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ENZYMATIC DEGRADATION OF RUBBER BASED DENTAL MATERIALS BY STAPHYLOCOCCUS AUREUS AND PSEUDOMONAS AERUGINOSA- A REVIEW

Dr. B. Eswaran[1], Dr. P. Vijayalakshmi[2], Dr. A. Ponsekar Abraham[3], Shivani.S[4], Thilak Ram.U[4].

[1]Professor, [2]Senior Lecturer, [3]Head of the Department and Professor, [4]Compulsory Rotatory Internship.
Thai Moogambigai Dental College and Hospital, DR. MGR Educational and Research Institute, Chennai.

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ABSTRACT

Rubber-based dental impression materials are widely used in prosthodontics due to their superior accuracy and dimensional stability; however, their susceptibility to microbial colonization poses both infection-control and material integrity concernsInitial bacterial adhesion is governed by physicochemical factors such as surface hydrophobicity, surface free energy, roughness, and salivary pellicle formation. Staphylococcus aureus demonstrates rapid adhesion to hydrophobic surfaces mediated by protein adhesins, whereas Pseudomonas aeruginosa exhibits strong persistence through biofilm formation on hydrophilic substrates. Beyond adhesion, both organisms contribute to material deterioration via the release of extracellular enzymes. Pseudomonas aeruginosa, in particular, produces elastase and other proteolytic enzymes capable of degrading polymeric chains, leading to alterations in surface integrity, elasticity, and dimensional stability. In contrast, Staphylococcus aureus exhibits comparatively moderate degradative potential through proteases and lipases. Conventional disinfection methods reduce planktonic bacterial load but are less effective against enzyme-producing biofilm communities. Emerging approaches, including antimicrobial and enzyme-resistant elastomers, offer promising strategies to mitigate both microbial contamination and biodegradation

KEYWORDS: *Dental impression materials; Staphylococcus aureus; Pseudomonas aeruginosa; Bacterial adhesion; Enzymatic degradation; Biofilm formation*

INTRODUCTION

Dental impressions play a fundamental role in prosthodontic practice by enabling the accurate reproduction of oral structures required for the fabrication of crowns, bridges, and removable or fixed dentures. Among the available materials, elastomeric impression materials such as addition silicone (polyvinyl siloxane), condensation silicone, and polyether are widely preferred because of their superior dimensional stability, elasticity, tear resistance, and precision in capturing fine anatomical details.[1] *Staphylococcus aureus* is frequently encountered as a commensal organism of the skin and oral cavity but is also associated with healthcare-related infections due to its strong ability to adhere to surfaces and form protective biofilms.[2,3]

Similarly, *Pseudomonas aeruginosa* is an opportunistic pathogen recognized for its intrinsic resistance to disinfectants and its capacity to establish persistent biofilms on moist biomaterial surfaces, thereby increasing contamination risks associated with impression materials.[4] Rubber-based elastomeric materials, including polyvinyl siloxane, condensation silicone, and polyether, are considered advantageous not only for their clinical accuracy but also for certain surface characteristics that may influence microbial adhesion, such as relative hydrophobicity and reduced micro-surface roughness, which help maintain surface integrity even after disinfection procedures compared with more hydrophilic impression alternatives. Nevertheless, existing research predominantly focuses on measuring contamination levels rather than exploring the underlying mechanisms of bacterial adhesion and affinity among different elastomeric materials.[6] Beyond serving as passive carriers of microbial contamination, rubber-based dental impression materials are increasingly recognized as substrates susceptible to active biodegradation by microorganisms. Following adhesion and biofilm establishment, certain bacteria are capable of secreting extracellular enzymes that initiate polymer breakdown through cleavage of molecular chains within elastomeric matrices. *Staphylococcus aureus* produces proteases and lipases that contribute to the degradation of organic components and surface conditioning layers, whereas *Pseudomonas aeruginosa* exhibits a more pronounced degradative potential through the production of elastase, a potent enzyme capable of disrupting elastomeric structures. This enzymatic activity may lead to alterations in surface topography, reduced elasticity, and compromised dimensional stability of impression materials.[7] Beyond surface adhesion, certain bacteria can actively degrade elastomeric materials through enzymatic activity, compromising both structural integrity and clinical performance.[8]

REVIEW OF LITERATURE

Studies have demonstrated that modifying impression materials with antimicrobial additives can significantly reduce bacterial colonization; for instance, Wangchuk et al. (2017)[9] reported that incorporation of silver nanoparticles into hydrocolloid impression

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materials resulted in nearly 95% reduction in *S. aureus* contamination, highlighting the potential of antimicrobial material engineering in infection control. The persistence of microbial contamination is further attributed to biofilm formation, as both *S. aureus* and *P. aeruginosa* exhibit complex biofilm architectures with unique rheological characteristics that enhance surface adhesion and resistance to chemical disinfectants, as discussed by Rogers et al. (2008)[10] and S. & F. (2009)[11]. Supporting these findings, Giammanco et al. (2009)[12] observed that biofilm-forming microorganisms on elastomeric impression materials demonstrated significant resistance to disinfection, particularly when biofilms were allowed to mature over time, thereby emphasizing the clinical importance of immediate post-removal disinfection to prevent biofilm stabilization. Advances in microbial detection techniques have also contributed to improved contamination monitoring, with Kim et al. (2022)[12] describing rapid identification of *S. aureus* and *P. aeruginosa* through flow cytometry using fluorescent antibody labeling, enabling early detection and timely infection control interventions. This bacterium is known for its strong adhesion capabilities, which facilitate biofilm formation on biomaterial surfaces. In a study on catheter surfaces, S. aureus showed significant adhesion, which is a precursor to biofilm development(Reid et al., 1994).This bacterium not only adheres to surfaces but also degrades rubber materials. It forms biofilms on rubber surfaces, leading to material disintegration over time(Linos et al).[8] Pseudomonas aeruginosa Demonstrates potent rubber-degrading properties, capable of mineralizing rubber polymers through enzymatic activity. This degradation is evidenced by the complete disintegration of rubber substrates over prolonged periods(Linos et al).[8] While specific studies on rubber-based dental materials are limited, the degradation of polymeric dental composites by oral biofilms is well-documented, suggesting similar vulnerabilities in rubber-based materials The degradation of dental materials by bacterial biofilms can lead to compromised marginal integrity and restoration failure(Zhang et al., 2017).[14]

Characteristics of Rubber-Based Impression Materials

Addition silicone (PVS) is predominantly hydrophobic, producing a smooth and non-wettable surface that limits bacterial attachment by reducing surface interactions with moisture and microorganisms; its low water sorption further enhances dimensional stability by preventing distortion caused by environmental humidity or saliva exposure.[13] The addition polymerization reaction of PVS occurs without the formation of volatile byproducts, allowing consistent reproduction of fine details even when delays occur before cast pouring.[14] In contrast, polyether impression material demonstrates hydrophilic properties, enabling excellent flow and accurate impression making in saliva-contaminated clinical conditions; however, its enhanced wettability and low contact angle facilitate increased microbial retention and adherence, potentially elevating contamination risk compared with hydrophobic materials.[15] Condensation silicone, while offering acceptable manipulation characteristics and initial accuracy, undergoes a setting reaction that releases alcohol as a byproduct, resulting in material shrinkage and alterations in surface microstructure over time; these dimensional changes may create microscopic irregularities capable of harboring bacteria and compromising both long-term accuracy and surface smoothness.[16]

Three-Stage Model of Bacterial Adhesion, Biofilm Formation, and Enzymatic Degradation of Rubber-Based Dental Impression Materials

Stage	Process	Key Mechanisms	Bacterial Behavior	Impact on Material
1. Initial Adhesion[17]	Reversible attachment to surface	Van der Waals forces, electrostatic interactions, hydrophobic bonding	*Staphylococcus aureus* shows rapid adhesion (especially to hydrophobic surfaces); *Pseudomonas aeruginosa* adheres better to hydrophilic surfaces	Minimal immediate damage; establishes colonization
2. Biofilm Formation[18]	Irreversible attachment and microcolony development	Extracellular polymeric substance (EPS) production, quorum sensing	Both organisms form structured biofilms; *P. aeruginosa* exhibits dense, resistant biofilm architecture	Increased resistance to disinfectants; persistent contamination
3. Enzymatic Degradation[19]	Active breakdown of material	Secretion of extracellular enzymes (elastase, proteases, lipases)	*P. aeruginosa* releases elastase causing polymer degradation; *S. aureus* produces proteases/lipases with moderate effect	Polymer chain cleavage, surface deterioration, reduced elasticity and dimensional stability

Enzymatic Activity of *Staphylococcus aureus*

Staphylococcus aureus exhibits a well-documented ability to colonize biomaterial surfaces through rapid adhesion and biofilm formation; however, its contribution to material degradation is comparatively moderate and primarily mediated by the secretion of extracellular enzymes such as proteases and lipases. These enzymes facilitate the breakdown of organic components present on material surfaces, including salivary pellicles and proteinaceous conditioning films, thereby enhancing bacterial survival and persistence.[20] Proteases produced by *S. aureus* can hydrolyze peptide bonds in adsorbed proteins, indirectly altering the surface chemistry of elastomeric materials and promoting further microbial colonization. Lipases, on the other hand, contribute to the degradation of lipid-containing substrates and may influence surface wettability and interfacial interactions. Despite these enzymatic capabilities, *S. aureus* lacks the potent elastolytic systems required for extensive degradation of synthetic rubber polymers, resulting in relatively limited direct impact on the structural integrity of elastomeric impression materials. Nevertheless, its enzymatic activity

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plays a supportive role in conditioning the surface for sustained biofilm formation, which can indirectly contribute to long-term material deterioration and increased susceptibility to colonization by more aggressive degradative organisms.[21]

Enzymatic Activity of *Pseudomonas aeruginosa*

Pseudomonas aeruginosa is widely recognized for its exceptional capacity to degrade biomaterials, attributed to its robust enzymatic arsenal and highly organized biofilm architecture. A key factor in its degradative potential is the production of elastase, a potent extracellular metalloprotease capable of cleaving elastin-like and polymeric structures within elastomeric materials.[22] This enzyme, along with other proteolytic and hydrolytic enzymes, enables *P. aeruginosa* to actively disrupt polymer chains, leading to progressive weakening of material integrity. In addition to enzymatic activity, the organism forms dense, structured biofilms regulated by quorum sensing mechanisms, which not only enhance adhesion but also create a microenvironment that facilitates sustained enzyme activity and protects bacterial communities from external stresses, including disinfectants. The combined effect of strong biofilm formation and continuous enzyme secretion allows *P. aeruginosa* to exhibit significantly higher degradation potential compared to *S. aureus*. Its well-established role in polymer and biomaterial degradation, particularly in moist environments, highlights its clinical relevance in compromising the durability and performance of rubber-based dental impression materials.[23]

Impact on Material Properties

The enzymatic activity of bacterial species, particularly within established biofilms, has a measurable and clinically significant impact on the physical and mechanical properties of rubber-based impression materials. Enzyme-mediated degradation leads to cleavage of polymer chains and disruption of the elastomeric matrix, resulting in increased surface roughness, which in turn promotes further microbial adhesion and biofilm accumulation. Concurrently, the breakdown of structural components reduces the elasticity of the material, impairing its ability to recover after deformation and compromising its functional resilience during clinical and laboratory procedures. Dimensional accuracy, a critical requirement for prosthodontic applications, is also adversely affected, as polymer degradation and surface alterations can lead to distortion, shrinkage, or loss of fine detail reproduction. Over time, these changes may significantly reduce the reliability of impressions, affecting the fit and precision of dental prostheses.[24,25]

CONCLUSION

While *Staphylococcus aureus* demonstrates rapid adhesion to rubber-based impression materials, *Pseudomonas aeruginosa* exhibits superior enzymatic degradation potential due to its elastolytic activity. This dual mechanism of adhesion followed by biochemical degradation highlights a critical risk not only for cross-infection but also for material deterioration, necessitating the development of enzyme-resistant and antimicrobial impression materials.

REFERENCES

1. *Gupta R, Brizuela M. Dental Impression Materials. [Updated 2023 Mar 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK574496/*
2. *Al Mortadi N, Al-Khatib A, Alzoubi KH, Khabour OF. Disinfection of dental impressions: knowledge and practice among dental technicians. Clin Cosmet Investig Dent. 2019 May 7;11:103-108. doi: 10.2147/CCIDE.S205144. PMID: 31191035; PMCID: PMC6511629.*
3. *Dr. Narendra Sathish, AWARENESS, KNOWLEDGE & PRACTICE OF DISINFECTION OF IMPRESSIONS, MODEL CASTS, BITE BLOCKS, TRIAL DENTURES AND DENTAL PROSTHESIS AMONG DENTAL PROFESSIONALS IN INDIA - A CROSS SECTIONAL DESCRIPTIVE STUDY, International Journal of Development Research Vol. 15, Issue, 04, pp. 68206-68215, April, 2025 https://doi.org/10.37118/ijdr.29432.04.2025*
4. *Tu Y, Ren H, He Y, Ying J, Chen Y. Interaction between microorganisms and dental material surfaces: general concepts and research progress. J Oral Microbiol. 2023 Apr 5;15(1):2196897. doi: 10.1080/20002297.2023.2196897. PMID: 37035450; PMCID: PMC10078137.*
5. *Masih A, Gandagule R R, Tiwari A, et al. (July 28, 2025) Evaluating the Influence of Spray and Immersion Disinfection on the Dimensional Accuracy of Impression Materials: A Comprehensive Review. Cureus 17(7): e88921. DOI 10.7759/cureus.88921*
6. *Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater. 1997 Jul;13(4):258-69. doi: 10.1016/s0109-5641(97)80038-3. PMID: 11696906.*
7. *Kumar L, Sen S, Agarwal D, Gupta M, Anwaar K, Jain S. Microbial adherence and surface roughness of denture base materials: An in vitro study. Bioinformation. 2025 May 31;21(5):1182-1190. doi: 10.6026/973206300211187. PMID: 40822816; PMCID: PMC12357699.*
8. *Linos, A., Reichelt, R., Keller, U., & Steinbuchel, A. (n.d.). A Gram-Negative Bacterium, Identified As Pseudomonas Aeruginosa AL98, is a Potent Degrader of Natural Rubber and Synthetic Cis-1, 4-Polyisoprene. https://doi.org/10.1016/s0378-1097(99)00583-2*
9. *Wangchuk, N. P., Nisalak, P., Thaweboon, B., Thawboon, S., & Sawaengkit, P. (2017). Antimicrobial Property of Hydrocolloid Impression Material Incorporated with Silver Nanoparticles Against Staphylococcus Aureus. 95, 01001. https://doi.org/10.1051/MATECCONF/20179501001*
10. *Rogers, S. S., van der Walle, C., & Waigh, T. A. (2008). Microrheology of bacterial biofilms In Vitro: staphylococcus aureus and pseudomonas aeruginosa. Langmuir, 24(23), 13549–13555. https://doi.org/10.1021/LA802442D*
11. *Weckbach, S., & Gebhard, F. (2009). Biofilmbildung von Staphylococcus aureus und Pseudomonas aeruginosa an mit Octenidin beladenen Knochenzement. https://doi.org/10.3205/09dkou345*

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12. *Giammanco, G. M., Melilli, D., Rallo, A., Pecorella, S., Mammina, C., & Pizzo, G. (2009). Resistance to disinfection of a polymicrobial association contaminating the surface of elastomeric dental impressions. New Microbiologica, 32(2), 167–172. https://www.ncbi.nlm.nih.gov/pubmed/19579694*
13. *Kim, J.-Y., Yun, H.-S., Yeom, C.-H., Kim, E.-J., Kim, W., Lee, C.-S., Kim, B.-G., & Jeong, H. J. (2022). Flow cytometry-based rapid detection of Staphylococcus aureus and Pseudomonas aeruginosa using fluorescent antibodies. RSC Advances, 12(53), 34660–34669. https://doi.org/10.1039/d2ra05694a*
14. *Zhang, N., Zhang, N., Yansong, M., Weir, M. D., Xu, H. H. K., Bai, Y., & Melo, M. A. S. (2017). Current Insights into the Modulation of Oral Bacterial Degradation of Dental Polymeric Restorative Materials. Materials, 10(5), 507. https://doi.org/10.3390/MA10050507*
15. *Mohammed, R. S., & Al-Mathkhury, H. J. F. (2023). The Ability of Staphylococcus aureus to Establish Biofilm on Acrylic, Plastic, and Metallic Denture Materials. Iraqi Journal of Science, 546–559. https://doi.org/10.24996/ijs.2023.64.2.5*
16. *Oliveira, I., Gomes, M. C. L., Gomes, L. C., Pereira, M. F. R., Soares, O. S. G. P., & Mergulhão, F. (2022). Performance of Graphene/Polydimethylsiloxane Surfaces against S. aureus and P. aeruginosa Single- and Dual-Species Biofilms. Nanomaterials, 12(3), 355. https://doi.org/10.3390/nano12030355*
17. *YU, Q., YIN, W., AI, Q., & ZHANG, W. (n.d.). Observation on Inhibitory Effect of Pyrolin Against Staphylococcus Aureus and Pseudomonas Aeruginosa. https://doi.org/10.3321/j.issn:1002-6630.2008.04.013*
18. *Peter, A., Ramesh, M., Bindiya, E. S., Bhat, S. G., & A. K. (2023). CuO/Ag hybrid nanomaterial coated hydrophilic natural rubber film with minimal bacterial adhesion and contact killing efficiency. Results in Engineering, 17, 100998. https://doi.org/10.1016/j.rineng.2023.100998*
19. *Kozmos M, Virant P, Rojko F, Abram A, Rudolf R, Raspor P, Zore A, Bohinc K. Bacterial Adhesion of Streptococcus mutans to Dental Material Surfaces. Molecules. 2021 Feb 21;26(4):1152. doi: 10.3390/molecules26041152. PMID: 33670043; PMCID: PMC7926644.*
20. *Bal, B. T., Yilmaz, H., Aydin, C., Yilmaz, C., & Al, F. D. (n.d.). Antibacterial and antifungal properties of polyether impression materials. https://doi.org/10.2334/josnusd.49.265*
21. *Wang, L., Wong, YC., Correira, J.M. et al. The accumulation and growth of Pseudomonas aeruginosa on surfaces is modulated by surface mechanics via cyclic-di-GMP signaling. npj Biofilms Microbiomes **9**, 78 (2023). https://doi.org/10.1038/s41522-023-00436-x*
22. *Yui S, Karia K, Ali S, Muzslay M, Wilson P. Thermal disinfection at suboptimal temperature of Pseudomonas aeruginosa biofilm on copper pipe and shower hose materials. J Hosp Infect. 2021 Nov;117:103-110. doi: 10.1016/j.jhin.2021.08.016. Epub 2021 Aug 21. PMID: 34428505.*
23. *Minkiewicz-Zochniak A, Jarzynka S, Iwańska A, Strom K, Iwańczyk B, Bartel M, Mazur M, Pietruczuk-Padzik A, Konieczna M, Augustynowicz-Kopeć E, Olędzka G. Biofilm Formation on Dental Implant Biomaterials by Staphylococcus aureus Strains Isolated from Patients with Cystic Fibrosis. Materials (Basel). 2021 Apr 17;14(8):2030. doi: 10.3390/ma14082030. PMID: 33920743; PMCID: PMC8073800.*
24. *Aziz, S.A.A.A., Mahmoud, R. & Mohamed, M.B.E.D. Control of biofilm-producing Pseudomonas aeruginosa isolated from dairy farm using Virokill silver nano-based disinfectant as an alternative approach. Sci Rep **12**, 9452 (2022). https://doi.org/10.1038/s41598-022-13619-x*
25. *Gholipour S, Nikaeen M, Mehdipour M, Mohammadi F, Rabbani D. Occurrence of chlorine-resistant Pseudomonas aeruginosa in hospital water systems: threat of waterborne infections for patients. Antimicrob Resist Infect Control. 2024 Sep 27;13(1):111. doi: 10.1186/s13756-024-01468-4. PMID: 39334230; PMCID: PMC11437889.*