

Jurnal Kesehatan Gigi

p-ISSN: [2407-0866](#)e-ISSN: [2621-3664](#)<http://ejournal.poltekkes-smg.ac.id/ojs/index.php/jkg/index>

An Integrated Design Approach for Complex Fixed Dental Prosthesis

Budiono¹, Murti Indrastuti², Sri Budi Barunawati³, Titik Ismiyati⁴

¹ Resident, Prosthodontics Specialist Dental Education Program, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

² Lecturer, Department of Prosthodontics, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

³ Lecturer, Department of Prosthodontics, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

⁴ Lecturer, Department of Prosthodontics, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

Corresponding author: Murti Indrastuti

Email: murtident@ugm.ac.id

Received: November 27, 2025; Revised: March 27, 2026; Accepted: June 19, 2026

ABSTRACT

Replacing two adjacent anterior teeth, especially canines, poses significant biomechanical and esthetic challenges. The canine region plays a critical role in occlusal guidance and receives substantial lateral forces, making the design of fixed dental prostheses (FDPs) in this area inherently complex. Anterior esthetic demands, occlusal function, and connector integrity must be carefully integrated into the prosthetic plan. This case report aims to demonstrate an integrated prosthodontic design approach for a complex five-unit zirconia FDP replacing maxillary teeth 22 and 23, focusing on biomechanical stability, esthetic proportion, and material selection. A 39-year-old female presented with missing teeth 22 and 23. A five-unit FDP with two pontics and three abutments (teeth 11, 21, and 24) was planned using monolithic 4Y-TZP zirconia. The abutment selection followed Ante's Law, and the connector was designed with an oval cross-sectional area of 13 mm² to accommodate increased functional stress. A modified ridge-lap pontic was selected for esthetics and hygiene access. Surface treatment before cementation included airborne particle abrasion, cleaning with NaOH-based agent, and application of 10-MDP primer prior to dual-cure resin cementation. At the one-week follow-up showed excellent soft tissue response, stable occlusion, and high patient satisfaction. Restoration of adjacent canines using 4Y-TZP zirconia FDP demands precise design strategies. This case illustrates how an integrated approach ensures biomechanical reliability, esthetic outcome, and long-term success in complex anterior prosthetic rehabilitation.

Keyword: Complex Fixed; Dental Prosthesis; Canine Replacement; 4Y-TZP Zirconia; Connector Design

Introduction

The selection of prosthetic tooth replacement for the loss of the maxillary canine teeth, such as in cases of edentulous teeth 22 and 23, requires careful treatment planning. The canine plays an important biomechanical role in the stomatognathic system because its position lies outside the inter-abutment axis, resulting in greater lateral forces, particularly in the labial direction. These forces generate additional loading on the prosthesis, thereby categorizing restoration in this region as a complex case [1].

There are two treatment options for replacing maxillary canine teeth, including implant-supported

prostheses and tooth-supported fixed prostheses [2]. Implant-supported prostheses are considered the best option for replacing missing teeth when the adjacent teeth are caries-free. However, due to the complexity of the surgical procedures, high treatment costs, and fear of surgery, many patients prefer tooth-supported fixed prostheses [3].

Ceramic materials are increasingly used for dental prostheses due to their excellent aesthetic properties that closely resemble natural teeth. However, there are two major challenges that hinder their broader application, namely brittleness and processing complexity. Zirconia and lithium disilicate exhibit high compressive strength, but their brittle nature increases the risk of fracture

during clinical use. According to Almohammed et al. (2023), monolithic zirconia possesses superior mechanical properties compared to other ceramics, yet its susceptibility to fracture remains a concern [4]. Muhetaer et al. (2024) reported that despite advancements in improving fracture resistance, achieving an optimal balance between mechanical strength and optical properties continues to be a challenge [5].

Monolithic zirconia, specifically yttria-stabilized tetragonal zirconia polycrystalline (3Y-TZP) containing approximately 3 mol% yttria, is commonly used for posterior restorations due to its high strength, although its aesthetic properties remain limited (Maharishi et al., 2024). Increasing the yttria content to 4 mol% (4Y) and 5 mol% (5Y) enhances translucency because of the increased cubic-phase fraction; however, this improvement leads to reduced fracture toughness and flexural strength [6]. A newer class of zirconia materials, often referred to as hybrid or multilayer zirconia with graded strength, was introduced in the 2020s. The outer layer contains a higher yttria concentration (5Y mol%) to maximize translucency, while the inner layer, which is subjected to the highest tensile forces during clinical function, contains a lower concentration (3Y mol%) to optimize strength [7]. This material exhibits gradation in both strength and color, allowing monolithic restorations to be used more broadly for both anterior and posterior applications [8].

The success of fixed dental prosthesis treatment is strongly influenced by the design [9], material selection and clinical procedures, including case indications, abutment preparation [10], temporary restoration, try-in procedures, surface treatment [11] and cementation protocols [12]. This case report aims to analyze the structural aspects of a fixed dental prosthesis for the replacement of the maxillary left canine and lateral incisor using hybrid monolithic zirconia (HMZ)

Case Report

A patient presented to the Prosthodontics Specialist Clinic at RSGM Prof. Soedomo seeking replacement of a permanent anterior maxillary fixed dental prosthesis due to discomfort. Intraoral examination revealed an acrylic fixed partial denture involving teeth 21, 22, 23, and 24, which exhibited wear, discoloration, and partial debonding. Tooth 11 displayed discolored composite restoration following endodontic treatment with a metal post, and tooth 36 was edentulous.

The patient demonstrated a Class I Angle malocclusion on the right side with distolabial rotation (torsion) of the canine, anterior mandibular crowding, and mesial drifting (tilting) of tooth 37. The measured overjet was 2 mm and overbite 1.5 mm, with an edentulous space width of 13 mm. Gingival tissue surrounding the involved teeth showed signs of inflammation, with gingival recession of 2 mm on tooth 24 and 3 mm on tooth 25, and the patient presented with good oral hygiene (Figure 1).

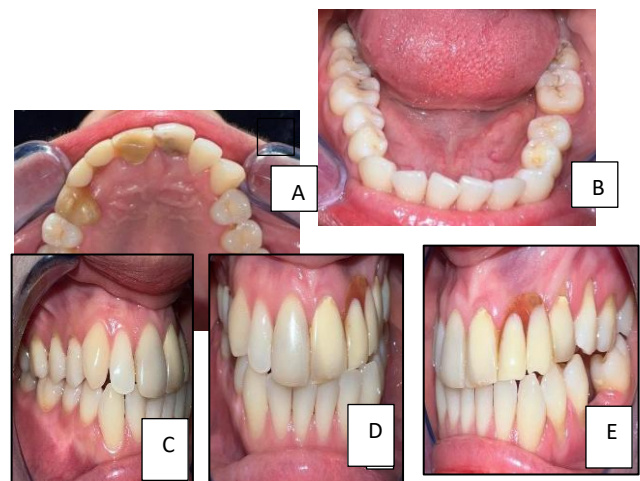


Figure 1 Intraoral photographs of the patient, showing the maxillary occlusal view (A), mandibular occlusal view (B), right lateral view (C), frontal view (D), and left lateral view (E)

Extraoral evaluation revealed an oval and symmetrical facial form with a convex profile. A mandibular midline deviation of 2 mm to the left relative to the maxillary midline (normal reference) was observed. The patient exhibited a complex smile type (Type IV), with a medium smile line and normal smile width, in which 57% of the display extended to the second premolars and 20% to the first molars (Figure 2)

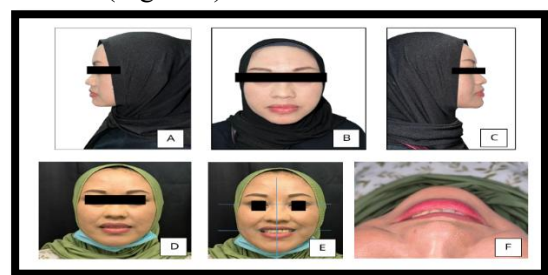


Figure 2. Extraoral photographs of the patient, including left profile view (A), frontal view (B), right profile view (C), resting position (D), full smile (E), and 12 o'clock position (F)

Radiographic examination demonstrated well-maintained alveolar bone condition, an adequate root-to-crown ratio of the abutment teeth,

and satisfactory status of teeth that had undergone root canal treatment and post placement (Figure 3)



Figure 3. Panoramic radiographic examination of the patient

The radiographic findings demonstrated good alveolar bone condition, an adequate root-to-crown ratio of the abutment teeth, and satisfactory status of the teeth that had undergone endodontic treatment and post placement. The diagnosis of this case is partial edentulism involving teeth 22, 23, and 36 with Kennedy Class III classification in both the maxillary and mandibular arches. The treatment plan includes a fixed-fixed bridge prosthesis; abutment teeth 11, 21, and 24; full coverage crown retainers (Figure 4A); modified ridge-lap pontics for teeth 22 and 23; a trapezoidal connector design with a cross-sectional area of 13 mm²; and monolithic hybrid zirconia (MHZ) material (Figure 4B).

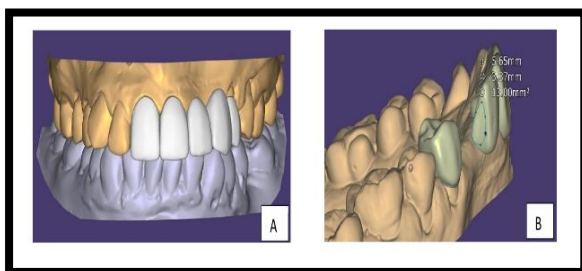


Figure 4. Design of the fixed dental prosthesis on teeth 11, 21, 22, 23, and 24 (A), and connector design and cross-sectional area (B) Results and Discussion

Procedure

Initial treatment consisted of scaling of both the maxillary and mandibular arches. A study model impression was taken using irreversible hydrocolloid with a perforated stock tray no. 2 to fabricate a 3D mock-up and putty index for the preparation guide (Figure 5C) and the fabrication of a GTC provisional restoration.

At the following appointment, tooth preparation was performed on the abutment teeth 11, 21, and 24 with a reduction depth of 1 mm at the cervical area, 1.2 mm at the labial/buccal surface, 2

mm at the incisal/occlusal surface, 1.2 mm at the palatal surface, and 1 mm at the proximal surface, with a convergence angle of 10°. The finishing line was a radial shoulder design, placed parallel to the gingival margin (Figure 5A and 5B).

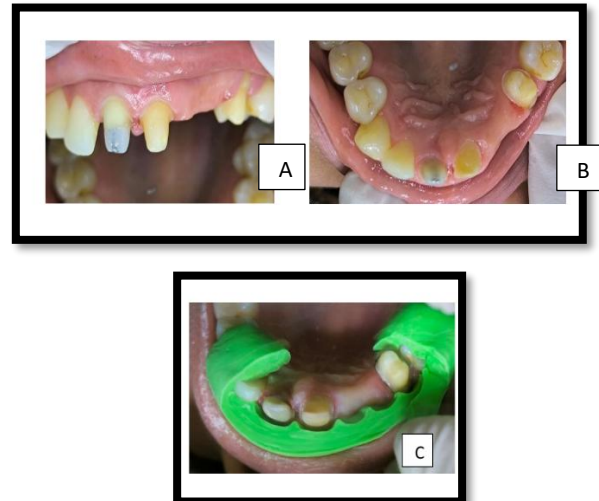


Figure 5. Preparation of the abutment teeth viewed from the labial/buccal surface (A), palatal surface (B), and preparation using a putty index preparation guide (C).

A working impression was taken using a two-step mucocompressive technique with polyvinyl siloxane impression material (putty and light-body) (Figure 6A), followed by fabrication and placement of a GTC provisional restoration using bis-acrylic composite and cemented with zinc oxide non-eugenol (freegenol) temporary cement (Figure 6B).

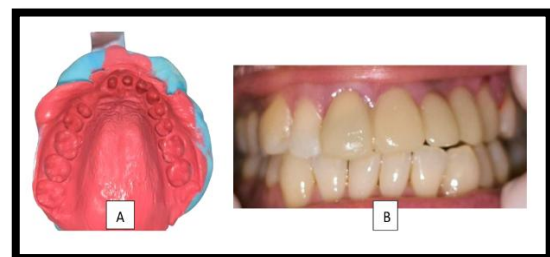


Figure 6. Mucocompressive impression technique (A), placement of bis-acrylic composite provisional fixed partial denture (B)

The insertion and cementation process of the zirconia fixed dental prosthesis (FDP) began with surface treatment of the internal surface of the crowns. The fitting surface was sandblasted with 30–50 µm aluminum oxide particles at 2 bar (≈30 psi) pressure to increase micromechanical roughness. After the try-in stage, the internal surface of the prosthesis was decontaminated from salivary phosphate using Ivoclean, then dried and coated with a zirconia primer (Monobond).

The abutment teeth were mechanically cleaned using pumice to remove remnants of the temporary zinc oxide non-eugenol-based cement. Cementation was performed using dual-cure resin cement (3M™ RelyX™ Universal). The cement was applied evenly on the internal surface of the crowns, and the prosthesis was inserted slowly with light pressure. After proper positioning, tack curing was performed for 2–3 seconds to facilitate removal of excess cement, followed by final curing for 20 seconds or allowed to fully polymerize for approximately 6 minutes (Figure 7).

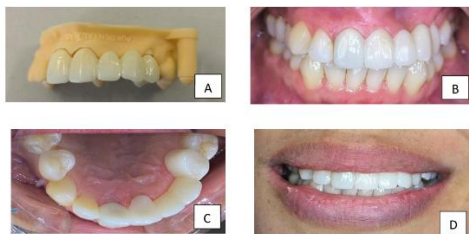


Figure 7. Hybrid monolithic zirconia FDP (A), FDP after insertion viewed from the labial aspect (B), FDP after insertion viewed from the palatal aspect (C), and ZMH FDP after insertion viewed from the labial aspect during smiling (D).

A follow-up appointment was conducted one week after insertion. The patient reported no discomfort during the first week of use. The gingival condition appeared healthy with no signs of inflammation (Figure 8).



Figure 8. Clinical condition of the ZMH fixed dental prosthesis at one-week follow-up, viewed from the labial aspect (A) and the palatal aspect (B).

Discussion

The design of a fixed dental prosthesis (FDP) for replacing the maxillary canine requires meticulous planning. This prosthesis experiences greater functional load because the canine is positioned outside the inter-abutment axis, thereby receiving laterally transmitted forces directed labially on the maxillary arch. These forces oppose the internal part of the dental arch, which is considered the weakest point; therefore, this type of prosthesis is categorized as a complex case [1]. The selection of teeth 11, 21, and 24 as abutments follows Ante's Law, stating that the periodontal

surface area of the abutment teeth must be equal to or greater than that of the teeth being replaced. Additionally, the crown-to-root ratio $\geq 1:1$ in these abutment teeth confirms their adequacy for supporting the prosthesis [13].

Zirconia was selected as the material for the FDP due to its superior load-bearing capacity compared to other ceramic materials, which is expected to prevent fracture of the pontic and connector. Zirconia is chemically and dimensionally stable, making it highly suitable for long-term restorations without structural alteration or significant degradation [14]. Monolithic yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP) containing approximately 3 mol.% yttria is commonly used for posterior restorations due to its high strength, although its esthetic properties are limited [15]. Increasing yttria concentration to 4 mol.% (4Y) and 5 mol.% (5Y) enhances translucency due to a higher cubic-phase fraction, but this compromises fracture toughness and flexural strength [16].

A new zirconia system known as monolithic multilayer zirconia with graded mechanical strength was introduced in the 2020s. The outer layer contains 5 mol.% yttria to maximize translucency, while the inner layer exposed to tensile forces contains 3 mol.% yttria to enhance strength [7]. This material exhibits both strength and color gradients, allowing broader use of monolithic restorations for both anterior and posterior teeth [15].

In this case, 4Y-TZP zirconia was selected as a combination of optimal esthetics and mechanical performance for a five-unit bridge with two pontics (22 and 23) supported by three abutments (11, 21, and 24). In vitro studies report flexural strength values of 900–1100 MPa and fracture toughness ranging from 4–5 MPa $\sqrt{m}$, sufficient to withstand physiological masticatory forces up to 300 N, provided that connector dimensions meet minimum standards [9]. The connector used in this case was oval-shaped, measuring 3.37 mm $\times$ 5.56 mm, producing a cross-sectional area of approximately 13 mm², exceeding the minimum requirement of 12.6 mm² for four-unit zirconia bridges under normal function [9]. Thus, 4Y-TZP is considered an ideal compromise between strength and esthetics, with connector dimensions supporting long-term resistance to fatigue failure and subcritical crack propagation in the moist oral environment.

The thickness of the abutment tooth preparation is also a determining factor influencing the mechanical properties of zirconia, including fracture resistance and marginal integrity. Research

indicates that monolithic 3Y zirconia crowns with 0.5-mm thickness possess high fracture resistance and acceptable marginal fit. Crowns with 1.5-mm thickness demonstrate the highest fracture resistance, tolerating forces up to 10 kN without failure [17]. Additional studies show that 0.5-mm zirconia crowns withstand thermal cycling and mechanical loading, demonstrating sufficient strength for mastication [18].

Finite element analysis (FEA) and fatigue studies show that zirconia frameworks require minimum connector dimensions to reduce stress levels below the critical threshold of 346 MPa for zirconia in wet conditions, thereby supporting a service life of over 20 years [9]. For bridges with two pontics, connector diameter should exceed 4 mm and cross-sectional area should exceed 12.6 mm², tolerating normal masticatory load ($\approx$ 250 N) and parafunctional clenching ($\approx$ 800 N) without increasing fatigue-related failure risk [19].

The radial shoulder margin design provides improved support for porcelain, ensuring marginal stability and long-term restoration integrity [20]. According to Shillingburg et al. (2017), a shoulder margin in the labial area provides adequate ceramic thickness, which is essential for anterior esthetics [13]. This margin also reduces marginal discrepancies and enhances the stability of PFM restorations [21]. Placing the finishing line at the equigingival level optimizes esthetics, retention, and periodontal health without violating biologic width, while facilitating plaque control [22].

The modified ridge-lap pontic design balances esthetics, function, and oral hygiene maintenance [23]. This pontic design provides natural emergence profile contact with the ridge on the labial/buccal aspect while being convex and non-contact on the palatal/lingual aspect, simplifying cleaning and minimizing plaque accumulation—critical for periodontal health [24].

Several cementation options are available for zirconia, including glass-ionomer cement, zinc phosphate cement, and resin cements. While glass-ionomer cement offers biocompatibility and fluoride release and zinc phosphate provides long-standing stability, resin cement remains the preferred option due to its superior bond strength and enhanced marginal seal, reducing microleakage and long-term restoration failure risk [25].

Conclusion

The design of a fixed dental prosthesis (FDP) to replace a canine requires meticulous

biomechanical planning because the canine is subjected to high lateral forces during mastication and protrusive movements, which increases the risk of fracture if the design is inadequate. The selection of abutment teeth is based on Ante's Law to ensure adequate structural stability of the bridge, considering the root surface area ratio and balanced distribution of functional loads between the anterior and posterior regions. The use of 4Y-TZP zirconia provides an optimal balance between mechanical strength and esthetic needs. This material offers sufficient flexural strength and fracture toughness for anterior bridge applications while improving translucency compared with 3Y-TZP, making it an ideal choice for restorations in the esthetic zone. Connector dimensions that meet the minimum recommended cross-sectional area of ≥ 12.6 mm² are essential to withstand physiological masticatory forces and prevent failure due to fatigue or subcritical crack propagation, particularly in prostheses with two pontics. The radial shoulder finishing line enhances structural support to the restoration margin and provides a smooth and esthetic transition at the preparation boundary, especially in the anterior region. The modified ridge-lap pontic design achieves a balance between esthetic requirements, speech and masticatory function, and ease of maintaining hygiene around the ridge tissue. Cementation using dual-cure resin cement improves adhesive bond strength between the prosthesis and the abutment teeth, minimizes microleakage, and contributes to the long-term durability of the restoration.

References

- [1] Auroy, P. and Lecerf, J "Prosthetic restoration of the canine" *Journal of Dentofacial Anomalies and Orthodontics*, vol. 13, no. 2, pp. 112–132, 2010, doi: <https://doi.org/10.1051/odfen/2010202>.
- [2] Hong, J.W. et al. "Immediate placement and functional loading of implants on canine with fixed partial denture for a patient having canine protected occlusion: a case report" *J Adv Prosthodont*, vol.4 no.1, pp. 52–56, (2012). doi: <https://doi.org/10.4047/jap.2012.4.1.52>.
- [3] Rohit, Abraham, P. and Eswaran. "An Alternative Minimal Invasive Approach to a Conventional Fixed Partial Denture – A Case report" *Journal of Clinical Prosthodontics and Implantology*, vol.4 no.1, pp. 18–20, (2022). doi: <https://doi.org/10.55995/J-CPI.2022005>.

- [4] Almohammed, S.N., Alshorman, B. and Abu-Naba'a, L. "Mechanical Properties of Five Esthetic Ceramic Materials Used for Monolithic Restorations: A Comparative In Vitro Study" *Ceramics*, vol.6 no.2, pp.1031-1049, (2023). doi: <https://doi.org/10.3390/ceramics6020061>.
- [5] Muhetaer, A. et al. "Advances in ceramics for tooth repair: From bench to chairside" *The Journal of dentists*, p. 105053, (2024). doi: <http://dx.doi.org/10.1016/j.jdent.2024.105053>.
- [6] Harada, A. et al. "Mechanical and microstructural properties of ultra-translucent dental zirconia ceramic stabilized with 5 mol% yttria" *Journal of the Mechanical Behavior of Biomedical Materials*, 111, p. 103974. (2020) doi:<https://doi.org/https://doi.org/10.1016/j.jmbm.2020.103974>.
- [7] White, S.N. et al. "Flexural strength of a layered zirconia and porcelain dental all ceramic system" *Journal of Prosthetic Dentistry*, vol.94 no.2, pp. 125–131, (2005). doi:<https://doi.org/10.1016/j.prosdent.2005.05.007>.
- [8] Maharishi, A., McLaren, E.A. and White, S.N. "Color- and strength-graded zirconia: Strength, light transmission, and composition" *Journal of Prosthetic Dentistry*. Vol.131 no.6, pp. 1236.e1-1236.e9, (2024).doi: <https://doi.org/10.1016/j.prosdent.2024.03.015>.
- [9] Studart, A.R. et al. "Fatigue of zirconia under cyclic loading in water and its implications for the design of dental bridges" *Dental Materials*, vol.23 no.1, pp. 106–114. (2007). doi: <https://doi.org/10.1016/j.dental.2005.12.008>.
- [10] Alsarani, M. et al. "Influence of crown design and material on chipping-resistance of all-ceramic molar crowns: An in vitro study" *Dental and Medical Problems*, vol.55 no.1, pp. 35–42. (2028) doi: <https://doi.org/10.17219/dmp/85000>.
- [11] McLaren, Edward A., Maharishi, A. and White, S.N. "Influence of yttria content and surface treatment on the strength of translucent zirconia materials" *Journal of Prosthetic Dentistry*, vol.129 no.4, pp. 638 643. (2023). doi: <https://doi.org/10.1016/j.prosdent.2021.07.001>.
- [12] Doreulee, N. et al. "The role of the mGluR allosteric modulation in the NMDA hypofunction model of schizophrenia", *Georgian medical news*, vol.177, pp. 59–6. (2009).
- [13] Shillingburg, H.T. et al. "Fundamentals of Fixed Prosthodontics, Jurnal Sains dan Seni ITS. (2017). doi: <http://repositorio.unan.edu.ni/2986/1/5624.pdf> %0Ahttp://fiskal.kemenkeu.go.id/ejournal%0Ahttp://dx.doi.org/10.1016/j.cirp.2016.06.001 %0Ahttp://dx.doi.org/10.1016/j.powtec.2016.12.055%0Ahttps://doi.org/10.1016/j.ijfatigue.2019.02.006%0Ahttps://doi.org/10.1.
- [14] Leos, M.F.S. "Materials used in rehabilitation of anterior teeth with Maryland adhesive bridge" *International Journal of Applied Dental Sciences*, vol.9 no.4, pp. 154–158, (2023).doi:<https://doi.org/10.22271/oral.2023.v9.i4c.1865>.
- [15] Maharishi, A. et al. "The Composition of Graded Dental Zirconias", *Jom*, vol.76 no.10, pp. 5735–5743. (2024). doi: <https://doi.org/10.1007/s11837-024-06791-0>.
- [16] Harada, A. et al. "Mechanical and microstructural properties of ultra-translucent dental zirconia ceramic stabilized with 5 mol% yttria" *Journal of the Mechanical Behavior of Biomedical Materials*, vol.111, p. 103974. (2020) doi: <https://doi.org/https://doi.org/10.1016/j.jmbm.2020.103974>.
- [17] Tekin, Y.H. and Hayran, Y. "Fracture resistance and marginal fit of the zirconia crowns with varied occlusal thickness", *Journal of Advanced Prosthodontics*, vol.12 no.5, pp. 283–290. (2020). doi: <https://doi.org/10.4047/jap.2020.12.5.283>.
- [18] Weigl, P. et al. "In-vitro performance and fracture strength of thin monolithic zirconia crowns", *The Journal of Advanced Prosthodontics*, vol.10 no.2, pp. 79–84. (2018) doi:<http://dx.doi.org/10.4047/JAP.2018.10.2.79>.
- [19] Quinn, G.D. et al. "Fatigue of zirconia and dental bridge geometry: Design implications", *Dental Materials*, vol.26 no.12, pp. 1133–1136. (2010). doi: <https://doi.org/10.1016/j.dental.2010.07.014>.
- [20] Hegde, S. et al. "Stress Distribution on Prepared Tooth With Shoulder and Radial Shoulder Margin to Receive Crowns of Three Different Materials: A Finite Element Analysis", *Cureus [Preprint]*.(2024). doi: <http://dx.doi.org/10.7759/cureus.55538>.
- [21] Jalalian, E. and Mirtorabi, M. "Comparison of the effect of chamfer and radial shoulder finish

- line designs on marginal adaptation of all-ceramic cercon restorations”, *Journal of Dental Medicine*, vol.23 no.364, pp. 147–152. (2010).
- [22] Shenoy, A., Shenoy, N. and Babannavar, R. “Periodontal considerations determining the design and location of margins in restorative dentistry”, *Journal of Interdisciplinary Dentistry*, vol.2 no.1, pp. 3. (2012). doi: <https://doi.org/10.4103/22295194.94184>.
- [23] Kazmi, S.M.R. et al. ”Different pontic design for porcelain fused to metal fixed dental prosthesis: Contemporary guidelines and practice by general dental practitioners”, *European Journal of Dentistry*, vol.12 no.3, pp. 375–9. (2018). Doi: <https://doi.org/10.4103/ejd.ejd>.
- [24] Rosenstiel, S., MF, L. and Fujimoto, J. (2016) Contemporary fixed prosthodontics, fifth edition, Elsevier. doi: <https://doi.org/10.1038/sj.bdj.2016.15>.
- [25] Dogan, S. and Raigrodski, A.J. “Cementation of Zirconia-Based Toothborne Restorations: A Clinical Review”, *Compendium of continuing education in dentistry*, vol.40 no.8, pp. 536–540. (2019).