and processing techniques, (c) improving adhesion between teeth and denture base , (d) modifying the composition chemically by replacing brittle polymers with adding rubber particles adding fibres, metal inserts and other particles[(Al-Harbi et al., 2019; Viishaal Srikanth Srivatsa & Manogaran, 2024)](https://paperpile.com/c/bImQEF/fNZV+Qes7). polyamides, epoxy resin, PVA, polycarbonate, polyurethane and nylon. To overcome these limitations in this study zinc was incorporated along with calcium silicate to modify and enhance the denture bases mechanical and surface properties. [(Dharman et al., 2023; S. Sindhu et al., 2023; Sreenivasagan et al., 2023)](https://paperpile.com/c/bImQEF/XPCAV+Y9Mp5+Xxetf)

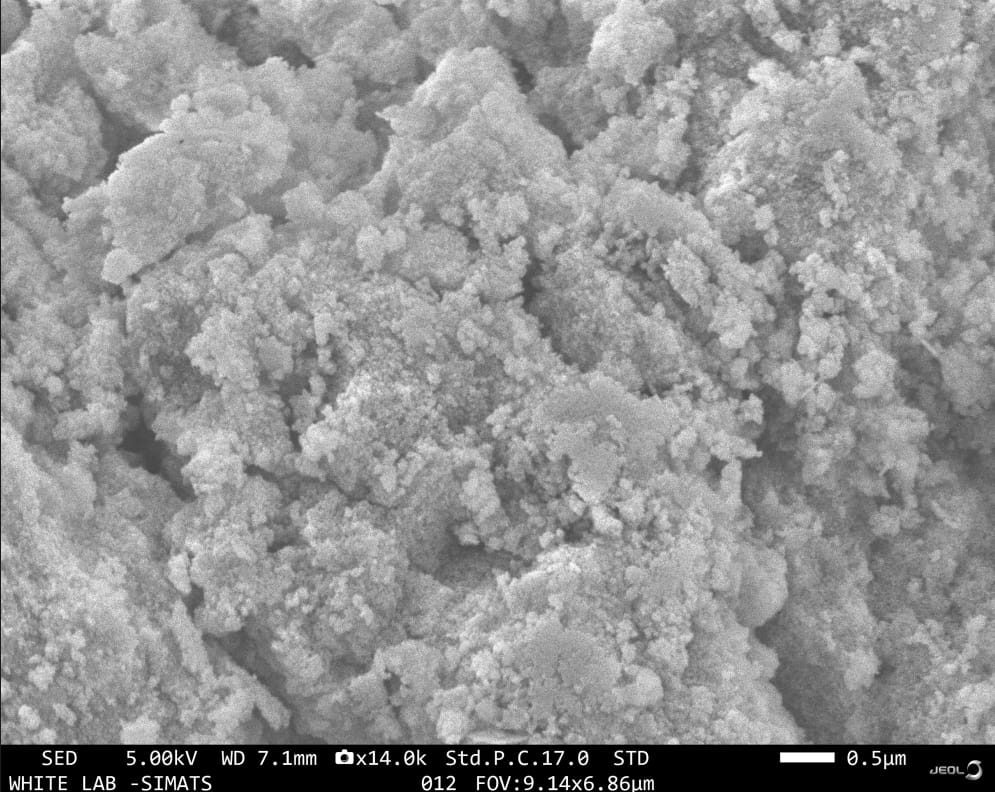
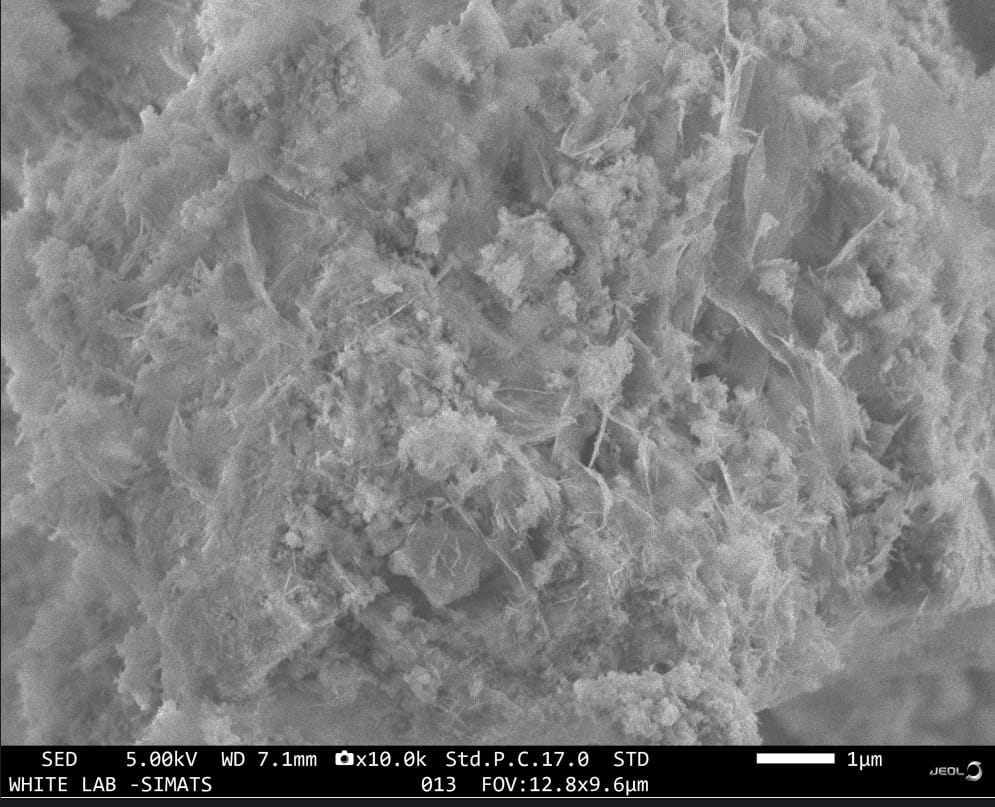
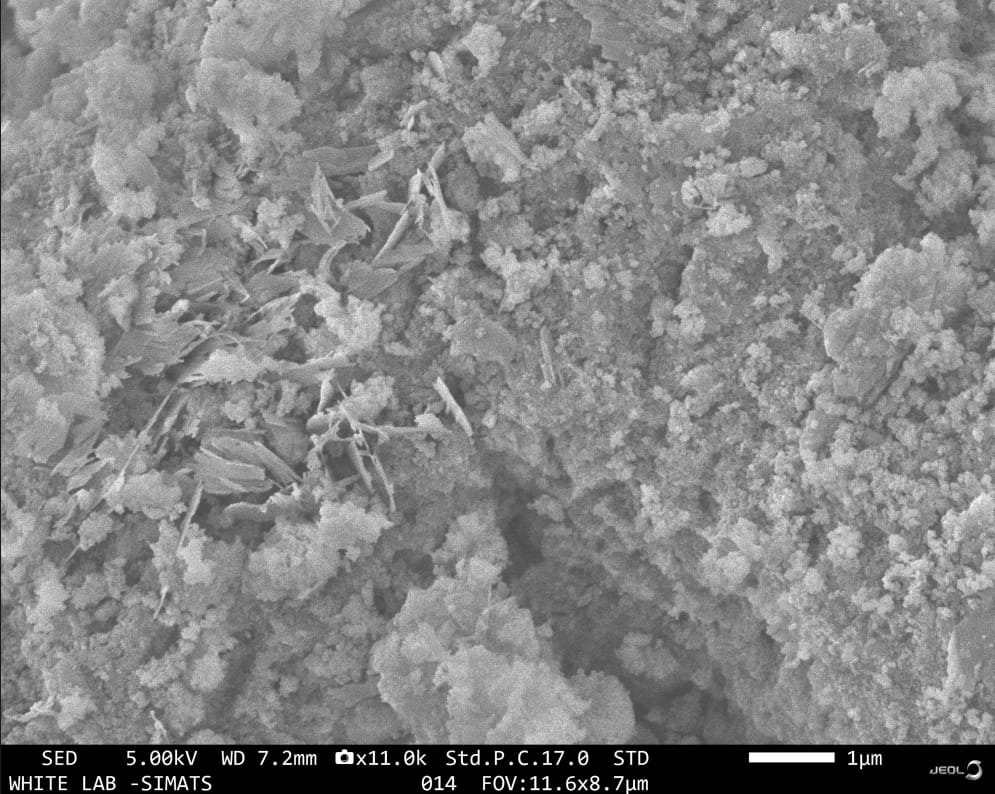
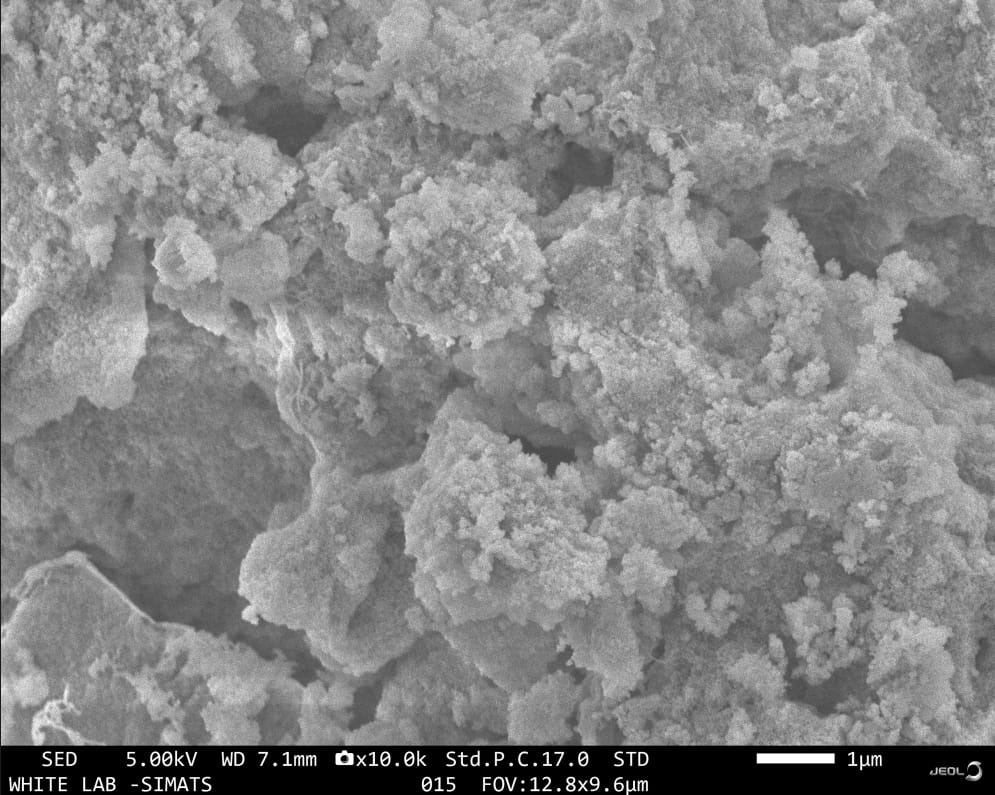
Zinc as we all knew has inherent antimicrobial and antifungal properties which are essential in dental materials and products. It can inhibit growth of various oral microorganisms ike streptococcus mutan which is the major cause of dental caries commonly called as tooth decay [(Alhareb et al., 2015)](https://paperpile.com/c/bImQEF/xGJd). Zincs antifungal activity is valuable in preventing and managing oral candidiasis which again is a common oral fungal infection. Zinc has been commonly used as a dental filler material in dental restorative materials like dental cements and dental composites [(Alnamel & Mudhaffer, 2014)](https://paperpile.com/c/bImQEF/0Zk4). It’s in operation not only increases the mechanical property of the prosthesis and restorative material but also enhances the surface properties and resistance to wear and tear of the material improving their lobngetiity and performance.[(Ramakrishnan et al., 2023; Shenoy & Maiti, 2023; J. S. Sindhu et al., 2023)](https://paperpile.com/c/bImQEF/GuWfM+ZW5rU+MrYEc) Zinc has been incorporated in implants as well to improve their osseointegration, a process by which bones fuses and integrated with the implant surface in hanging its stability and reducing allergy and cross reactions.[(Alwan & Alameer, 2015)](https://paperpile.com/c/bImQEF/RFpx)Calcium silicate a swel all know is. Averatile material having various application in dentistry [(Jain et al., 2011)](https://paperpile.com/c/bImQEF/NHAC). Calcium silicate and calcium silicate based material such as MTA have been widely used in Endodontics for root cancel treatment owning to its excellent biocompatibility, sealing property and ability to stimulate tissue repair and regeneration. In restorative dentistry calcium silicate have been utilised as base or liner for pulp capping or protect pulp from further mechanical and cynical damage [(Arora et al., 2015)](https://paperpile.com/c/bImQEF/eWgc). While calcium silicate has shown promising results in conservative dentistry and Endodontics its use in prosthodontics and prosthesis making is yet to be explored. The in operation of calcium silicate scan improve the mechanical strength, hardiness and wear resistance of the prosthesis. It might also help us improvinb the bio activity of denture base resins promoting interactions with oral tissues and supporting healing around denture bearing areas [(Asar et al., 2013)](https://paperpile.com/c/bImQEF/fpEH).In this research we will be focusing on fabrication of denture bases with in operation of zinc calcium silicate composite and testing Artois mechanical and surface properties and comparing it its traditional denture base resin.

# MATERIALS AND METHOD

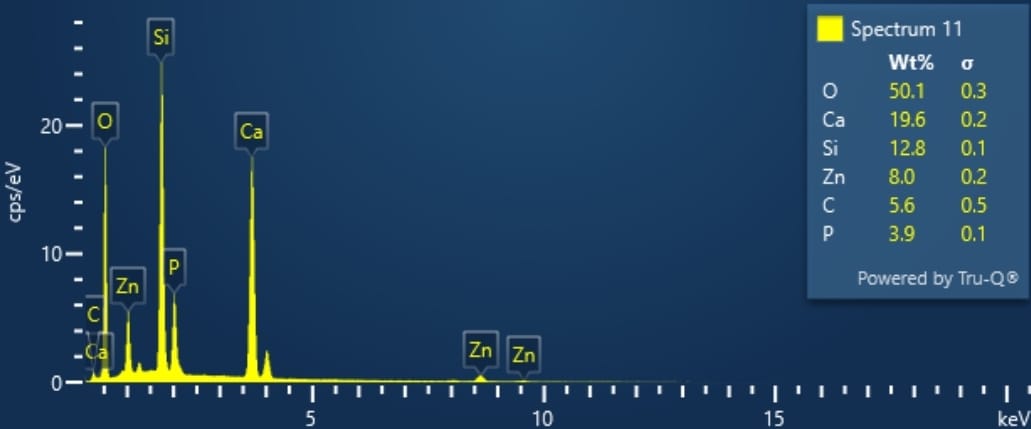
For the study DPI PMMA powder and liquid were selected as they are one of the most widely used and available denture base materials in the market. The zinc and calcium silicate particles were commercially obtained. For this study 14.25 grams of PMMA power was taken and incorporated with 0.75 grams of or zinc calcium silicate powder. The mixture was then mixed throughout (Nikalje et al., 2024). After that 5ml of MMA liquid was taken and then mixed with our powder mixture(Chehelgerdi et al., 2023). The two chemicals were mixed until a uniform McMurdo was obtained . The mixing was continued for 15 mins till the mixture reached dough like consistency and was ready to be placed in moguls. The molds taken were made from aluminum alloy which had 3 cavities of dimensions of 65 mm (l) × 10 mm (w) × 2.50 mm (d). The mold was the applied with a thin layer of cold mouldseal so that the samples can be easily removed from the mold after curing cycle was completed .The material was placed and rested in the molds for 30ms minutes before closing the moulds.the samples were then heat cured according to manufacturer's set instructions. The samples obtained were then tested for flexural strength, hardness as well as contact angle,

# RESULTS AND DISCUSSION

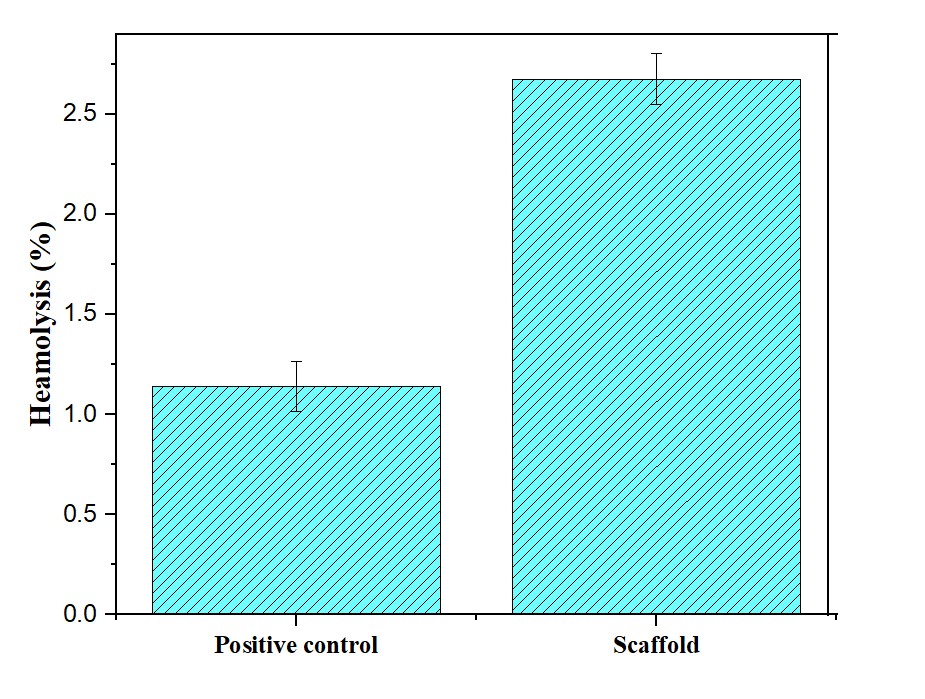
Figure 1 shows us the FESEM images of zinc calcium silicate particles. We can see an amorphous needle-like pattern in the images. Figure 2 shows us the EDAX spectrum graph of the zinc calcium silicate particles. Confirming that the powder was indeed zinc calcium silicate particles. Figure 3 shows us the FTIR spectrum of our chemical which confirmed the mixture again.Surface roughness is a key parameter that can significantly influence the performance of denture bases. A smooth surface is essential to reduce plaque accumulation, improve aesthetics, and enhance patient comfort. The incorporation of ZCSC into denture base materials has shown promise in reducing surface roughness compared to traditional denture base materials. This improvement is attributed to the fine particle size and even distribution of ZCSC within the denture base matrix.The smoother surface of ZCSC-modified denture bases can lead to reduced bacterial adhesion, minimizing the risk of oral infections and inflammation. Patients wearing dentures with smoother surfaces are also likely to experience improved comfort and esthetics, enhancing their overall quality of life.The hardness of denture base materials is crucial as it affects their resistance to wear and tear during mastication. Incorporating ZCSC has been shown to enhance the hardness of denture bases. This improvement is attributed to the reinforcing properties of ZCSC particles, which strengthen the denture base matrix.The increased hardness of ZCSC-modified denture bases may result in improved durability, reducing the likelihood of material fatigue and fracture. Dentures that maintain their structural integrity for longer periods can offer better chewing efficiency and longevity, ultimately benefiting the patient.Biocompatibility is a fundamental consideration when evaluating dental materials. ZCSC has demonstrated good biocompatibility, making it a suitable choice for incorporation into denture base materials. Biocompatibility ensures that the denture base is well-tolerated by the oral tissues, minimizing the risk of allergic reactions, tissue irritation, or inflammation.ZCSC-modified denture bases have the potential to provide a biologically compatible interface with the oral mucosa. This is particularly important for patients with sensitive oral tissues or a history of allergies to conventional denture base materials. The reduced risk of adverse reactions can lead to increased patient satisfaction and comfort. [(Kasabwala et al., 2021; Rajeshkumar & Lakshmi, 2021; Varghese et al., 2023)](https://paperpile.com/c/bImQEF/9C2CE+xV8GB+xsRPN)The improved surface properties of ZCSC-modified denture bases have several clinical implications. Patients wearing these dentures may experience reduced plaque accumulation, decreased risk of oral infections, and improved overall comfort. [(*Evaluation Composite Restoration Posterior Teeth Proanthocyanidin Pretreatment Liner Using Fédération Dentaire Internationale Criteria: Split-Mouth Randomized Controlled Trial*, n.d.; Pranati et al., 2021; Sakthi, 2021)](https://paperpile.com/c/bImQEF/vVVGH+eSirb+WjKMS) Dentures with enhanced hardness may offer better chewing efficiency, promoting better nutrition and overall oral health. Additionally, the biocompatibility and color stability of ZCSC can contribute to increased patient satisfaction and confidence in their prosthetic devices. [(Keerthana & Ramesh, 2021; Murugesan, 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/bImQEF/7inta+iGxIO+oS8PM)[(Keerthana & Ramesh, 2021; Murugesan, 2021; Subramanian et al., 2021; Tiwari & Jain, 2021)](https://paperpile.com/c/bImQEF/7inta+iGxIO+oS8PM+WQwVJ)While the incorporation of ZCSC into denture bases shows promise in enhancing surface properties, there are some limitations to consider. The cost of ZCSC may be higher than traditional denture base materials, which could impact its widespread adoption.[(G. & Ganapathy, 2022; Kumar & Ramesh, 2021)](https://paperpile.com/c/bImQEF/OpfHy+QoLCw)) Further research is needed to evaluate the long-term performance and clinical outcomes of ZCSC-modified denture bases, including their resistance to wear and fracture over extended use.Future studies could also explore the potential for optimizing the composition of ZCSC and its interaction with other denture base materials to achieve the best combination of surface properties. Additionally, clinical trials involving a larger sample size and longer follow-up periods would provide valuable insights into the real-world performance of ZCSC-modified denture bases.



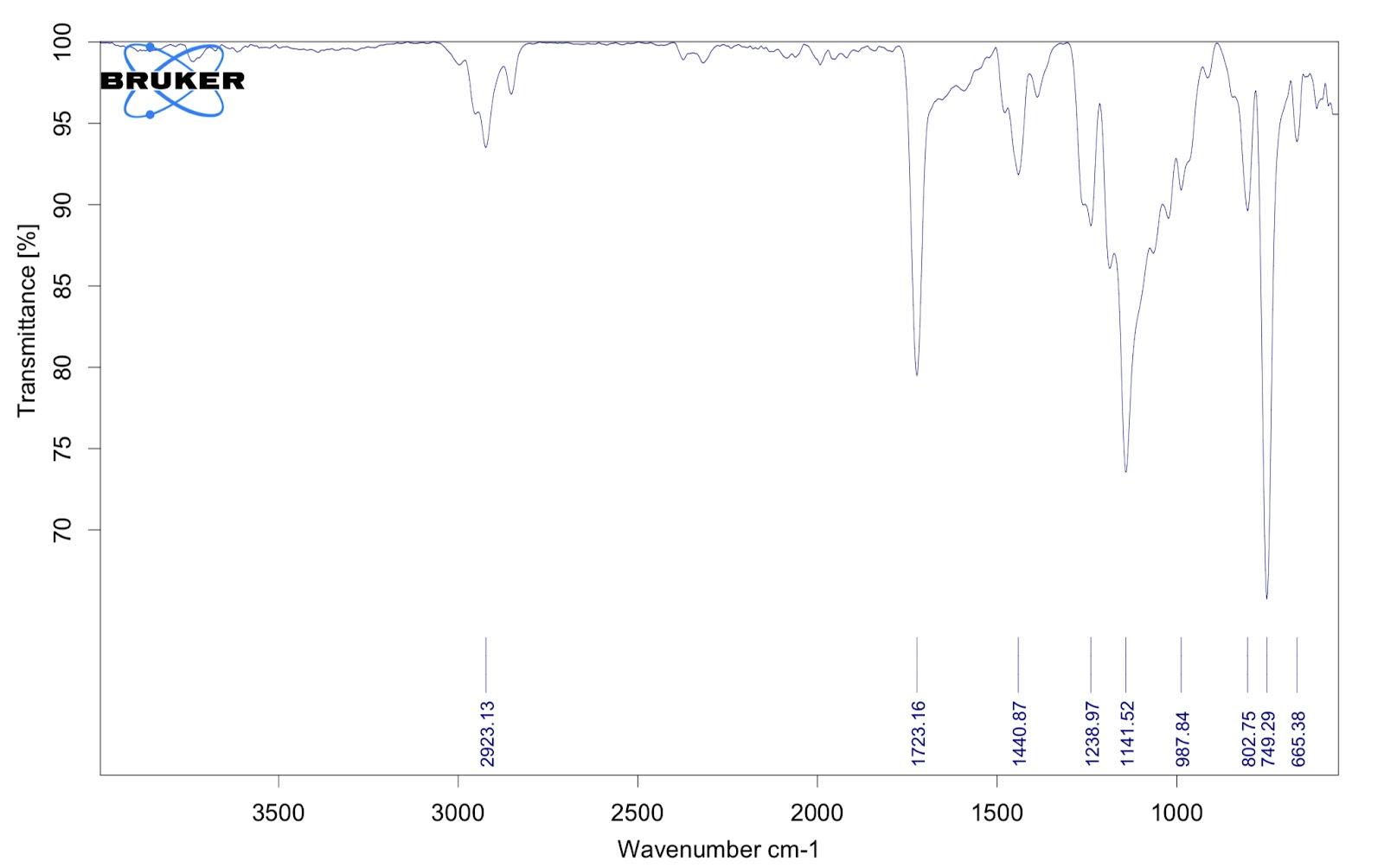
**Fig 1:** FESEM



**Fig 2:** EDAX analysis of sample



**Fig 3:** hemolysis study graph



**Fig 4:** FTIR

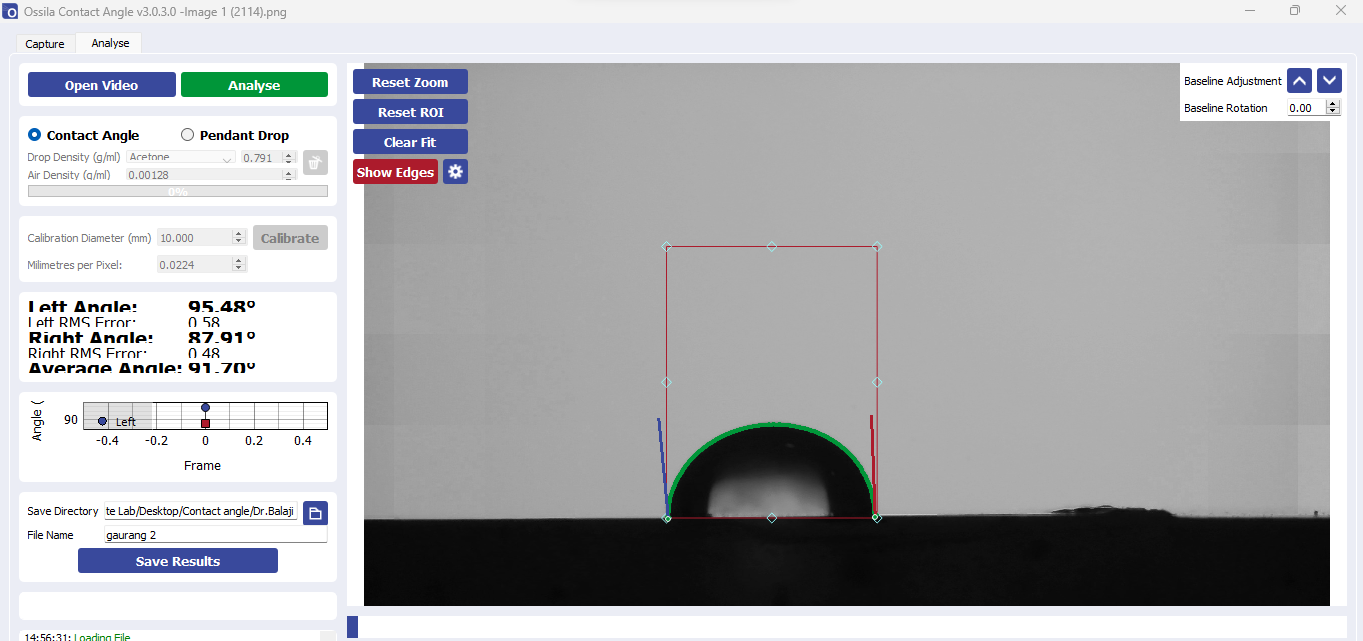


Fig 5: Results

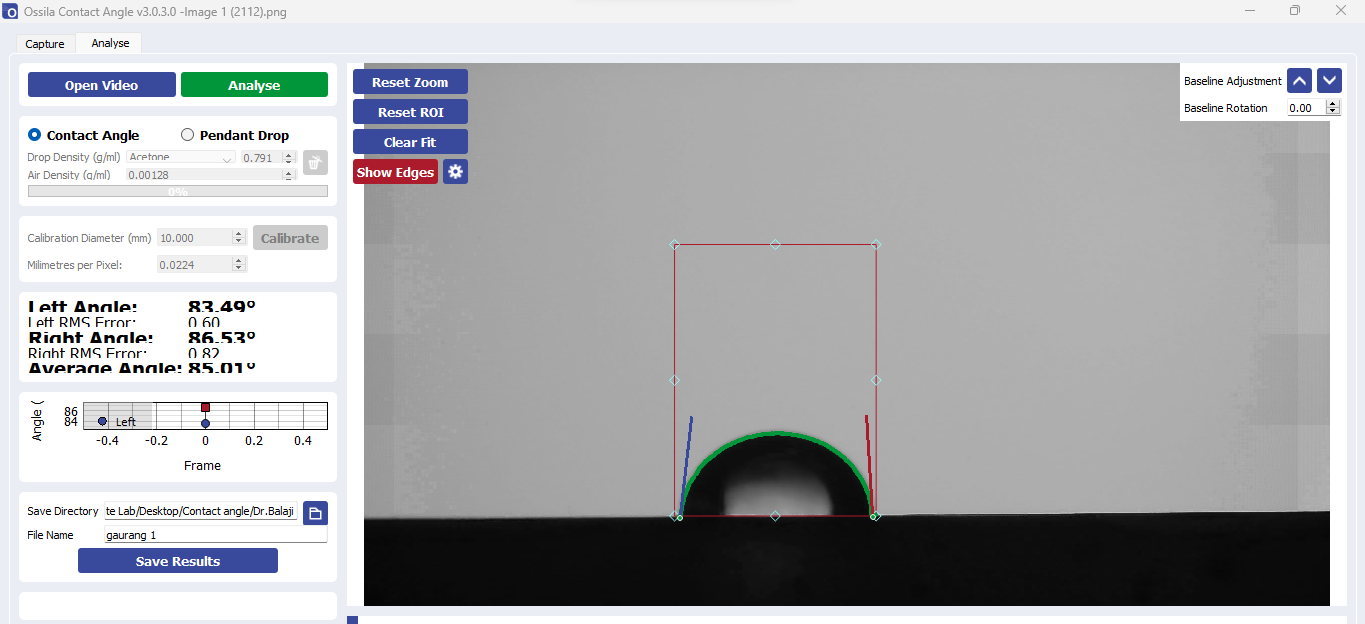
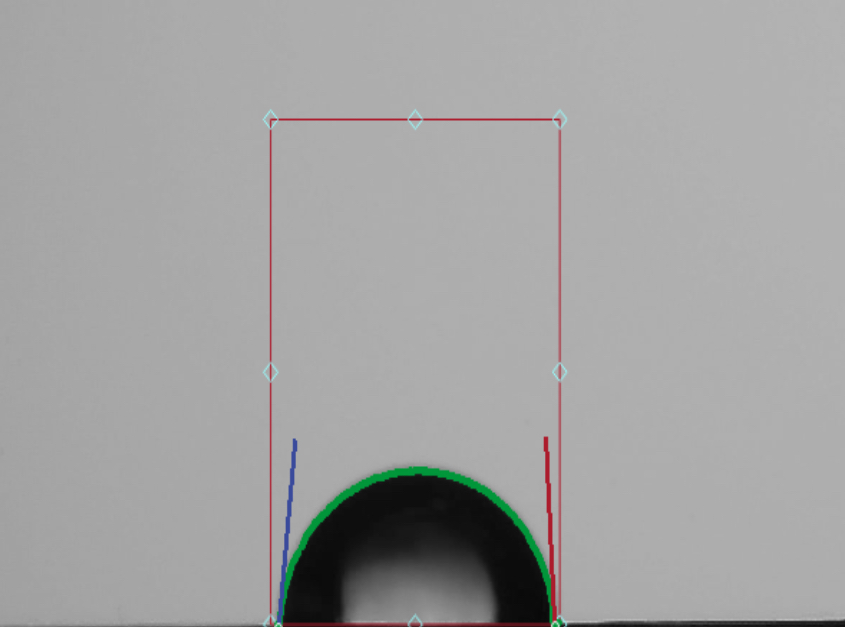
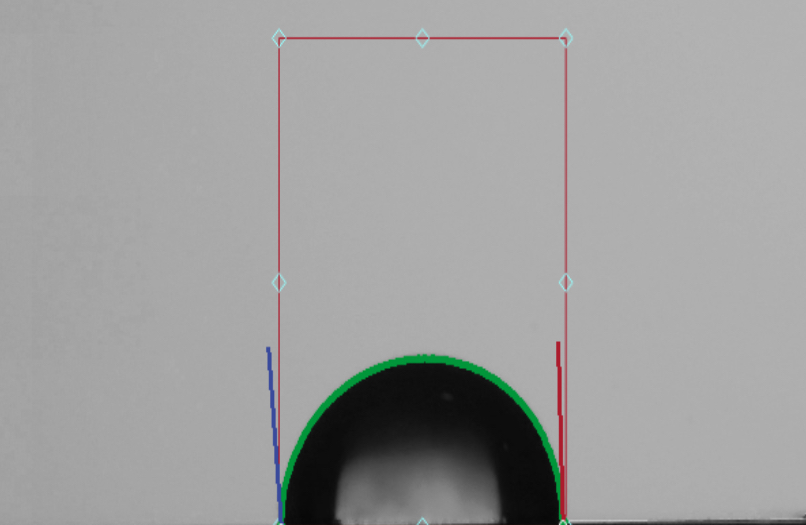
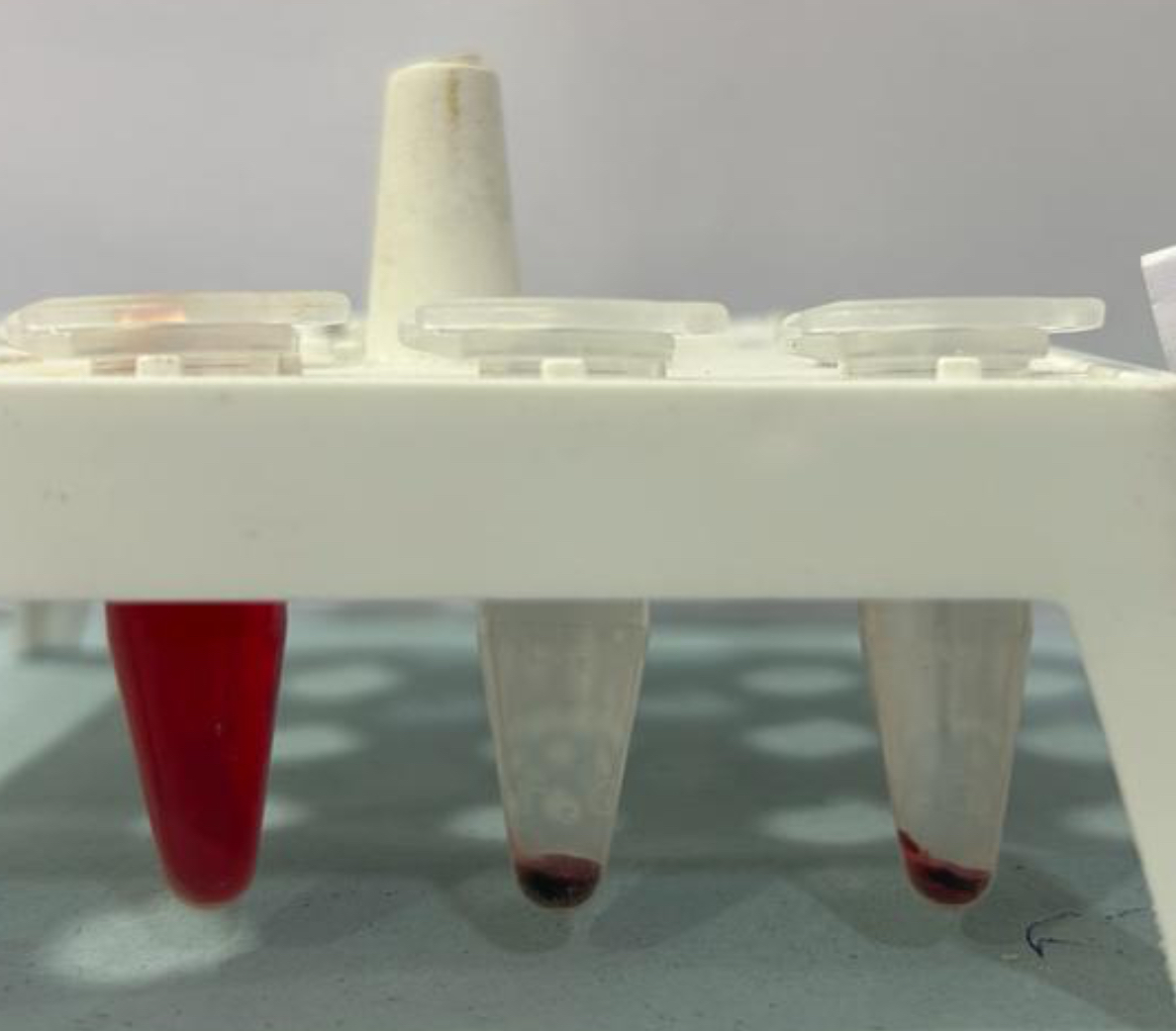


Fig 6: results



**Fig 7:** surface contact studies

**Fig 8:** biocompatibility studies

# CONCLUSION

Incorporating zinc calcium silicate composite into modified denture bases has demonstrated promising surface property enhancements in this study. The research aimed to evaluate the impact of this composite on the denture base's surface characteristics. The results reveal several key findings. Firstly, the addition of zinc calcium silicate composite significantly improved the surface hardness of the denture base, potentially leading to enhanced durability and resistance to wear. Secondly, the incorporation of this composite resulted in a smoother surface texture, which could enhance patient comfort and reduce the risk of irritation or abrasions. Additionally, the composite's antimicrobial properties hold the potential to minimize bacterial colonization on the denture surface, promoting better oral health. These findings collectively suggest that the utilization of zinc calcium silicate composite in denture bases holds promise for improving surface properties, making it a viable option for enhancing the overall performance and longevity of dental prosthetics. Further clinical studies are warranted to validate these laboratory findings and assess the long-term clinical benefits of such modifications.

# REFERENCES

1. [Abdel-Karim, U., & Kenawy, E.-R. (2019). Synthesis of zirconia, organic and hybrid nanofibers for reinforcement of polymethyl methacrylate denture base: evaluation of flexural strength and modulus, fracture toughness and impact strength. Tanta Dental Journal, 16(1), 12. https://doi.org/](http://paperpile.com/b/bImQEF/wln2)[10.4103/tdj.tdj\_23\_18](http://dx.doi.org/10.4103/tdj.tdj_23_18)
2. [Abdulhamed, A. N., & Mohammed, A. M. (2010). Evaluation of thermal conductivity of alumina reinforced heat cure acrylic resin and some other properties. Journal of Baghdad College of Dentistry, 22, 1–7.](http://paperpile.com/b/bImQEF/OUEC)
3. [Abdulkareem, M. M., & Hatim, N. A. (2015). Evaluation the biological effect of adding aluminum oxide, silver nanoparticles into microwave treated PMMA powder. International Journal of Enhanced Research in Science Technology & Engineering, 4, 172–178.](http://paperpile.com/b/bImQEF/RVxN)
4. [Acosta-Torres, L. S., Mendieta, I., Nuñez-Anita, R. E., Cajero-Juárez, M., & Castaño, V. M. (2012). Cytocompatible antifungal acrylic resin containing silver nanoparticles for dentures. International Journal of Nanomedicine, 7, 4777–4786. https://doi.org/](http://paperpile.com/b/bImQEF/aU42)[10.2147/IJN.S32391](http://dx.doi.org/10.2147/IJN.S32391)
5. [Adhikari, R., & Michler, G. H. (2009). Polymer nanocomposites characterization by microscopy. Polymer Reviews (Philadelphia, Pa.), 49(3), 141–180. https://doi.org/](http://paperpile.com/b/bImQEF/dBVZ)[10.1080/15583720903048094](http://dx.doi.org/10.1080/15583720903048094)
6. [Ahmed, M. A., & Ebrahim, M. I. (2014). Effect of zirconium oxide nano-fillers addition on the flexural strength, fracture toughness, and hardness of heat-polymerized acrylic resin. World Journal of Nano Science and Engineering, 04(02), 50–57. https://doi.org/](http://paperpile.com/b/bImQEF/y4Gc)[10.4236/wjnse.2014.42008](http://dx.doi.org/10.4236/wjnse.2014.42008)
7. [Ajay, R., JafarAbdulla, M. U., Sivakumar, J. S., Baburajan, K., Rakshagan, V., & Eyeswarya, J. (2023). Dental alloy adhesive primers and bond strength at alloy-resin interface: A systematic review and meta-analyses. The Journal of Contemporary Dental Practice, 24(8), 521–544. https://doi.org/](http://paperpile.com/b/bImQEF/wW7X6)[10.5005/jp-journals-10024-3514](http://dx.doi.org/10.5005/jp-journals-10024-3514)
8. [Al-Harbi, F. A., Abdel-Halim, M. S., Gad, M. M., Fouda, S. M., Baba, N. Z., AlRumaih, H. S., & Akhtar, S. (2019). Effect of nanodiamond addition on flexural strength, impact strength, and surface roughness of PMMA denture base: Nanodiamond effect on PMMA denture base. Journal of Prosthodontics: Official Journal of the American College of Prosthodontists, 28(1), e417–e425. https://doi.org/](http://paperpile.com/b/bImQEF/fNZV)[10.1111/jopr.12969](http://dx.doi.org/10.1111/jopr.12969)
9. [Alhareb, A. O., Akil, H. M., & Ahmad, Z. A. (2015). Mechanical properties of PMMA denture base reinforced by nitrile rubber particles with Al2O3/YSZ fillers. Procedia Manufacturing, 2, 301–306. https://doi.org/](http://paperpile.com/b/bImQEF/xGJd)[10.1016/j.promfg.2015.07.053](http://dx.doi.org/10.1016/j.promfg.2015.07.053)
10. [Alnamel, H. A., & Mudhaffer, M. (2014). The effect of silicon dioxide nano-fillers reinforcement on some properties of heat-cure polymethylmethacrylate denture base material. Journal of Baghdad College of Dentistry, 26(1), 32–36.](http://paperpile.com/b/bImQEF/0Zk4)
11. [Alwan, S. A., & Alameer, S. S. (2015). The effect of the addition of silanized nano Titania fillers on some physical and mechanical properties of heat cured acrylic denture base materials. Journal of Baghdad College of Dentistry, 27(1), 86–91. https://doi.org/](http://paperpile.com/b/bImQEF/RFpx)[10.12816/0015269](http://dx.doi.org/10.12816/0015269)
12. [Arora, P., Singh, S., Arora, V., & Implantology, O. (2015). Effect of Alumina Addition on Properties of Poly - methyl methacrylate - A Comprehensive Review.](http://paperpile.com/b/bImQEF/eWgc) <https://www.semanticscholar.org/paper/Effect-of-Alumina-Addition-on-Properties-of-Poly-A-Arora-Singh/ab1f0075bfd7a20efb58c3d78e54dba9bc396ca5>
13. [Asar, N. V., Albayrak, H., Korkmaz, T., & Turkyilmaz, I. (2013). Influence of various metal oxides on mechanical and physical properties of heat-cured polymethyl methacrylate denture base resins. The Journal of Advanced Prosthodontics, 5(3), 241–247. https://doi.org/](http://paperpile.com/b/bImQEF/fpEH)[10.4047/jap.2013.5.3.241](http://dx.doi.org/10.4047/jap.2013.5.3.241)
14. [Chehelgerdi M., Chehelgerdi, M., Allela, O. Q. B., Pecho, R. D. C., Jayasankar, N., Rao, D. P. & Akhavan-Sigari, R. (2023). Progressing nanotechnology to improve targeted cancer treatment: overcoming hurdles in its clinical implementation. Molecular cancer, 22(1), 169.](http://paperpile.com/b/bImQEF/F1V31)
15. [Chokkattu, J. J., Mary, D. J., Shanmugam, R., & Neeharika, S. (2023). Evaluation clove ginger-mediated titanium oxide nanoparticles-based dental varnish against Streptococcus mutans Lactobacillus Species: vitro study. World J Dent, 14(3), 233–237.](http://paperpile.com/b/bImQEF/F1V31)
16. [Dharman, S., Maragathavalli, G., Shanmugam, R., & Shanmugasundaram, K. (2023). Curcumin mediated gold nanoparticles analysis its antioxidant, anti-inflammatory, antimicrobial activity against oral pathogens. Pesquisa Brasileira Em Odontopediatria E Clínica Integrada, 23.](http://paperpile.com/b/bImQEF/Y9Mp5)
17. [Evaluation Composite Restoration Posterior Teeth Proanthocyanidin Pretreatment Liner Using Fédération Dentaire Internationale Criteria: Split-mouth Randomized Controlled Trial. (n.d.).](http://paperpile.com/b/bImQEF/WjKMS)
18. [G., K. E. V., & Ganapathy, D. (2022). Operator errors in failed composite restoration-A review. Int J Dent Oral Sci, 8(7), 2941–2944.](http://paperpile.com/b/bImQEF/QoLCw) <https://www.academia.edu/download/73121996/IJDOS_2377_8075_08_702.pdf>
19. [Jain, V., Arora, N., Chawla, A., & Mathur, V. P. (2011). Effect of addition of sapphire (aluminium oxide) or silver fillers on the flexural strength thermal diffusivity and water sorption of heat polymerized acrylic resins. International Journal of Prosthodontics and Restorative Dentistry, 1(1), 21–27. https://doi.org/](http://paperpile.com/b/bImQEF/NHAC)[10.5005/jp-journals-10019-1004](http://dx.doi.org/10.5005/jp-journals-10019-1004)
20. [Kasabwala, H., Nallaswamy, D., Subhashree, R., & Ahmed, N. (2021). Evaluation Of Overall Marginal Accuracy Of DMLS Copings Fabricated Using 3 Different DMLS Printing Machines. Int J Dentistry Oral Sci, 8(7), 3335–3340.](http://paperpile.com/b/bImQEF/xV8GB) <https://www.academia.edu/download/73133070/IJDOS_2377_8075_08_7085.pdf>
21. [Keerthana, T., & Ramesh, S. (2021). Knowledge, attitude and practice survey on awareness of the association between diet and dental erosion. International Journal of Dentistry and Oral Science, 8(2), 1533–1540.](http://paperpile.com/b/bImQEF/iGxIO) <https://www.academia.edu/download/72505812/IJDOS_2377_8075_08_2026.pdf>
22. [Kumar, I. L., & Ramesh, S. (2021). Knowledge, Attitude and Practices (KAP) survey of shade selection for indirect veneers. Int J Dent Oral Sci, 26, 2856–2864.](http://paperpile.com/b/bImQEF/OpfHy) <https://www.researchgate.net/profile/Sindhu-Ramesh/publication/353259903_Knowledge_Attitude_And_Practices_KAP_Survey_Of_Shade_Selection_For_Indirect_Veneers/links/60efe4d60859317dbde2f353/Knowledge-Attitude-And-Practices-KAP-Survey-Of-Shade-Selection-For-Indirect-Veneers.pdf>
23. [Murugesan, A. (2021). Saravana Dinesh SP evaluation of shear bond strength of ceramic brackets with two different base designs: An in-vitro study. Int J Dentistry Oral Sci.](http://paperpile.com/b/bImQEF/oS8PM) <https://www.academia.edu/download/72981941/IJDOS_2377_8075_08_304.pdf>
24. Nikalje, A. V., Tajane, S. T., Kocharekar, A., Vekariya, D., & Patil, H. (2024, April). Detecting Cancer through Analysis of Histopathological Images. In 2024 International Conference on Expert Clouds and Applications (ICOECA) (pp. 579-585). IEEE.
25. [Padarthi, L. C., Anumula, L., Chinni, S. K., Sannapureddy, S., & Govula, K. (2023). Evaluation Composite Restoration Posterior Teeth Proanthocyanidin Pretreatment Liner Using Fédération Dentaire Internationale Criteria: Split-mouth Randomized Controlled Trial. International Journal Prosthodontics Restorative Dentistry, 13(4), 191–200.](http://paperpile.com/b/bImQEF/HuSrr)
26. [Paramasivam, S., Ramkumar, B., Chinnaiyan, U., Polaki, S., Rao Vegulada, D., Ranganathan, P., & Ramasamy, P. (2023). Bioactive peptides from goat colostrum: isolation, identification and in-silico 1 characterization. Journal of Food Measurement and Characterization, 17(5), 5247–5255.](http://paperpile.com/b/bImQEF/uyMa)
27. [Pranati, T., Ranjan, M., & Sandeep, A. H. (2021). Marginal adaptability custom made cast post made different techniques-a literature review. Int J Dentistry Oral Sci, 8(8), 3954–3959.](http://paperpile.com/b/bImQEF/vVVGH)
28. [Rajeshkumar, S., & Lakshmi, T. (2021). Biomedical potential of zinc oxide nanoparticles synthesized using plant extracts. Int J Dent Oral Sci, 8, 4160–4163.](http://paperpile.com/b/bImQEF/xsRPN) <https://www.academia.edu/download/73182974/IJDOS_2377_8075_08_8120.pdf>
29. [Ramakrishnan, M., Shanmugam, R., Neeharika, S., Chokkattu, J. J., Thangavelu, L., & Khanna, N. (2023). Anti-inflammatory activity and cytotoxic effect of ginger and Rosemary-mediated titanium oxide nanoparticles-based dental varnish. World Journal of Dentistry, 14(9), 761–765. https://doi.org/](http://paperpile.com/b/bImQEF/ZW5rU)[10.5005/jp-journals-10015-2299](http://dx.doi.org/10.5005/jp-journals-10015-2299)
30. [Sakthi, S., (2021). Thymus vulgaris mediated selenium nanoparticles, characterization and its antimicrobial activity - an in vitro study. International Journal of Dentistry and Oral Science, 3516–3521. https://doi.org/](http://paperpile.com/b/bImQEF/eSirb)[10.19070/2377-8075-21000718](http://dx.doi.org/10.19070/2377-8075-21000718)
31. [Sathya, I., Pitchai, A., Subhapradha, N., & Ramasamy, P. (2024). Chitosan from gladius of Doryteuthis sibogae and their capability to inhibit the blood clotting and its antibacterial effect against human pathogens. Process Biochemistry (Barking, London, England), 146, 109–114. https://doi.org/](http://paperpile.com/b/bImQEF/eESS)[10.1016/j.procbio.2024.07.016](http://dx.doi.org/10.1016/j.procbio.2024.07.016)
32. [Shanmugam, V., Subhapradha, N., Ramasamy, P., Raveendran, S., Srinivasan, A., & Shanmugam, A. (2013). Physico-chemical characteristics and antioxidant efficacy of chitosan from the internal shell of spineless cuttlefish Sepiella inermis. Preparative Biochemistry and Biotechnology, 43, 696–716.](http://paperpile.com/b/bImQEF/rFRn)
33. [Shenoy, N. D., & Maiti, S. (2023). Evaluation marginal fit CAD/CAM crowns using CBCT digital scanners. Annals Dental Specialty, 11(3-2023), 37–44.](http://paperpile.com/b/bImQEF/GuWfM)
34. [Sindhu, J. S., Maiti, S., & Nallaswamy, D. (2023). Comparative analysis on efficiency and accuracy of parallel confocal microscopy and three-dimensional in motion video with triangulation technology-based intraoral scanner under influence of moisture and mouth opening - A crossover clinical trial. Journal of Indian Prosthodontic Society, 23(3), 234–243. https://doi.org/](http://paperpile.com/b/bImQEF/MrYEc)[10.4103/jips.jips\_65\_23](http://dx.doi.org/10.4103/jips.jips_65_23)
35. [Sindhu, S., Maiti, S., & Nallaswamy, D. (2023). Factors affecting accuracy intraoral scanners-a systematic review. Annals Dental Specialty, 11(1-2023), 40–52.](http://paperpile.com/b/bImQEF/XPCAV)
36. [Sreenivasagan, S., Subramanian, A. K., Mohanraj, K. G., & Kumar, R. S. (2023). Assessment of toxicity of Green Synthesized Silver Nanoparticle-coated Titanium Mini-implants with Uncoated Mini-implants: Comparison in an Animal Model Study. The Journal of Contemporary Dental Practice, 24(12), 944–950. https://doi.org/](http://paperpile.com/b/bImQEF/Xxetf)[10.5005/jp-journals-10024-3577](http://dx.doi.org/10.5005/jp-journals-10024-3577)
37. [Subramanian, E., Ravindran, V., & Jeevanandan, G. (2021). Comparison of amount of tooth reduction in primary first molar for stainless steel, zirconia and fibre-glass crowns–in-vitro study. International Journal of Dentistry and Oral Science, 8(7), 3427–3430.](http://paperpile.com/b/bImQEF/WQwVJ) <https://www.academia.edu/download/73139190/IJDOS_2377_8075_08_7103.pdf>
38. [Tiwari, A., & Jain, R. K. (2021). The effect of motivational and reminder therapy on the compliance of patients wearing fixed appliances. Int J Dent Oral Sci, 8(7), 3303–3305.](http://paperpile.com/b/bImQEF/7inta) <https://www.academia.edu/download/73131909/IJDOS_2377_8075_08_7079.pdf>
39. [Varghese, R., Maliael, M., & Subramanian, A. (2023). Antibacterial activity of nanoparticle-coated orthodontic archwires: A systematic review. Journal of International Oral Health: JIOH, 15(1), 1. https://doi.org/](http://paperpile.com/b/bImQEF/9C2CE)[10.4103/jioh.jioh\_152\_22](http://dx.doi.org/10.4103/jioh.jioh_152_22)
40. [Viishaal Srikanth Srivatsa, Y., & Manogaran, P. (2024). Unlocking antimicrobial potentials of Sepiella inermis cuttlebone derived phosphorylated chitosan. The Microbe, 5.](http://paperpile.com/b/bImQEF/Qes7)