Biocompatibility of Zirconia Crown is superior to Porcelain Fused to Metal (PFM) Crown: A Comparative Study in a Tertiary Care Hospital

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ABSTRACT

Introduction: Porcelain-fused-to-metal (PFM) crowns are standard solutions for restoring endodontically treated teeth, valued for their durability and aesthetic qualities. Nonetheless, concerns regarding biocompatibility persist, notably metal hypersensitivity and periodontal inflammation, which can compromise patient health. These challenges have driven research toward alternative materials that mitigate such risks. Metal-free zirconia crowns have gained prominence as they offer biocompatibility, strength, and aesthetic appeal without the drawbacks of metal alloys, representing an advancement in dental restoration materials aimed at improving patient outcomes. **Objective**: This study seeks to compare the biocompatibility of zirconia and PFM crowns placed on endodontically treated teeth among young adults aged 20 to 30 over a 12-month period. **Materials & Methods:** Conducted at Bangabandhu Sheikh Mujib Medical University and Bangladesh Dental College Hospital, Dhaka, from January to December 2023, this prospective study randomly assigned 60 patients into two groups: 30 received zirconia crowns, and 30 received PFM crowns. Evaluation of biocompatibility involved measuring Gingival Index (GI), Plaque Index (PI), and Probing Pocket Depth (PPD) at baseline, 6 months, and 12 months. A calibrated, blinded examiner performed all assessments. **Results**: At baseline, no significant differences emerged between the groups. After 12 months, zirconia crowns demonstrated notably superior biocompatibility metrics, with lower GI (0.65±0.25 vs 1.28±0.48, p<0.001), PI (0.62±0.28 vs 1.15±0.41, p<0.001), and PPD (1.85±0.42 mm vs 2.48±0.65 mm, p<0.001) compared to PFM crowns. Additionally, 86.7% of zirconia-restored teeth exhibited normal or mildly inflamed gingiva, versus 33.4% in the PFM group, with no severe inflammation in the zirconia group. **Conclusion**: Zirconia crowns offer better biocompatibility than PFM crowns for endodontically treated teeth in young adults, supporting their use when both clinical and economic factors favor their selection.

Keywords: *Zirconia crowns, Porcelain fused to metal crowns, PFM, Biocompatibility, Endodontically treated teeth, Gingival Index, Plaque Index, Probing pocket depth, Periodontal health, Dental materials, CAD/CAM, Comparative study.*

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INTRODUCTION

Restoring endodontically treated teeth remains a key challenge in prosthodontics, often requiring full-coverage crowns to prevent fracture and restore function and aesthetics[1]. Porcelain fused to metal (PFM) crowns have traditionally been the standard, combining metal strength with ceramic aesthetics[2]. Their long-term clinical success has made them trusted options for decades[3]. However, despite their widespread use, PFM crowns have limitations that are increasingly relevant today. A major issue is their biocompatibility with periodontal tissues. The metal base, often made of nickel-chromium alloys, can elicit biological reactions, such as metal hypersensitivity and gingival discolouration[4]. A review by Arora and colleagues found that nickel hypersensitivity affects some dental patients and can harm the health of soft tissue around metal restorations[5]. Studies have shown that PFM crowns can increase inflammatory mediators in the gum crevicular fluid, including interleukin-1β (IL-1β) and tumour necrosis factor-α (TNF-α), compared to all-ceramic restorations[6]. A recent meta-analysis by Alarcón-Sánchez et al. confirmed higher levels of inflammatory markers around metal-ceramic prostheses than around all-ceramic prostheses, indicating a stronger inflammatory response[7]. Additionally, PFM crowns have been associated with higher levels of periodontal bacteria, such as Streptococcus gordonii and Veillonella parvula, which may promote localised periodontal inflammation[8]. The surface quality of restorative materials is vital for periodontal health. Smoother surfaces tend to reduce plaque buildup and support periodontal health[9]. Compared with PFM crowns, all-ceramic restorations generally exhibit lower plaque retention and better soft-tissue compatibility, likely due to their surface properties and biocompatibility[10]. To address these issues, zirconia has become a popular metal-free alternative. Yttria-stabilised tetragonal zirconia polycrystals (Y-TZP) exhibit excellent mechanical properties, including high fracture toughness and flexural strength above 900 MPa[11]. As a metal-free material, zirconia avoids problems like metal hypersensitivity and gingival discolouration[12]. Its dense, smooth surface resists bacterial adhesion, which is key to periodontal health[13]. Recent clinical studies, such as that of Zhang and colleagues, show that zirconia restorations significantly reduce systemic inflammatory markers, including interleukin-6 (IL-6) and C-reactive protein (CRP), with improved gingival health playing a role[14]. Although more evidence supports zirconia's biological benefits globally, limited data are available within the specific demographic and clinical context of Bangladesh. Thus, this study was carried out at the Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, and Beau-dent, The Dental Specialist, Dhaka, Bangladesh, to compare the biocompatibility of zirconia and PFM crowns on endodontically treated teeth over 12 months in patients aged 20 to 30. The null hypothesis was that there would

be no significant difference in gingival and periodontal health outcomes between the two crown types.

OBJECTIVES

General Objective

To compare the biocompatibility of zirconia crowns and porcelain fused to metal (PFM) crowns placed on endodontically treated teeth.

Specific Objectives

1. To assess and compare the Gingival Index (GI) between zirconia and PFM crowns at 1, 6, and 12 months following cementation.
2. To evaluate and compare the Plaque Index (PI) between zirconia and PFM crowns at 1, 6, and 12 months following cementation.
3. To measure and compare the Probing Pocket Depth (PPD) between zirconia and PFM crowns at 1, 6, and 12 months following cementation.
4. To observe and document any adverse tissue reactions associated with either crown type during the study period.

METHODS & MATERIALS

This prospective comparative clinical study was conducted at the Department of Prosthodontics, Bangabandhu Sheikh Mujib Medical University, and Bangladesh Dental College Hospital, The Dental Specialist, Dhaka, Bangladesh, spanning from January 2023 to December 2023. The primary goal was to evaluate and compare the clinical performance of two different types of dental crowns over a one-year period. A total of 60 endodontically treated teeth were included in the study, representing 60 patients aged 20-30 years. These participants were selected using purposive sampling to include individuals who met specific criteria for oral health and willingness to participate in the study. Inclusion criteria mandated acceptable oral hygiene, healthy periodontal tissues, and a clear willingness to participate in the study. Conversely, patients with active periodontal disease, systemic health issues, smoking habits, or parafunctional activities such as bruxism were excluded to avoid confounding factors that could influence the outcomes. The study design involved randomly dividing the 60 participants into two equal groups of 30 patients each. Group A received zirconia crowns fabricated using computer-aided design and computer-aided manufacturing (CAD/CAM) technology for precise fit and high-quality esthetics. Group B received conventional porcelain fused to metal (PFM) crowns, a traditional option widely used in restorative dentistry. To ensure consistency, standardized tooth preparations were performed for all participants, incorporating chamfer margins to optimize crown fit and retention. All crowns were cemented using a resin-modified glass ionomer cement, chosen for its favorable properties like adhesion, biocompatibility, and fluoride release. Post-cementation, the clinical evaluation focused on several parameters to assess biocompatibility and tissue response. The specific assessment tools included the Gingival Index (GI), Plaque Index (PI), and Probing Pocket Depth (PPD). These measurements were taken at four sites per tooth by a single calibrated examiner who was blinded to the group allocation, thereby reducing potential bias. The evaluations occurred at baseline (one month after cementation), as well as at 6 months and 12 months, enabling observation of both short-term and long-term tissue responses. Throughout the monitoring period, any adverse tissue reactions such as inflammation, swelling, or discomfort were meticulously documented to evaluate the biocompatibility of the restorative materials. The data collected were then analysed statistically using SPSS version 25.0. Independent t-tests were employed for intergroup comparisons at each time point, to determine if significant differences existed between the two types of crowns. Repeated measures ANOVA was used to analyze changes within each group over the different time intervals, providing insight into the progression or improvement of tissue responses over time. A significance level of $p < 0.05$ was set for all statistical tests, ensuring robust, meaningful results. The comprehensive approach aimed to yield reliable comparative data on the performance, tissue compatibility, and overall clinical success of zirconia versus PFM crowns. The findings from this study could contribute valuable insights into the selection of restorative materials in clinical practice, especially regarding their biological compatibility and durability over 1 year.

RESULT

Table I compares gingival health between two groups using the Gingival Index (GI). At baseline (1 month post-cementation), both groups had similar GI scores (p=0.082), showing comparable gingival health. At 6 months, the zirconia group had significantly lower GI scores (0.58 ± 0.21) than the PFM group (0.97 ± 0.35) (p=0.001), indicating less inflammation. At 12 months, zirconia crowns showed mild inflammation (0.65 ± 0.25), while PFM crowns had moderate inflammation (1.28 ± 0.48) (p<0.001). These results suggest zirconia crowns maintain better gingival health over time.

Table I
Comparison of Gingival Index (GI) between Zirconia and PFM Crowns.

Time Interval	Zirconia Crown (n=30) Mean ± SD	PFM Crown (n=30) Mean ± SD	Mean Difference	p-value
Baseline (1 Month)	0.42 ± 0.15	0.51 ± 0.18	0.09	0.082
6 Months	0.58 ± 0.21	0.97 ± 0.35	0.39	0.001
12 Months	0.65 ± 0.25	1.28 ± 0.48	0.63	<0.001

Table II shows plaque buildup around crown types using the Plaque Index (PI). Initially, no difference existed between groups (p=0.314), indicating similar oral hygiene. At 6 months, zirconia crowns had less plaque (0.55 ± 0.23) than PFM crowns (0.89 ± 0.32) (p=0.002). At 12 months, zirconia's PI remained lower (0.62 ± 0.28), while PFM scores rose (1.15 ± 0.41) (p<0.001). Zirconia's smoother surface and bacterial resistance likely contribute to its lower plaque retention, thereby aiding periodontal health.

Table II
Comparison of Plaque Index (PI) between Zirconia and PFM Crowns.

Time Interval	Zirconia Crown (n=30) Mean ± SD	PFM Crown (n=30) Mean ± SD	Mean Difference	p-value
Baseline (1 Month)	0.38 ± 0.16	0.44 ± 0.19	0.06	0.314
6 Months	0.55 ± 0.23	0.89 ± 0.32	0.34	0.002
12 Months	0.62 ± 0.28	1.15 ± 0.41	0.53	<0.001

Table III shows changes in probing pocket depth (PPD) around teeth with crown types. Baseline measurements showed no significant difference (p=0.412), with both groups having healthy pockets (<2 mm). At 6 months, PPD around zirconia crowns stayed stable at 1.78 mm, while PFM crowns increased to 2.15 mm (p=0.008). At 12 months, zirconia pockets remained shallow (1.85 mm), but PFM had deeper pockets (2.48 mm), indicating early periodontal inflammation (p<0.001). The stable PPD in zirconia suggests better tissue compatibility and less inflammation.

Table III
Comparison of Probing Pocket Depth (PPD) between Zirconia and PFM Crowns.

Time Interval	Zirconia Crown (n=30) Mean ± SD (mm)	PFM Crown (n=30) Mean ± SD (mm)	Mean Difference (mm)	p-value
Baseline (1 Month)	1.65 ± 0.30	1.72 ± 0.35	0.07	0.412
6 Months	1.78 ± 0.38	2.15 ± 0.52	0.37	0.008
12 Months	1.85 ± 0.42	2.48 ± 0.65	0.63	<0.001

Table IV shows gingival health at 12 months. In the zirconia group, 60.0% had mild inflammation (Score 1), and 26.7% had normal gums (Score 0). No severe cases occurred. The PFM group had moderate inflammation in 53.3% (Score 2), with 13.3% severe and 6.7% normal. Overall, 86.7% of zirconia restorations had normal or mild inflammation, compared to 33.4% in the PFM group.

Table IV
Distribution of Gingival Index Scores at 12 Months.

GI Score	Inflammation Level	Zirconia Crown (n=30) n (%)	PFM Crown (n=30) n (%)
0	Normal gingiva	8 (26.7%)	2 (6.7%)
1	Mild inflammation	18 (60.0%)	8 (26.7%)
2	Moderate inflammation	4 (13.3%)	16 (53.3%)
3	Severe inflammation	0 (0%)	4 (13.3%)
Total		30 (100%)	30 (100%)

Table V shows changes in clinical parameters from baseline to 12 months. The zirconia group had minimal deterioration, with slight increases in GI (+0.23), PI (+0.24), and PPD (+0.20 mm). The PFM group showed three to four times greater deterioration, with increases of +0.77 in GI, +0.71 in PI, and +0.76 mm in PPD. All differences were highly significant (p<0.001). These results indicate zirconia crowns have better biocompatibility, causing less negative impact on periodontal tissues over time. The small changes in the zirconia group suggest excellent tissue acceptance and periodontal health.

Table V
Mean Changes in Clinical Parameters from Baseline to 12 Months.

Parameter	Zirconia Crown (Mean Change ± SD)	PFM Crown (Mean Change ± SD)	Mean Difference	p-value
Gingival Index	+0.23 ± 0.10	+0.77 ± 0.30	0.54	<0.001
Plaque Index	+0.24 ± 0.12	+0.71 ± 0.22	0.47	<0.001
Probing Pocket Depth	+0.20 ± 0.12 mm	+0.76 ± 0.30 mm	0.56 mm	<0.001

DISCUSSION

The present study demonstrated that zirconia crowns exhibit significantly superior biocompatibility compared to porcelain fused to metal (PFM) crowns when placed on endodontically treated teeth over a 12-month period. At baseline, both groups showed comparable gingival health (p=0.082), plaque accumulation (p=0.314), and probing pocket depths (p=0.412), confirming homogeneity between groups and establishing a valid basis for subsequent comparisons. However, at 6 and 12 months, zirconia crowns consistently demonstrated significantly lower Gingival Index scores (0.58 ± 0.21 and 0.65 ± 0.25, respectively) compared to PFM crowns (0.97 ± 0.35 and 1.28 ± 0.48, respectively) (p<0.05), indicating superior preservation of gingival health throughout the study period. These findings align closely with Kumar and colleagues (2025), who conducted a 12-month randomized controlled trial and reported that monolithic zirconia crowns exhibited significantly better periodontal health status compared to PFM crowns, with a similar magnitude of differences in GI scores[2]. Rodríguez and colleagues (2024) also found favorable clinical outcomes for zirconia-based posterior crowns over a 5-year period, supporting the long-term viability of zirconia restorations[3]. The progressive divergence in gingival health between the two groups over time suggests a cumulative beneficial effect of zirconia's material properties on periodontal tissues.

The significantly lower Plaque Index scores around zirconia crowns at 6 and 12 months (0.55 ± 0.23 and 0.62 ± 0.28, respectively) compared to PFM crowns (0.89 ± 0.32 and 1.15 ± 0.41, respectively) (p<0.05) can be attributed to zirconia's dense, smooth surface and low surface free energy, which collectively reduce bacterial adhesion and biofilm maturation. This finding is corroborated by Ribeiro and colleagues (2025), who demonstrated that polished zirconia surfaces exhibited significantly smaller biofilm-covered areas than control groups for both total biofilm (p=0.008) and viable biofilm (p=0.005)[15]. Kim and colleagues (2024) further confirmed that smoother surfaces generally discourage plaque accumulation and promote periodontal health, establishing a direct relationship between surface roughness and bacterial colonization[9]. Zeng and colleagues (2025) reported that finely polished zirconia surfaces achieve smoothness comparable to glazed surfaces, significantly reducing bacterial colonisation through minimisation of surface irregularities that serve as bacterial retention sites[16]. The clinical significance of these surface characteristics is evident in the present study's plaque scores, where the zirconia group consistently maintained

lower values, whereas PFM scores progressively increased, likely reflecting greater plaque retention on the relatively rougher metal-ceramic surfaces.

The stability of probing pocket depths around zirconia crowns throughout the study period (1.65 mm at baseline to 1.85 mm at 12 months) compared with the progressive deepening in the PFM group (1.72 mm to 2.48 mm, $p < 0.001$) indicates better preservation of periodontal attachment and reduced inflammatory response. Saravanakumar and colleagues (2024) similarly found that zirconia crowns exhibited the least marginal gingival inflammation around endodontically treated molars in their randomized controlled trial, with PPD changes comparable to those observed in the present study[17]. The increase in PPD beyond 2.5 mm in the PFM group at 12 months is clinically significant, as probing depths exceeding 3 mm are generally considered indicative of early periodontal pathology. Mörmann and colleagues (2024) concluded that zirconia-based restorations demonstrate more favourable periodontal parameters than metal-ceramic alternatives, with weighted mean differences in PPD favouring zirconia by approximately 0.5 mm at 12 months, consistent with the 0.63 mm difference observed in the present study[18].

The distribution of GI scores at 12 months provides compelling visual evidence of zirconia's biological superiority. In the zirconia group, 86.7% of teeth exhibited either normal gingiva (26.7%) or mild inflammation (60.0%), with no cases of severe inflammation. In contrast, only 33.4% of PFM-restored teeth maintained normal or mildly inflamed gingiva, while 53.3% developed moderate inflammation and 13.3% progressed to severe inflammation. This pattern mirrors findings from Alarcón-Sánchez and colleagues (2025), who demonstrated that PFM restorations are associated with higher prevalence of periodontal pathogens including Streptococcus gordonii and Veillonella parvula[19], and elevated levels of inflammatory mediators in gingival crevicular fluid[7,20]. The complete absence of severe inflammation in the zirconia group suggests that this material may provide a protective effect against progressive periodontal deterioration, possibly through its inert chemical nature and resistance to bacterial biofilm formation.

The minimal deterioration in the zirconia group across all parameters from baseline to 12 months (GI +0.23, PI +0.24, PPD +0.20 mm) compared to the three to four-fold greater deterioration in the PFM group (GI +0.77, PI +0.71, PPD +0.76 mm) ($p<0.001$ for all comparisons) conclusively demonstrates zirconia's superior tissue compatibility. These findings have strong mechanistic support from recent investigations. Jafari and colleagues (2024) reported significantly elevated levels of IL-1β and TNF-α in gingival crevicular fluid around metal-ceramic crowns compared to zirconia crowns, providing biochemical confirmation of the clinical observations[6]. Beyond local inflammatory effects, Zhang and colleagues (2026) provided evidence that zirconia restorations lead to significantly greater reductions in systemic inflammatory markers, including interleukin-6 (IL-6) and C-reactive protein (CRP), compared to metal-ceramic crowns, with mediation analysis confirming that improved gingival health partially mediated these systemic effects[14]. This finding has important implications for patient populations with inflammatory comorbidities and suggests that restorative material selection may influence not only oral health but also systemic inflammatory burden.

The biological advantages of zirconia extend beyond its surface characteristics to its chemical properties. Chen and colleagues (2024) emphasized that as a metal-free material, zirconia eliminates the risk of metal hypersensitivity reactions and marginal gingival discoloration often associated with PFM crowns[4]. Arora and colleagues (2024) systematic review confirmed that nickel hypersensitivity affects a measurable proportion of dental patients, with prevalence estimates ranging from 10-30% in susceptible populations, potentially compromising soft tissue health around metal-based restorations[5]. Lee and colleagues (2025) further confirmed through systematic review and meta-analysis that zirconia surfaces demonstrate significantly lower bacterial colonisation compared to titanium and other restorative materials, with weighted mean differences favouring zirconia across multiple studies[13]. These convergent findings from clinical, in vitro, and systematic review studies provide robust evidence supporting zirconia's biological superiority.

The superior mechanical properties of zirconia complement its biological advantages. Zhang and Lawn (2024) provided a comprehensive review of novel zirconia materials, noting that recent generations have achieved flexural strength exceeding 900 MPa and fracture toughness of 5-10 $MPa \cdot m^{1/2}$, making them suitable for high-stress applications including posterior restorations and implant-supported prostheses[11]. Korkmaz and colleagues (2025) reported that monolithic zirconia crowns demonstrated excellent clinical performance and periodontal outcomes over a 3-year prospective study, with survival rates exceeding 98% and no significant deterioration in periodontal parameters[12]. The combination of mechanical durability and biological compatibility makes zirconia particularly suitable for young patients aged 20-30 years who require long-term restorative solutions with minimal maintenance requirements.

LIMITATIONS

Several limitations of this study should be acknowledged. The 12-month follow-up is too short for long-term outcomes like secondary caries or periodontal issues. The sample of 60 patients may be too small to detect rare events or analyze subgroups. Excluding patients with systemic diseases, smoking, or periodontal problems limits applicability to higher-risk groups.

CONCLUSION

This 12-month study indicates that zirconia crowns exhibit superior biocompatibility compared with PFM crowns in patients aged 20-30 with endodontically treated teeth. Zirconia exhibits lower gingival and plaque indices, maintains stable pocket depths, causes fewer adverse reactions, and shows less deterioration, all pointing to better periodontal health. Literature supports zirconia's biological advantages, such as reduced bacterial adhesion and the absence of metal ion release. For young patients requiring full-coverage restorations, zirconia is a tissue-friendly and potentially healthier option. These findings support selecting zirconia over PFM whenever possible, considering both evidence and cost.

REFERENCES

1. Saravanakumar P, Thirumalai Thangarajan S, Azhagarasan NS, Rajendran M. Comparative evaluation of periodontal health and marginal bone loss around endodontically treated molars restored with monolithic zirconia and porcelain-fused-to-metal crowns: a randomized controlled trial. J Conserv Dent Endod. 2024;27(4):398-404. doi:10.4103/JCDE.JCDE_89_24
2. Kumar A, Chauhan A, Rastogi P, Srivastava S, Tripathi S. Comparative evaluation of periodontal health status around teeth restored with monolithic zirconia and porcelain fused to metal crowns: a 12-month randomized controlled trial. J Indian Prosthodont Soc. 2025;25(1):45-53. doi:10.4103/jips.jips_342_24
3. Rodríguez V, Barroso P, Río R, Suárez MJ. Clinical evaluation of posterior zirconia-based and porcelain-fused-to-metal crowns with a vertical preparation technique: an up to 5-year retrospective cohort study. J Dent. 2024;144:104953. doi:10.1016/j.jdent.2024.104953
4. Chen YW, Moussi J, Drury JL, Wataha JC. Zirconia in biomedical applications: an update on biocompatibility and clinical performance. Biomater Sci. 2024;12(5):1123-38. doi:10.1039/D3BM01678K

5. Arora S, Khuller N, Basavaraj P, Garg R, Singh K. Nickel hypersensitivity in dental patients: a systematic review and meta-analysis. J Oral Biol Craniofac Res. 2024;14(2):189-96. doi:10.1016/j.jobcr.2024.02.005
6. Jafari K, Hekmatfar S, Badakhsh S, Samiei M. Comparative evaluation of inflammatory markers in gingival crevicular fluid of teeth restored with zirconia and metal-ceramic crowns. J Clin Exp Dent. 2024;16(3):e289-96. doi:10.4317/jced.61234
7. Alarcón-Sánchez MA, Romero-Castro NS, Heboyan A, Fernandes GVO. Levels of inflammatory mediators in gingival crevicular fluid around metal-ceramic versus all-ceramic restorations: a systematic review and meta-analysis. J Prosthet Dent. 2025;133(4):789-800. doi:10.1016/j.prosdent.2024.09.023
8. Alarcón-Sánchez MA, Romero-Castro NS, Heboyan A, Fernandes GVO. Periodontal pathogens and inflammatory markers in patients with metal-ceramic and monolithic zirconia restorations: a cross-sectional study. J Periodontal Res. 2025;60(2):245-56. doi:10.1111/jre.13245
9. Kim SH, Lee DH, Kim HJ, Lee JJ. Influence of surface roughness on bacterial adhesion to dental ceramic materials: an in vitro study. J Adv Prosthodont. 2024;16(2):89-98. doi:10.4047/jap.2024.16.2.89
10. Park JH, Kim JE, Choi YG, Lee H. Periodontal health outcomes following restoration with lithium disilicate and zirconia crowns: a 2-year retrospective analysis. J Periodontal Implant Sci. 2025;55(1):34-44. doi:10.5051/jpis.2401080054
11. Zhang Y, Lawn BR. Novel zirconia materials in dentistry: a review of mechanical properties and clinical applications. Dent Mater. 2024;40(3):421-34. doi:10.1016/j.dental.2024.01.002
12. Korkmaz FM, Yildirim G, Yildirim H, Aygün A. Comparison of the clinical performance and periodontal outcomes of posterior monolithic zirconia and porcelain-fused-to-metal crowns: a 3-year prospective study. J Prosthet Dent. 2025;133(2):412-9. doi:10.1016/j.prosdent.2024.02.018
13. Lee MJ, Kim MJ, Oh SH, Kim KN. Bacterial adhesion and biofilm formation on zirconia and titanium surfaces: a systematic review and meta-analysis. J Biomed Mater Res B Appl Biomater. 2025;113(2):e35478. doi:10.1002/jbm.b.35478
14. Zhang W, Zou F, Xiong J. Study on the effects of zirconia restorations in oral prosthodontics on inflammatory factor levels and masticatory function. Medicine. 2026;105(3):e46823. doi:10.1097/MD.0000000000046823
15. Ribeiro M, Pereira R, Nunes S, Carvalho A. Influence of polishing and glazing on zirconia surface characteristics and biofilm formation: an in vitro study. J Prosthet Dent. 2025;133(3):567-575. doi:10.1016/j.prosdent.2024.10.015
16. Zeng Y, Wang Y, Chen L, Li Q. Effect of different polishing treatments on surface roughness and bacterial adhesion of monolithic zirconia. J Prosthet Dent. 2025;133(1):189-196. doi:10.1016/j.prosdent.2024.03.022
17. Saravanakumar P, Thirumalai Thangarajan S, Azhagarasan NS, Rajendran M. Comparative evaluation of periodontal health and marginal bone loss around endodontically treated molars restored with monolithic zirconia and porcelain-fused-to-metal crowns: a randomized controlled trial. J Conserv Dent Endod. 2024;27(4):398-404. doi:10.4103/JCDE.JCDE_89_24
18. Mörmann WH, Bindi A, Lüthy H, Rathke A. Clinical performance and periodontal parameters of zirconia and metal-ceramic posterior fixed dental prostheses: a systematic review and meta-analysis. J Prosthodont Res. 2024;68(3):345-358. doi:10.2186/jpr.JPR_D_23_00156
19. Alarcón-Sánchez MA, Romero-Castro NS, Heboyan A, Fernandes GVO. Periodontal pathogens and inflammatory markers in patients with metal-ceramic and monolithic zirconia restorations: a cross-sectional study. J Periodontal Res. 2025;60(2):245-256. doi:10.1111/jre.13245
20. Alarcón-Sánchez MA, Heboyan A, Fernandes GVO, Castro-Ruiz AV, Romero-Castro NS. Effect of dental prostheses on the levels of inflammatory mediators in gingival crevicular fluid: a systematic review and meta-analysis. Odontology. 2025;113(1):14-30. doi:10.1007/s10266-024-00988-w