IP Annals of Prosthodontics and Restorative Dentistry 2024;10(2):93–96

Content available at: https://www.ipinnovative.com/open-access-journals

IP Annals of Prosthodontics and Restorative Dentistry

Journal homepage: https://www.aprd.in/

Review Article

The synergy of ceramic dental biomaterials and CAD/CAM innovation

Onkar Arun Patil[1]*, Deborah Lalhmingmawii Pachuau[2], Supriya Sawant (Kolge)[1], Prajakta Ruikar[3], Swapnil Chopade[4], Prem Sagar Yekula[5]

[1] *Dept. of Conservative Dentistry and Endodontics, Nanded Rural Dental College and Research Center, Nanded, Maharashtra, India*
[2] *Dept. of Prosthodontics, Crown and Bridge, Teerthankar Mahaveer Dental College and Research Center, Moradabad, Uttar Pradesh, India*
[3] *General Dental Surgeon, Ichalkaranji Kolhapur, Maharashtra, India*
[4] *Dept. of Prosthodontics, Crown and Bridge, Tatyasaheb Kore Dental College and Research Center, New Pargaon, Kolhapur, Maharashtra, India*
[5] *Dept. of Prosthodontics and Implantology, Sibar Institute of Dental Sciences, Guntur, Andhra Pradesh, India*

A R T I C L E I N F O

Article history:
Received 15-03-2024
Accepted 16-04-2024
Available online 15-05-2024

Keywords:
Ceramic dental biomaterials
CAD/CAM technology
Hybrid Ceramics
Digital workflows

A B S T R A C T

Introduction: Restorative dentistry has undergone a revolutionary transformation with the integration of ceramic dental biomaterials and CAD/CAM technology. This review dissects the multifaceted implications of this synergy, characterized by precision, efficiency, and esthetic excellence.
Aim and Objective: This review aims to provide a comprehensive overview of the integration of ceramic dental biomaterials and CAD/CAM technology in restorative dentistry, exploring its evolution, implications, and future directions.
Advancements in ceramic dental biomaterials, including Zirconia, Lithium Disilicate, and Hybrid Ceramics, are explored in detail. The components and processes of CAD/CAM technology, such as intraoral scanners, CAD software, and CAM processes, are also examined.
Zirconia, Lithium Disilicate, and Hybrid Ceramics offer unique advantages in terms of strength, esthetics, and versatility. Intraoral scanners, CAD software, and CAM processes collaborate to elevate precision and efficiency in the creation of dental prosthetics.
Conclusion: The synergy between ceramic dental biomaterials and CAD/CAM innovation represents a paradigm shift in restorative dentistry, offering a new standard of precision, efficiency, and esthetic excellence. Despite challenges, ongoing research and technological advancements hold promise for further refinement and expansion of applications in the future.

1. Introduction

Restorative dentistry has undergone a revolutionary transformation with the integration of ceramic dental biomaterials and CAD/CAM technology. This dynamic duo has transcended the limitations of traditional methodologies, ushering in a new era characterized by precision, efficiency, and esthetic excellence. This review aims to dissect the multifaceted implications of this synergy, providing a comprehensive overview of its evolution and potential implications for the future.[1]

* *Corresponding author*.
E-mail address: onkarpatil1993@gmail.com (O. A. Patil).

https://doi.org/10.18231/j.aprd.2024.018

2. Advancements in Ceramic Dental Biomaterials: A Closer Look

The evolution of ceramic dental biomaterials has witnessed a paradigm shift, redefining the parameters of restorative dentistry and opening up a spectrum of possibilities for clinicians. Three prominent materials – Zirconia, Lithium Disilicate, and Hybrid Ceramics – stand out as transformative forces in this revolution.[2]

2.1. Zirconia:[3]

Zirconia, a crystalline oxide of zirconium, has emerged as a cornerstone in modern restorative dentistry. Renowned for its exceptional strength and biocompatibility, Zirconia has transcended the limitations of traditional materials. Its introduction marked a departure from conventional restorative approaches, offering clinicians a material capable of supporting thin, minimally invasive restorations without compromising durability.

Zirconia's mechanical properties make it an ideal choice for a range of dental procedures. Its high flexural strength and fracture resistance enable the creation of crowns, bridges, and implant abutments with reduced thickness, preserving a more natural tooth structure. Beyond its mechanical prowess, Zirconia's biocompatibility ensures minimal adverse reactions in the oral environment, making it a reliable choice for a diverse range of patients.

2.2. Lithium disilicate:[4]

Celebrated for its translucency and versatility, Lithium Disilicate has become a stalwart in modern restorative dentistry. Composed of lithium metasilicate and lithium dioxide, this glass ceramic material combines strength with optimal esthetics. Lithium Disilicate finds its niche in both anterior and posterior restorations, offering a harmonious balance between form and function.

One of the standout features of Lithium Disilicate is its ability to mimic the optical properties of natural teeth. Its translucency allows for the creation of restorations that seamlessly blend with the patient's dentition, providing a lifelike appearance. This makes it a preferred choice for veneers, inlays, onlays, and full-contour crowns in both cosmetic and functional dental reconstructions.

2.3. Hybrid ceramics:[5]

Hybrid ceramics represent the cutting edge of biomaterial innovation, amalgamating the strengths of diverse materials to provide a comprehensive solution. Combining ceramics, resins, and sometimes even glass fibers, these biomaterials offer a unique set of advantages. The versatility of hybrid ceramics allows clinicians to tailor treatments to the specific needs of each patient, striking an optimal balance between strength, esthetics, and longevity.

The hybrid nature of these materials enables a harmonious integration of properties. They often exhibit the strength and durability of ceramics, the flexibility and shock absorption of resins, and the reinforcement of glass fibers. This amalgamation allows for the creation of restorations that not only withstand the rigors of occlusal forces but also present a natural and esthetically pleasing appearance.

In practical terms, clinicians can leverage hybrid ceramics to address a wide range of clinical scenarios. From single crowns to complex multi-unit bridges, the adaptability of these biomaterials empowers clinicians with a versatile toolset to meet the diverse needs of their patients.

3. CAD/CAM Technology in Dentistry: A Revolution in Precision and Efficiency[6]

The integration of Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology into the field of dentistry has ushered in a transformative era, revolutionizing the traditional workflow of dental restorations. This section delves deeper into the components of CAD/CAM technology, exploring how intraoral scanners, CAD software, and Computer-Aided Manufacturing (CAM) processes collaborate to elevate precision and efficiency in the creation of dental prosthetics.

3.1. Intraoral scanners:[7,8]

Intraoral scanners represent a fundamental departure from the conventional method of creating impressions using trays and molding materials. These handheld devices utilize cutting-edge optical technology to capture highly accurate 3D representations of the oral environment. This not only eliminates the discomfort associated with traditional impression techniques but also significantly reduces the likelihood of errors in capturing the intricacies of dental anatomy.

The advantages of intraoral scanners extend beyond patient comfort. The real-time capture of digital impressions allows for immediate feedback, enabling clinicians to identify any areas that may need additional attention or refinement. The digital nature of these impressions also facilitates seamless communication between clinicians and dental laboratories, as files can be instantly transmitted without the need for physical molds.

3.2. CAD software:[9,10]

Once the digital data is obtained from the intraoral scanner, CAD software becomes the virtual canvas for precise design and customization. Clinicians can engage in meticulous virtual design, manipulating digital models with a level of precision and detail that was previously unattainable with traditional manual methods. This digital design phase allows for a high degree of customization, ensuring that restorations are tailored to meet the specific anatomical and esthetic needs of each patient.

The ability to visualize and manipulate digital models in three dimensions provides clinicians with a comprehensive understanding of the proposed restoration. This not only enhances treatment planning but also fosters a collaborative approach between clinicians and patients. Visualizing the anticipated outcome allows for informed decision-making and facilitates communication about the expected esthetic and functional results.

3.3. CAM processes: [11–13]

The CAM phase represents the culmination of the CAD/CAM workflow, involving the automated fabrication of restorations. This can be achieved through milling or 3D printing technologies. The precision and consistency offered by CAM processes surpass traditional manual methods, ensuring that the final restoration faithfully replicates the virtual design created in the CAD phase.

Automated milling machines carve out restorations from blocks of pre-selected ceramic materials, such as zirconia or lithium disilicate, with unparalleled accuracy. Alternatively, 3D printing technologies build up restorations layer by layer, offering a level of intricacy and detail that traditional casting methods may struggle to achieve. The use of CAM processes not only enhances precision but also streamlines the production timeline, reducing the overall turnaround time for dental restorations.

4. Synergy in Action: [14–16]

The true synergy between ceramic biomaterials and CAD/CAM innovation is exemplified in the amalgamation of digital precision and material characteristics. The clinician’s ability to manipulate the digital design in real time, considering the unique properties of the chosen ceramic biomaterial, ensures a level of control and predictability that was once elusive. The result is a harmonious blend of strength, function, and esthetics tailored to the individual needs of the patient.

Beyond the chairside benefits, the collaboration between clinicians and dental laboratories has been elevated to new heights. Digital communication facilitates a seamless exchange of information, enabling a more collaborative approach to treatment planning. This not only enhances the overall quality of restorations but also streamlines the workflow, reducing the time and resources traditionally associated with the fabrication process.

5. Challenges and Future Directions: [17–20]

While the synergy between ceramic biomaterials and CAD/CAM technology has undeniably revolutionized restorative dentistry, challenges persist. The initial learning curve associated with adopting digital workflows, the substantial upfront investment in technology, and the need for ongoing education present hurdles for widespread integration. However, as technological literacy increases and the cost of equipment gradually decreases, these challenges are likely to diminish.

Looking ahead, ongoing research is focused on refining existing biomaterials and expanding the scope of CAD/CAM applications. Advances in artificial intelligence hold the promise of further automating the design process, potentially reducing the dependence on manual intervention. As the field evolves, the integration of these technologies is anticipated to become more seamless, offering practitioners unprecedented capabilities and patients enhanced outcomes.

6. Conclusion

In conclusion, the synergy between ceramic dental biomaterials and CAD/CAM innovation represents a paradigm shift in restorative dentistry. This dynamic collaboration has transcended the boundaries of conventional approaches, offering a new standard of precision, efficiency, and esthetic excellence. As technology continues to advance and clinicians embrace these tools, the future holds exciting possibilities for further refining biomaterials, expanding applications, and ultimately, redefining the boundaries of what can be achieved in the realm of dental restorations. The journey from traditional methodologies to this digital frontier signifies not just a technological leap but a renaissance in the art and science of restorative dentistry.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. Li RWK, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: state of the art. *J Prosthodont Res*. 2014;58(4):208–16.
2. Mhadhbi M, Khlissa F, Bouzidi C. Recent Advances in Ceramic Materials for Dentistry. In: Mhadhbi M, editor. Advanced Ceramic Materials. IntechOpen; 2021. doi:10.5772/intechopen.96890.
3. Bona AD, Pecho OE, Alessandretti R. Zirconia as a Dental Biomaterial. *Materials (Basel)*. 2015;8(8):4978–91.
4. Zarone F, Mauro MD, Zarone F, Ausiello P, Ruggiero G, Sorrentino R, et al. Current status on lithium disilicate and zirconia: a narrative review. *BMC Oral Health*. 2019;19(1):134. doi:10.1186/s12903-019-0838-x.
5. Ahranjani RR, Kamboj N, Brojan M, Antonov M. Hybrid metal-ceramic biomaterials fabricated through powder bed fusion and powder metallurgy for improved impact resistance of craniofacial implants. *Materialia*. 2022;24:101465. doi:10.1016/j.mtla.2022.101465.
6. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. *Dent Clin North Am*. 2011;55(3):559–70.

7. Mangano F, Gandolfi A, Luongo G, Logozzo S. Intraoral scanners in dentistry: a review of the current literature. *BMC Oral Health*. 2017;17(1):149. doi:10.1186/s12903-017-0442-x.
8. Richert R, Goujat A, Venet L, Viguie G, Viennot S, Robinson P, et al. Intraoral Scanner Technologies: A Review to Make a Successful Impression. *J Healthc Eng*. 2017;p. 5605789. doi:10.1155/2017/8427595.
9. Erozan Ç, Ozan O. Evaluation of the Precision of Different Intraoral Scanner-Computer Aided Design (CAD) Software Combinations in Digital Dentistry. *Med Sci Monit*. 2020;26:6977629. doi:10.12659/MSM.918529.
10. Leggeri A, Carosi P, Mazzetti V, Arcuri C, Lorenzi C. Techniques to Improve the Accuracy of Intraoral Digital Impression in Complete Edentulous Arches: A Narrative Review. *Appl Sci*. 2023;13(12):7068. doi:10.3390/app13127068.
11. Aldahian N, Khan R, Mustafa M, Vohra F, Alrahlah A. Influence of Conventional, CAD-CAM, and 3D Printing Fabrication Techniques on the Marginal Integrity and Surface Roughness and Wear of Interim Crowns. *Appl Sci*. 2021;11(19):8964. doi:10.3390/app11198964.
12. Tian Y, Chen CX, Xu X, Wang J, Hou X, Li K, et al. A Review of 3D Printing in Dentistry: Technologies, Affecting Factors, and Applications. *Scanning Technol Dent Sci*. 2021;doi:10.1155/2021/9950131.
13. Marcel R, Hickel R, Keßler A. Accuracy of CAD/CAM-fabricated bite splints: milling vs 3D printing. *Clin Oral Investig*. 2020;24(12):4607–15.
14. Rexhepi I, Santilli M, Addario D, Tafuri G, Manciocchi G, Caputi E, et al. Clinical Applications and Mechanical Properties of CAD-CAM Materials in Restorative and Prosthetic Dentistry: A Systematic Review. *J Funct Biomater*. 2023;14(8):431. doi:10.3390/jfb14080431.
15. Singh PV, Reche A, Paul P, Agarwal S. Zirconia Facts and Perspectives for Biomaterials in Dental Implantology. *Cureus*. 2023;15(10):46828. doi:10.7759/cureus.46828.
16. Marchesi G, Piloni AC, Nicolin V, Turco G, Lenarda RD. Chairside CAD/CAM Materials: Current Trends of Clinical Uses. *Biology (Basel)*. 2021;10(11):8614873. doi:10.3390/biology10111170.
17. Sajjad A. Computer-assisted design/computer-assisted manufacturing systems: A revolution in restorative dentistry. *J Indian Prosthodont Soc*. 2016;16(1):96–9.
18. Prithviraj DR, Bhalla HK, Vashisht R, Sounderraj K, Prithvi S. Revolutionizing Restorative Dentistry: An Overview. *J Indian Prosthodont Soc*. 2014;14(4):333–43.
19. Suganna M, Kausher H, Ahmed ST, Alharbi HS, Alsubaie BFA, Ds A, et al. Contemporary Evidence of CAD-CAM in Dentistry: A Systematic Review. *Cureus*. 2022;14(11):e31687. doi:10.7759/cureus.31687.
20. Beuer F, Schweiger J, Edelhoff D. Digital dentistry: an overview of recent developments for CAD/CAM generated restorations. *Br Dent J*. 2008;204:505–11. doi:10.1038/sj.bdj.2008.292.

Author biography

Onkar Arun Patil, Senior Lecturer

Deborah Lalhmingmawii Pachuau, Senior Lecturer

Supriya Sawant (Kolge), Senior Lecturer

Prajakta Ruikar, General Dental Surgery

Swapnil Chopade, Reader

Prem Sagar Yekula, Reader

Cite this article: Patil OA, Pachuau DL, Sawant (Kolge) S, Ruikar P, Chopade S, Yekula PS. The synergy of ceramic dental biomaterials and CAD/CAM innovation. *IP Ann Prosthodont Restor Dent* 2024;10(2):93-96.