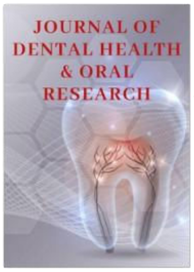

e-ISSN 3050-9432
Journal of Dental Health and Oral Research

ATHENAEUM SCIENTIFIC PUBLISHERS

Review Article

Check for updates

3D-Printed Permanent Restorations vs Milled Zirconia: A Review of Wear Resistance and Polish Retention: Contemporary Literature Review

Yorlem Loran Iglesias[1], Aury Bailon[2], Brenda L Gonzalez Herrera[3], Danae Alvarez Reyes[1], Carolin Santos de Sandoval[4], Guido Castro[5], Luisana Rodríguez[6*]

[1]University of Medical Sciences of Havana, Havana, Cuba
[2]School of Dentistry La Universidad del Zulia, Zulia, Venezuela
[3]University of Medical Sciences of Matanzas, Matanzas, Cuba
[4]School of Dentistry, Catholic and Technologic University of Cibao, La Vega, Dominican Republic
[5]Autonomous University of Manizales, Colombia
[6]Boston University, United States, DDS - Universidad de Carabobo, Venezuela

***Correspondence author:** Luisana Rodríguez, DMD - Boston University, United States, DDS - Universidad de Carabobo, Venezuela;
E-mail: lrodriguezc.29@gmail.com

Citation: Iglesias YL, et al. 3D-Printed Permanent Restorations vs Milled Zirconia: A Review of Wear Resistance and Polish Retention: Contemporary Literature Review. J Dental Health Oral Res. 2026;7(1):1-8.

https://doi.org/10.46889/JDHOR.2026.7130

Received Date: 22-03-2026
Accepted Date: 12-04-2026
Published Date: 19-04-2026

Abstract

The objective of this presentation is to evaluate a resistance and polish retention of 3D-printed and Milled Zirconia by an exhaustive analysis of a contemporary literature review. The information collected by different authors enables us to contrast 3D- printed permanent restoration and milled zirconia highlighting their advantages, limitations and implications for clinical practice. After analyzing both 3D printing and milled zirconia, each material carries meaningful implications for modern dentistry. 3D printing stands out for its cost efficiency and streamlined production, while milled zirconia continues to earn its place through exceptional durability and resistance to wear. Mechanically, the two materials are more comparable than one might expect, yet their real-world performance tells a different story, particularly when surface longevity is put to the test over time. For now, milled zirconia remains the more dependable choice for long-term restorations. That said, dismissing 3D printing would be shortsighted. The technology is evolving rapidly and closing the gap in surface properties and longevity is well within reach. When that happens, the benefits for both patients and dental practices, in terms of accessibility and cost, could decrease substantially.

Keywords: Milled; Zirconia; 3D; Printed; Restoration; Crowns; Biomaterials; Durability; Resistance

3D Printed and Zirconia Restoration in General Dentistry

Advances in 3D printing technology and improvements in print quality have driven the growing adoption of additive manufacturing in dentistry [1]. The primary categories of printable materials include polymers, metals and ceramics and ongoing material development has facilitated the integration of novel dental biomaterials into clinical workflows [2-4].

Growth of Digital Dentistry

3D printing supports a wide range of clinical and laboratory applications across various dental specialties (prosthodontics, implantology, oral and maxillofacial surgery, orthodontics, endodontics and periodontics) including custom prostheses and restorations, surgical guides, patient-specific implants and models, orthodontic appliances and other personalized devices that optimize digital workflows and improve treatment planning [2].

These capabilities have driven the adoption of additive manufacturing in dental practice and facilitated the integration of new biomaterials; however, to ensure safe and effective implementation, clinical interest must be complemented by long-term clinical studies and standardized evaluation protocols that validate performance and define best practices [2,4,6].

Increasing Use of 3D-Printed Permanent Restorations

Current 3D printing technologies include stereolithography, digital light processing, fused deposition modeling, selective laser sintering/fusion, photopolymer injection, powder-bed fusion and 3D laser bioprinting. The main categories of 3D printing materials are polymers, metals and ceramics. 3D printing technology is now capable of offering a wide variety of potential applications across different fields of dentistry [1]. Understanding the current spectrum of 3D printing applications in dentistry will help further expand its use in the dental field. The clinical use of 3D printing has led to versatile applications that streamline our digital workflow [5].

The first generation of 3D-printed CRCs offers customization advantages but is still in early development and exhibits lower mechanical strength and higher wear rates than CAD-CAM CRCs and traditional ceramics [5]. Additionally, the classification and definitions surrounding CRCs remain ambiguous, as ADA categorizations do not clearly differentiate CRCs from ceramics, complicating clinical indication, usage and billing practices [7].

Zirconia as the Current Gold Standard

Zirconia is widely used for crowns and bridges, as well as for fixed prostheses, implant abutments and endodontic posts, owing to properties such as high mechanical strength notably high compressive strength and good fracture toughness [9]. Regarding aesthetics, newer formulations with increased cubic/yttria content display enhanced translucency, enabling reproduction of the gingival-to-incisal color transition and more natural aesthetic outcomes [13].

Why Wear Resistance and Polish Retention Matter for Long-Term Success

The use of 3D-printed permanent restorations is increasing due to their practicality and lower cost. These techniques allow for improved fit and greater precision; however, there is still insufficient long-term clinical evidence on their mechanical performance, which depends on both the material and the printing technique used [5].

Wear resistance and polish retention are key determinants of the long-term success of permanent restorations [8]. Restorations that resist wear preserve occlusal form and vertical dimension, reduce wear of opposing teeth and maintain marginal integrity; likewise, durable polish reduces plaque accumulation, staining and soft-tissue irritation, while enhancing esthetics [8]. Therefore, clinical selection should prioritize materials and protocols with demonstrated wear and polish stability, employ minimally invasive surface conditioning that preserves structural strength and apply validated polishing regimens [9-11].

Restoration Materials and Clinical Understanding

Dental resins are popular dental materials used to repair caries, which have low compressive strength and therefore a higher risk of fracture. Over the years, various technologies have been developed to improve these materials, such as bulk-fill resins, which contain larger filler particles. However, two key challenges for long-term success remain: fracture and secondary caries [14]. Dental resins are materials composed of organic components (matrix), which allow the material to be manipulated and adapted easily to the tooth, inorganic components (filler), which provide strength, durability and reduced shrinkage, coupling agent that help bond the filler particles to the resin matrix, usually its silane and chemical elements that are incorporated to allow the material to harden when it is exposed to light [15].

Resin-based materials undergo continuous academic and industrial testing to improve their longevity. One of the greatest achievements has been the development of contemporary materials capable of replacing biological tissue while meeting the same standards of function and esthetics [14].

Most 3D printing materials are light-curable resin composites designed to solidify through Vat Photopolymerization (VPP). These resins usually contain ceramic or silica fillers that enhance hardness, wear resistance and color stability. Their main advantages are high precision, customization and reduced material waste, although their mechanical strength and long-term durability remain lower than those of fully ceramic systems [15,16].

In contrast, zirconia-based ceramics continue to serve as the gold standard biomaterials for definitive restorations. Yttria-stabilized Tetragonal Zirconia Polycrystal (Y-TZP) is recognized for its outstanding fracture resistance, chemical stability and excellent biocompatibility, qualities that make it ideal for crowns, bridges and implant abutments [16]. However, some technical limitations persist, such as shrinkage during sintering and the need to standardize printing and post-processing protocols [17].

Both 3D-printed hybrid resin-ceramic composites and milled zirconia ceramics are key materials in current dental biomaterials research. Resin composites stand out for their flexibility and integration into digital workflows, whereas zirconia remains the benchmark for strength, stability and long-term clinical reliability [4,20]. Combining both materials in hybrid and layered structures represent a promising direction for future restorative dentistry. Digital dentistry has introduced advanced manufacturing techniques for dental restorations, particularly subtractive manufacturing (milling) and additive manufacturing (3D printing) [18].

Milled CAD-CAM biomaterials are produced by cutting solid blocks into the desired restoration shape, which allows restorations with reliable dimensions and strong mechanical properties showing high hardness and durability making them suitable for indirect restoration [19]. In contrast, 3D printing builds restorations layer by layer using digital designs. This method reduces material waste and allows the fabrication of complex structures. However, printed materials may contain fewer inorganic fillers, which can influence their mechanical performance, although their hardness remains lower than that of milled materials [20].

Composition and Material Benefits

Modern hybrid resins for 3D printing (specifically for VPP processes like SLA or DLP) aim to capture the best of both worlds. They use a light-curable polymer base, which ensures the material is easy to print and flexible [20]. This matrix is reinforced with ceramic fillers like zirconia, silica or hydroxyapatite to boost stiffness and hardness. Essentially, this blend offers the mechanical strength of ceramics with the processing ease of polymers [18].

Performance and Similarity to Natural Teeth

The goal is to mimic the behavior of a real tooth as closely as possible. By fine-tuning the filler content and particle size, these materials achieve impressive stats: Strength: Flexural values between 150 and 230 MPa, Elasticity: A modulus of 8 to 12 GPa, Precision: Shrinkage during curing is less than 2%, ensuring a precise fit, lab tests also confirm these materials are biologically safe, showing high cell viability and no signs of toxicity [22].

Challenges and Long-Term Durability

After simulating use over time (thermomechanical aging), surface analysis via SEM showed: Formation of microcracks and loss of filler particles, Accumulation of debris and wear on the surface [21]. While we still need to improve how the ceramic fillers bond to the polymer to increase surface lifespan, these 3D-printed resins are currently a fantastic, aesthetic and sufficiently strong option for short-term pediatric restorations [22].

Wear Resistance: 3D printed hybrid vs Zirconia

The long-term success of dental restorations depends largely on the mechanical properties of the materials used, especially their ability to resist wear. In the oral environment, restorations are regularly exposed to occlusal forces during chewing and other parafunctional habits. Over time, these forces can lead to gradual surface deterioration and loss of material [23]. Excessive surface wear may change occlusal morphology, reduce chewing efficiency and affect the longevity of the restoration. For this reason, resistance to surface wear is an important factor when selecting restorative materials. Different restorative materials used in dentistry have been studied in relation to their mechanical behavior and performance under functional loading [24].

Recent laboratory studies have investigated the mechanical performance of restorative materials under controlled experimental conditions. In one investigation, researchers analyzed 3D-printed micro-filled hybrid resin crowns and prefabricated zirconia crowns using extracted teeth in a controlled experimental setting [25]. In another investigation, crowns fabricated from CAD-CAM zirconia and a 3D-printed nano-hybrid resin material were evaluated under laboratory conditions designed to simulate functional forces. These studies help researchers better understand how traditional ceramic materials and newer additively manufactured restorations behave under conditions that simulate the oral environment [26].

Laboratory studies have examined how well different restorative materials resist surface wear over time. Many of these investigations use chewing simulators to reproduce the repeated forces that occur during normal chewing. These simulators help researchers observe how restorative materials respond after repeated chewing cycles [26]. Overall, the available research shows a similar pattern. Zirconia generally shows very high resistance to surface wear and tends to maintain its structure even after extended simulated function. In contrast, 3D-printed hybrid materials often show moderate wear resistance [27]. Although these newer materials perform well in many situations, their surfaces tend to show more changes after repeated loading compared with zirconia. These findings suggest that different restorative materials may respond differently to long-term functional forces [28].

From a clinical perspective, these findings help explain which materials may perform better under daily chewing forces. Because zirconia shows very high resistance to surface wear, it is often considered a durable option for restorations exposed to significant functional loading. This becomes especially relevant in patients who generate higher occlusal forces, such as those with parafunctional habits like bruxism [28]. In these cases, restorations must tolerate repeated mechanical stress over time. Although 3D-printed hybrid materials offer advantages in manufacturing and design, their moderate wear resistance suggests that they may be more suitable for situations where functional loads are lower. Taken together, current evidence suggests that zirconia restorations generally show greater durability under chewing forces and are more likely to maintain their integrity over time [29].

Polish Retention Over the Time

Polish Retention-Surface Smoothness Over Time

The Brunauer-Emmett-Teller (BET) theory highlights the significance of surface smoothness in dental materials. Rougher surfaces tend to adsorb more discolorants, which can compromise the long-term esthetics of restorations [30]. Therefore, proper polishing is essential to maintain a natural appearance over time. In addition, smooth surfaces help reduce bacterial adhesion, as plaque accumulates more readily on rough areas, providing an environment where bacteria can thrive. Ensuring a polished, smooth surface not only improves esthetics but also contributes to the longevity and oral health performance of restorations [31,37].

Gloss Surface Maintenance

There are different restorative materials that can maintain their surface gloss for longer periods, which is essential for achieving optimal esthetic outcomes and proper color matching with adjacent teeth. One example is 3D-printed zirconia crowns, which have been shown to provide better esthetic color and contour matching than milled crowns [32]. However, discoloration of dental materials may still occur due to intrinsic and extrinsic factors. Surface smoothness plays an important role in limiting the adsorption of extrinsic staining agents such as coffee, tea and wine, helping to keep discoloration within acceptable limits [31].

Zirconia

It has been demonstrated that 3D-printed zirconia crowns are esthetically favorable due to their similarity to natural teeth compared with milled crowns [32]. Additionally, zirconia crowns show less influence from bur deterioration during milling compared with other materials such as feldspathic ceramic, which tends to present higher surface roughness [33]. Therefore, surface smoothness is a critical factor in restorative materials because rough surfaces can promote plaque accumulation and increase the transfer of allergenic compounds compared with natural tooth surfaces [34].

Printed Material

Studies have shown that 3D-printed interim restorations can become discolored after six months when exposed to artificial saliva and beverages such as tea, coffee and wine [37]. Among these drinks, red wine caused the greatest staining. However, when these restorations need to remain in the mouth for a longer time, applying a nano-filled light-polymerizing protective coating can help reduce discoloration, especially staining caused by coffee [35]. In addition, monolithic zirconia has shown excellent wear resistance and causes minimal abrasion to the opposing teeth [36].

Importance of Maintenance and Long-Term Appearance

Long-term aesthetics of restorative materials depend on their ability to maintain a color like natural teeth. Discoloration may occur when pigments from beverages such as coffee, tea and wine adsorb onto the material surface [35]. According to the

Brunauer-Emmett-Teller (BET) theory, this adsorption process increases with surface area. Therefore, smoother surfaces tend to exhibit less discoloration and remain within clinically acceptable limits [30].

Advantages and Disadvantages

Currently, a wide range of materials is available for definitive dental restoration. Among these, the two most used are Zirconia and 3D-printed restorations. The characteristic that makes this restoration one of the most useful for dental practice is that it enables the creation of high-precision, excellent-fit and high-quality restorations [38].

Advantages of 3D- Printed Restoration

3D printing restoration is an important tool in modern dentistry laboratories. These restorations are produced through ultimate manufacturing technology, layer by layer, according to the prosthetic dentistry designer. The characteristics of this restoration that make it one of the most useful for dental practice are that it allows the creation of a restoration with high precision and quality [39].

3D printing offers several advantages in clinical and laboratory settings, such as the fabrication of crowns, bridges, dentures and implant-supported restorations. The quality of this technology, which is ideal for patient rehabilitation, is high resolution, faster production, reduced material waste, a digital workflow and potentially lower cost for patients with limited economic resources. [38,39].

Disadvantages of 3D Restauration

Despite the advantages, the cost, need for technology training, equipment requirements and limited knowledge among dental professionals would affect the application of this technology in dental practice and in addressing patients' needs [40].

Advantages of Milled Zirconia

When we talk about strength or durability, Zirconia is a popular restorative material. Zirconia crowns have several properties that make them an excellent choice, such as high fracture resistance and a lower risk of fracture. It has a smooth, chemically stable surface that limits bacterial accumulation and is stain-resistant. This is ideal for children due to its long-term longevity [41].

Stain Resistant: Zirconia Crowns maintain color stability better than other materials. Has a dense structure and a smooth glaze, which reduces the susceptibility to color change from food and drinks [41].

Strength: Zirconia is achieved through precise tooth preparation with ideal adhesive cementation. Techniques such as sandblasting or texturing would improve bonding with ideal dental cement [42]. It has excellent tissue compatibility, integrating with gingival tissues and helping maintain soft tissue architecture [45].

Disadvantages of Milled Zirconia

Zirconia can be recycled; however, because of its material durability, several processes, such as heat treatment, mechanical milling and chemical processing, may be required, along with a specific technique [43].

Porosity Formation: Zirconia has high viscosity, which, during formation, may create pores and, consequently, lead to cracks or fractures. In addition, the porosity would reduce the accuracy and mechanical strength of the restoration [44]. In some cases, the manufacturing process may trigger a local inflammatory reaction [45].

Wear of Natural Dentition: Due to its rigid nature, the opposing tooth may be affected by wear. Because Zirconia is hard, it can cause wear on the opposing natural tooth. Experts have been analyzing this process because it may lead to a doubling of enamel loss in a short period [46-53].

Outlook and Clinician Conclusions

Our literature review aims to compare the wear resistance and polish retention of two prominent dental restoration methods: Milled zirconia and 3D-printed crowns. Milled zirconia currently dominates the market, accounting for over 65% of definitive restorations in the United States by 2026, according to market data. 3D-printed crowns, however, have gained considerable traction due to their cost-effectiveness and manufacturing advantages, such as reduced material waste. Numerous studies indicate that both methods yield crowns with comparable clinical characteristics in terms of hardness, density, wear resistance and mechanical stability. Nevertheless, certain distinctions warrant consideration when selecting the optimal option, particularly concerning occlusion type, function and the tooth's intraoral location. The internal structure significantly influences the material's long-term stability and its interaction with opposing dentition.

Milled zirconia crowns exhibit a denser microstructure and a smoother surface, which enhances polishing efficacy and minimizes plaque accumulation [49]. Final polishing is a critical factor in safeguarding the antagonist tooth's long-term integrity. Milled zirconia crowns, even after polish degradation, tend to maintain a more homogeneous surface and greater stability for up to five years.

3D-printed crowns demonstrate slightly lower surface stability, directly influenced by the printing orientation. Depending on whether the orientation is 0 degrees or 90 degrees, this can result in lower or higher final porosity, respectively. Consequently, 3D-printed crowns necessitate a specialized glaze. While this glaze can achieve results comparable to milled zirconia, its durability beyond two to three years has not been consistently demonstrated. Upon glaze loss, the resulting cracked and porous surface increases abrasion of the natural tooth and heightens susceptibility to staining.

Ultimately, the gold standard, the milled zirconia crown, offers a less abrasive surface, superior microhardness and enhanced final surface and long-term polishing retention. This significantly benefits the integrity of the antagonist tooth enamel and provides resistance to pigmentation. While 3D-printed crowns are establishing their presence in dentistry and offer comparable fracture resistance, they exhibit greater roughness prior to glazing and require optimization of surface properties before clinical application.

Although glazing and polishing can statistically reduce the differences between 3D-printed and milled zirconia crowns, studies recommend live clinical trials exceeding five years to confirm polishing stability, wear resistance and long-term clinical performance under actual intraoral conditions.

Conflict of Interest
The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Funding Statement
This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors.

Acknowledgement
None.

Data Availability Statement
Not applicable.

Ethical Statement
The project did not meet the definition of human subject research under the purview of the IRB according to federal regulations and therefore, was exempt.

Informed Consent Statement
Informed consent was taken for this study.

Authors’ Contributions
All authors contributed equally to this paper.

References

1. Alghauli M, Alqahtani AS, Alharthi AA, Almutairi FA, Alghamdi YA, Alzahrani FA. 3D-printed zirconia versus milled zirconia restorations: Wear resistance and surface properties. J Dent. 2024;144:104925.
2. Kihara H, Hatakeyama W, Takahashi H, Kondo T, Kurokawa H. Applications of additive manufacturing in dentistry: Current status and future perspectives. J Oral Sci. 2021;63(3):212-6.
3. Alqutaibi AY, Alnazzawi AA, Algabri RS. Revolution of 3D printing in dentistry: materials, applications and future perspectives. Molecules. 2022;27(5):1699.
4. Balhaddad AA, Garcia IM, Collares FM. 3D printing in restorative dentistry: A systematic review of materials, applications and clinical outcomes. Clin Oral Investig. 2023;27(6):2465-81.
5. Jeong M, Kim JH, Kim WC, Kim HY. Additive manufacturing for dental restorations: Current status and future directions. Dent J (Basel). 2023;12(1):1.
6. Tian Y, Chen C, Xu X, Wang J, Hou X. Accuracy of 3D-printed dental models: A systematic review. Scanning. 2021;2021:9950131.
7. Duarte S Jr, Phark JH. Ceramic resin-based materials: Classification, properties and clinical applications. J Esthet Restor Dent. 2025;37(1):257-76.
8. Blatz MB, Vonderheide M, Conejo J. The effect of material selection on the longevity of dental restorations. J Dent Res. 2018;97(2):132-9.
9. Alyami MH. The applications of 3D-printing technology in prosthodontics: A review of the current literature. Cureus. 2024;16(9):e68501.
10. Joteppa V, Ramesh S, Kumar S. Accuracy of 3D-printed models acquired from different types of intraoral scanners and 3D printers. J Pharm Bioallied Sci. 2024;16(Suppl 2):S1433-4.
11. Yahyazadehfar N. Mechanical performance and wear resistance of dental restorative materials. J Dent Res Dent Clin Dent Prospects. 2021;15(3):210-8.
12. Saini RS. Advances in biomaterials for dental restorations: clinical perspectives. Int Dent J. 2025;75(6):103899.
13. Elsayed MS, El-Kouedi AY, Shokry TE. Translucency and mechanical properties of zirconia-based restorations. BMC Oral Health. 2025;25(1):221.
14. Yazi W, Meifang Z, Zhu X. Functional fillers for dental resin composites. Acta Biomater. 2021;122:50-65.
15. Al-Ibrahim I. Five years of restorative resin-based composite advancements: A narrative review. BMC Oral Health. 2025;25:1061.
16. Timofticiuc IA. Biomaterials adapted to vat photopolymerization in 3D printing: Characteristics and medical applications. J Funct Biomater. 2024;15(1):7.
17. Temizci T, Bozoğulları HN. Effect of thermocycling on mechanical properties of CAD-CAM restorative materials produced by additive and subtractive techniques. BMC Oral Health. 2024;24(1):334.
18. Passent E. Color stability and surface roughness of provisional fixed partial dentures fabricated by different techniques. J Dent. 2023;104458.
19. Albrecht M. Comparative analysis of modern 3D-printed hybrid resin-ceramic materials for indirect restorations. Polymers. 2024;16(22):3161.
20. Park S. Strength and surface characteristics of 3D-printed resin crowns for the primary molars. Polymers. 2023;15(21):4241.
21. Morsy N. Surface roughness, wear and abrasiveness of printed and milled occlusal veneers after thermomechanical aging. J Prosthet Dent. 2024;132(5):984-7.
22. Song JS. Mechanical performance of 3D-printed and milled resins for pediatric provisional restorations. Sci Rep. 2025;15(1):38927.
23. Aldowish AF. Evaluation of mechanical behavior of dental restorative materials under occlusal forces. Cureus. 2024.
24. Abhay SS. Mechanical performance of polymer-based restorative materials: a review. Polymers (Basel). 2021.
25. Elnagar EIA. Comparison of 3D-printed and zirconia crowns in pediatric dentistry. Eur Arch Paediatr Dent. 2025.
26. Ghabchi B. *In-vitro* comparison of CAD-CAM zirconia and 3D-printed crowns under simulated function. J Prosthet Dent. 2025.
27. Sulaiman TA. Wear behavior of dental restorative materials under simulated mastication. J Esthet Restor Dent. 2024.
28. Chopra D. Comparative wear resistance of zirconia and resin-based materials. Dent Mater. 2024.
29. Miura S. Long-term performance of zirconia restorations under functional loading. Odontology. 2025.
30. Robinson J. Surface properties and discoloration of dental materials. Dent J (Basel). 2021.

31. Gawriołek M. Surface roughness and bacterial adhesion in dental biomaterials. J Funct Biomater. 2024;15(9):246.
32. Alghauli M. Esthetic and surface properties of zirconia crowns fabricated by different techniques. J Dent. 2024.
33. Hamad KQ. Surface roughness of ceramic restorations after milling. J Prosthodont. 2022;31(4):320-5.
34. Ramesh S. Surface characteristics and plaque accumulation of restorative materials. J Pharm Bioallied Sci. 2025;17(Suppl 1):S522-4.
35. Almejrad L. Discoloration of dental materials after exposure to beverages. J Prosthodont. 2021;30(8):704-10.
36. Fouda AM. Wear resistance of monolithic zirconia restorations. BMC Oral Health. 2022;22:537.
37. Raja SR. Color stability of interim restorations under staining conditions. J Pharm Bioallied Sci. 2025;17(Suppl 1):S522-4.
38. Kim MS. Digital manufacturing techniques in restorative dentistry. Appl Sci. 2022.
39. Abualsaud R. 3D printing applications in prosthetic dentistry. Dent J. 2022.
40. Loges K. Barriers and limitations of additive manufacturing in dentistry. Materials. 2022.
41. Alrassan AM. Clinical performance of zirconia crowns. Cureus. 2025.
42. Benalcázar-Jalkh EB. Bonding strategies for zirconia restorations. Materials. 2023.
43. Alqutaibi AY. Recycling and sustainability of zirconia biomaterials. BMC Oral Health. 2025.
44. Su G. Porosity and structural defects in zirconia materials. J Biol Eng. 2023.
45. Ionescu RN. Biocompatibility of dental restorative materials. Materials. 2022.
46. Mao Z. Wear of opposing dentition caused by zirconia restorations. J Dent. 2024.
47. Khan N. Digital dentistry trends and material selection for restorations. Dent J. 2022;9(3):104.
48. Ahmed A. Mechanical comparison of 3D-printed and milled restorative materials. Materials. 2025.
49. Mahmoud MS. Surface properties and polishing behavior of zirconia restorations. BMC Oral Health. 2025.
50. Pantea M. Surface treatment and polishing of dental biomaterials. J Funct Biomater. 2025.
51. Al-Hajji M. Effect of printing orientation on 3D-printed dental restorations. Appl Sci. 2026.
52. Tabatabaian F. Surface glazing and durability of dental restorations. J Periodontol. 2026.
53. Abid M. Long-term clinical performance of dental restorative materials. BMC Oral Health. 2025.

About the journal

ATHENAEUM SCIENTIFIC PUBLISHERS

Journal of Dental Health and Oral Research is an international, peer-reviewed, open-access journal published by Athenaeum Scientific Publishers. The journal publishes original research articles, case reports, editorials, reviews and commentaries relevant to its scope. It aims to disseminate high-quality scholarly work that contributes to research, clinical practice and academic knowledge in the field.

All submissions are evaluated through a structured peer-review process in accordance with established editorial and ethical standards. Manuscripts are submitted and processed through the journal's online submission system.

Manuscript submission: https://athenaeumpub.com/submit-manuscript/