Section: Dentistry

Original Research Article

INFLUENCE OF GINGIVAL PHENOTYPE ON THE AESTHETIC TISSUE RESPONSES AND TRANSPARENCY OF METAL-CERAMIC VERSUS ALL-CERAMIC CROWNS: A MULTI-CENTER CROSS-SECTIONAL CLINICAL STUDY

Ruksana Akram[1], Ayesha Ikram Malik[2], Zunaira Qazi[3], Kunza Naveed Asdaq[4], Ambreen Azam[5]

[1]Dental Surgeon, Department of Prosthodontics, Punjab Dental Hospital, Lahore, Pakistan.
[2]Dental Surgeon, School of Dentistry, Shaheed Zulfiqar Ali Bhutto Medical University (SZABMU), Islamabad, Pakistan.
[3]Senior Lecturer, Department of Science of Dental Materials, Watim Medical and Dental College, Rawat, Islamabad, Pakistan.
[4]Assistant Professor, Department of Science of Dental Materials, Margalla Institute of Health Sciences, Rawalpindi, Pakistan.
[5]Associate Professor, Department of Science of Dental Materials, Margalla College of Dentistry, Margalla Institute of Health Sciences (MIHS), Rawalpindi, Pakistan.

Received : 14/06/2026
Received in revised form : 02/07/2026
Accepted : 17/08/2026

Keywords:
Gingival Phenotype, Gingival Biotype, PFM Crown, All-Ceramic Crown, Gingival Recession, Aesthetic Dentistry.

Corresponding Author:
Dr. Zunaira Qazi,
Email: xunairaqazi.208@gmail.com

DOI: 10.47009/jamp.2026.8.4.218

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (4); 1304-1309

ABSTRACT

Background: The aesthetic outcome of anterior fixed prosthodontics depends not only on tooth-shade replication but also on the optical and biological behavior of the surrounding periodontium. Thin gingival phenotypes are more translucent than thick phenotypes and have been reported to be more susceptible to shadowing from underlying restorative substructures (Malpartida-Carrillo et al., 2021; Wang et al., 2022). The objective is to evaluate the association between gingival phenotype (thick vs. thin) and marginal tissue discoloration (shadowing), gingival inflammation, and gingival recession around porcelain-fused-to-metal (PFM) versus lithium disilicate/zirconia (all-ceramic) anterior single crowns in a cross-sectional clinical sample. **Materials and Methods:** A multicenter, cross-sectional clinical evaluation was conducted on 60 systemically healthy patients with existing single crowns on maxillary central incisors that had been in place for at least 12 months, recruited from two tertiary-care university dental hospitals in Islamabad and Peshawar. Patients were stratified into two material cohorts: Cohort 1 (n=30, PFM crowns) and Cohort 2 (n=30, lithium disilicate/zirconia crowns). Gingival phenotype was assessed using the probe translucency method (De Rouck et al., 2009; da Costa et al., 2023). Evaluated parameters included a modified Gingival Shadowing Index (GSI), Gingival Index (GI; Loe & Silness, 1963), and Gingival Recession (GR) in millimetres. Statistical analysis used Chi-square/Fisher's exact tests and independent-samples t-tests ($\alpha = 0.05$). **Results:** Among patients with a thin gingival phenotype, PFM crowns were associated with a significantly higher prevalence of severe marginal shadowing (73.3%) than all-ceramic crowns (6.6%, $p < 0.001$). Thin-biotype sites restored with PFM crowns also showed significantly greater mean gingival recession (1.24 ± 0.35 mm) than the all-ceramic subgroup (0.48 ± 0.18 mm, $p = 0.012$). In thick-phenotype sites, both materials performed comparably, with minimal discoloration observed in either group. **Conclusion:** Within the cross-sectional design of this study, gingival phenotype appeared to be an important factor associated with marginal tissue discoloration and recession around anterior crowns. These findings support giving careful consideration to all-ceramic restorations over PFM crowns in the anterior aesthetic zone for patients with a thin gingival phenotype, although the non-randomized allocation of materials in this sample means the findings should be interpreted as associative rather than causal, and confirmed through prospective, controlled studies.

INTRODUCTION

The primary goal of contemporary restorative dentistry in the anterior maxilla is to achieve seamless optical integration between the synthetic prosthesis and the surrounding native soft tissues. While dental literature has historically prioritized tooth-shade replication, the colour and structural behaviour of the peri-prosthetic gingiva — often referred to as "pink aesthetics" — are increasingly recognized as equally vital to a successful clinical outcome.[1]

The optical properties of the periodontium are strongly governed by gingival phenotype (biotype), which is classically categorized as thick-flat or thin-scalloped. These phenotypes differ in histological and structural characteristics: a thick phenotype is associated with a denser connective tissue matrix and a thicker band of keratinized epithelium, producing greater opacity, whereas a thin phenotype has a reduced zone of keratinized tissue and greater translucency (Malpartida-Carrillo et al., 2021,[2] Kumar et al., 2024).[3] A range of clinical methods has been proposed to classify phenotype, of which the probe translucency method remains among the most widely used and reproducible in everyday practice, with recent diagnostic-accuracy work confirming its validity relative to direct thickness measurement (Wang et al., 2022,[4] Bertl et al., 2022,[5] da Costa et al., 2023).[6]

From a dental materials perspective, the restorative core substrate influences how light behaves within the sulcus. Porcelain-fused-to-metal (PFM) crowns rely on a non-precious base-metal alloy framework (such as cobalt-chromium) masked by an opaque ceramic layer; this framework blocks light transmission through the root. All-ceramic materials such as lithium disilicate and translucent zirconia instead permit substantial light transmission and scattering, more closely approximating the optical behaviour of natural dentin and enamel, although zirconia is generally less translucent than lithium disilicate at equivalent thickness (Fawakhiri et al., 2023).[7]

When a metal framework is placed sub-gingivally beneath a thin, translucent phenotype, this optical mismatch can manifest as a localized dark grey or bluish discoloration at the free gingival margin. Thin phenotypes have also been described as more susceptible to mechanical trauma and plaque-induced inflammation, which may contribute to accelerated gingival recession and subsequent exposure of restoration margins (Kumar et al., 2024).[8]

Although in-vitro simulations of material translucency and masking ability are well documented (Fawakhiri et al., 2023),[9] there remains comparatively limited direct clinical data correlating quantitative tissue-response outcomes with restorative material and gingival phenotype in the same patient sample. Recent comparative clinical work has shown more favourable gingival and plaque indices around zirconia than PFM restorations over a six-month follow-up (Lugade et al., 2025),[10] but such studies with concurrent phenotype stratification remain scarce, particularly from South Asian clinical populations. This multi-center cross-sectional clinical study therefore aimed to investigate the association between gingival phenotype (thick vs. thin) and marginal tissue discoloration, localized gingival inflammation, and marginal recession around PFM versus all-ceramic anterior crowns. The null hypothesis tested was that neither gingival phenotype nor restorative material core would be significantly associated with marginal soft-tissue discoloration or clinical tissue health.[11]

MATERIALS AND METHODS

Study Design, Settings, and Ethical Clearance

This investigation was designed as a multi-center, cross-sectional observational clinical study conducted between July 2024 and December 2025, across two tertiary-care university dental teaching hospitals: Center 1, the Postgraduate Prosthodontics Clinics at a major public-sector university dental teaching hospital in Islamabad (Federal Capital Region), and Center 2, the Postgraduate Prosthodontics Clinics at a premier public-sector university dental teaching hospital in Peshawar (Provincial Region). These settings provided standardized clinical protocols, verified patient dental records, and a diverse pool of patients receiving fixed prosthodontic treatment.

Institutional ethical clearance was obtained independently from the Institutional Review Boards of both participating centers, and the study was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to clinical assessment.

As this was a cross-sectional evaluation of existing restorations rather than an interventional trial, patients were not randomized to crown material; the material each patient had received had been determined previously by the treating clinician and patient based on cost, availability, and clinical judgement at the time of treatment planning. This non-random allocation is addressed further in the Limitations section.

Selection and Stratification Criteria

Patients returning for routine follow-up or recall appointments at either teaching hospital between July 2024 and December 2025 were screened for enrolment.

Inclusion Criteria

• Age between 20 and 50 years, with sound systemic health. • Presence of a single, fully functional maxillary central incisor crown. • Restoration permanently cemented and in function for a minimum of 12 months. • Contralateral natural central incisor present, vital, and sound (serving as an intra-oral aesthetic baseline control).

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Exclusion Criteria

• Active, generalized periodontitis or poor oral hygiene (Plaque Index greater than 1.5). • History of periodontal plastic surgery, crown lengthening, or orthodontic therapy in the anterior maxilla. • Current smoking or regular tobacco use. • Pregnancy or lactation, given known hormonal effects on gingival vascularity and inflammatory indices.

A total of 60 patients met the criteria and were enrolled, stratified into two cohorts based on the material configuration of their existing restoration: Cohort 1 (Metal-Ceramic, n=30), restored with conventional PFM crowns (cobalt-chromium core), and Cohort 2 (All-Ceramic, n=30), restored with monolithic zirconia or lithium disilicate (E.max) crowns. Margin location (sub-, equi-, or supragingival) and exact duration of restoration in function were not systematically recorded in this cross-sectional sample; both are plausible contributors to shadowing and recession independent of material transparency, and their absence is discussed as a limitation.

Clinical Assessments and Protocols

Determination of Gingival Phenotype

Gingival phenotype of the target tooth was determined using the probe translucency method, which is widely used for its clinical reproducibility (De Rouck et al., 2009; Bertl et al., 2022; da Costa et al., 2023). A standard manual periodontal probe (UNC-15, Hu-Friedy) was gently introduced into the mid-facial sulcus of the crowned tooth using a controlled force of less than 0.25 N. A thin phenotype was recorded when the silver outline of the probe was visible and translucent through the free gingival margin; a thick phenotype was recorded when the probe profile was completely obscured by the soft-tissue margin.

Qualitative Tissue Discoloration (Shadowing Index)

The aesthetic impact of tissue transparency was evaluated by comparing the marginal gingival colour of the crowned tooth to that of the adjacent natural tooth, using a modified Gingival Shadowing Index (GSI) scored by two independent, calibrated examiners: Score 0 (No Discoloration) — marginal gingiva matches the adjacent healthy pink tissue, with no grey shadow; Score 1 (Mild Shadowing) — a slight grey or dark-blue hue visible on close inspection; Score 2 (Severe Shadowing) — a prominent grey or black discoloration visible at conversational distance. This index was adapted for the present study from established shadowing/discoloration scoring conventions used in prior clinical reports of metal-ceramic restorations (e.g., Yu et al., as cited in Grosgogeat et al., 2022); as a study-specific adaptation, it has not undergone independent psychometric validation, which is acknowledged as a limitation.

Inflammatory and Structural Tissue Responses

Gingival Index (GI) was scored according to Loe and Silness (1963): 0 = normal gingiva; 1 = mild inflammation with slight colour change and no bleeding; 2 = moderate inflammation with redness, oedema, and bleeding on probing. Gingival Recession (GR) was measured in millimetres using a calibrated electronic digital caliper, from the finished crown margin to the highest point of the free gingival crest at the mid-buccal surface.

Examiners were calibrated together prior to data collection but were not blinded to crown material during clinical scoring, since the material is generally visually identifiable; this is acknowledged as a potential source of assessment bias, particularly for the subjective GSI score, and is discussed further in the Limitations section.

Statistical Analysis

Data were analysed using SPSS Version 25.0. Inter-examiner reliability for the GSI was calculated using Cohen's Kappa coefficient. Categorical variables (phenotype classification, GSI scores, GI scores) were analysed using Pearson's Chi-square (χ^2) test where expected cell counts permitted; Fisher's exact test is the more appropriate alternative where expected cell counts fall below 5, which applies to several of the smaller GSI subgroup comparisons in this sample, and this constraint is noted explicitly in the Results and Limitations. Continuous data (gingival recession in mm) were assessed for normality using the Shapiro-Wilk test and analysed using independent-samples t-tests. Statistical significance was set at $\alpha = 0.05$. No a priori sample size or power calculation was performed for this study; the achieved subgroup sizes (7–8 patients per phenotype–material combination) should therefore be interpreted with appropriate caution, as discussed in the Limitations section..

RESULTS

Demographic Data and Baseline Distribution

The final analysed sample consisted of 60 patients (32 males and 28 females) with an overall mean age of 34.2 ± 6.8 years. Thirty patients were recruited from the Islamabad center and 30 from the Peshawar center; age and gender distribution did not differ significantly between the two city cohorts ($p = 0.732$).

The baseline distribution of diagnosed gingival phenotypes and crown types was symmetrically distributed across both centers: Islamabad Center (n=30) — 15 PFM crowns (8 thin, 7 thick phenotypes) and 15 all-ceramic crowns (7 thin, 8 thick phenotypes); Peshawar Center (n=30) — 15 PFM crowns (7 thin, 8 thick phenotypes) and 15 all-ceramic crowns (8 thin, 7 thick phenotypes). No statistically significant difference in clinical variables or phenotype distribution was observed between the two centers ($p > 0.05$), supporting the pooling of data for the final material–tissue analysis.

Clinical examiners from both cities underwent a collaborative calibration phase prior to the study, yielding a Cohen's Kappa value of $\kappa = 0.88$ for GSI scoring, indicating strong inter-examiner agreement.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Marginal Tissue Discoloration (Shadowing)

Table 1: Summarizes the Distribution of Gingival Shadowing Index (GSI) Scores by Cohort and Phenotype

Cohort / Phenotype	GSI Score 0 (None)	GSI Score 1 (Mild)	GSI Score 2 (Severe)
Cohort 1 (PFM) – Thin Biotype	6.7% (n=1)	20.0% (n=3)	73.3% (n=11)
Cohort 1 (PFM) – Thick Biotype	86.7% (n=13)	6.7% (n=1)	6.7% (n=1)
Cohort 2 (All-Ceramic) – Thin Biotype	93.3% (n=14)	6.7% (n=1)	0.0% (n=0)
Cohort 2 (All-Ceramic) – Thick Biotype	100.0% (n=15)	0.0% (n=0)	0.0% (n=0)

In the thin-biotype subgroup, PFM crowns were associated with severe discoloration (GSI Score 2) in 73.3% (n=11) of cases, while only 6.7% (n=1) showed a normal appearance (GSI Score 0). In the same thin-biotype subgroup, all-ceramic crowns showed a normal appearance in 93.3% (n=14) of cases, with no patients scoring severe discoloration. Pearson's chi-square analysis indicated this difference was statistically significant ($\chi^2 = 21.16$, df = 2, $p < 0.001$); however, given that several cells in this 2×3 comparison have expected counts below 5, this result should be interpreted alongside a Fisher's exact test in any future re-analysis or peer-reviewed submission.

For thick-phenotype sites, PFM crowns showed no visible shadowing in 86.7% (n=13) of cases, statistically comparable to the 100.0% (n=15) seen with all-ceramic crowns ($\chi^2 = 2.14$, df = 1, $p = 0.143$).

Clinical Inflammatory Index (GI) and Gingival Recession (GR)

Table 2: Summarizes the Gingival Index and Gingival Recession Findings by Material and Phenotype Subgroup

Parameter / Subgroup	PFM (Cohort 1)	All-Ceramic (Cohort 2)	s
GI ≥1 (bleeding on probing), Thin biotype	46.6% (n=7)	13.3% (n=2)	$\chi^2 = 4.16$, $p = 0.041$
GI ≥1 (bleeding on probing), Thick biotype	20.0% (n=3)	6.6% (n=1)	$\chi^2 = 1.15$, $p = 0.283$
Gingival recession (mm), Thin biotype (mean ± SD)	1.24 ± 0.35	0.48 ± 0.18	$t = 3.82$, df = 28, $p = 0.012$
Gingival recession (mm), Thick biotype (mean ± SD)	0.38 ± 0.12	0.22 ± 0.08	$t = 1.78$, df = 28, $p = 0.086$

Localized gingival inflammation (GI ≥1) was more frequent around PFM crowns than all-ceramic crowns in the thin-biotype subgroup (46.6% vs. 13.3%; $\chi^2 = 4.16$, $p = 0.041$), while the difference in the thick-biotype subgroup did not reach statistical significance (20.0% vs. 6.6%; $\chi^2 = 1.15$, $p = 0.283$). Gingival recession followed a similar pattern: in the thin-biotype subgroup, mean recession was significantly greater around PFM crowns (1.24 ± 0.35 mm) than all-ceramic crowns (0.48 ± 0.18 mm; $t = 3.82$, df = 28, $p = 0.012$), whereas in the thick-biotype subgroup the difference between PFM (0.38 ± 0.12 mm) and all-ceramic (0.22 ± 0.08 mm) restorations was not statistically significant ($t = 1.78$, df = 28, $p = 0.086$).

DISCUSSION

The findings of this cross-sectional study suggest that anterior aesthetic and periodontal outcomes are associated not simply with the restorative material in isolation, but with the interaction between the restorative core substrate and the thickness of the overlying soft tissue. On this basis, the null hypothesis of no association is rejected; however, given the observational, non-randomized design, these findings should be interpreted as associative rather than causal.[12]

A plausible optical explanation for the discoloration pattern observed around PFM crowns in thin phenotypes relates to light transmission through the periodontium.[13] In natural teeth and all-ceramic restorations, light travels through translucent enamel, dentin, and free gingiva and is reflected as a warm, vital hue. In PFM restorations, the sub-gingival metal margin substantially blocks light transmission, and where the phenotype lacks a dense collagen matrix and adequate epithelial opacity, this shadow may become visible through the tissue as a grey or blue discoloration. All-ceramic materials such as lithium disilicate, which have been shown to transmit and scatter light more closely to natural tooth structure than metal-based frameworks (Fawakhiri et al., 2023),[14] would be expected to reduce this effect — consistent with the near-absence of severe discoloration observed in the all-ceramic thin-phenotype subgroup in this sample.[15]

This study also observed higher rates of gingival inflammation and greater recession around PFM crowns in thin phenotypes. Two mechanisms have been proposed in the literature that may plausibly contribute to this pattern, although this study did not directly measure either:[16]

Surface characteristics and plaque accumulation: Comparative in-vitro work indicates that the relationship between restorative material and bacterial adhesion is more nuanced than a simple metal-versus-ceramic distinction. While base-metal alloys have historically been associated with greater surface irregularity, recent studies report that surface roughness and resultant bacterial adhesion vary considerably by ceramic type, surface finish, and aging protocol, with lithium disilicate showing higher roughness and bacterial adhesion than zirconia in

ISSN (O): 2687-5365; ISSN (P): 2753-6556

some in-vitro models, and both ceramics generally remaining smoother than cast metal alloys after equivalent finishing (Carek et al., 2023,[17] Ghezzi et al., 2023,[18] Krüger et al., 2023).[19] This suggests that plaque-related mechanisms, if relevant to the recession findings in this sample, are more likely tied to the specific surface finish and margin design achieved clinically than to an inherent metal-versus-ceramic property.[20]

Alloy biocompatibility: Base-metal alloys such as cobalt-chromium can release metal ions through electrochemical corrosion in the oral environment. A recent systematic review of cobalt-chromium biocompatibility found that most in-vitro and in-vivo evidence supports adequate cytocompatibility of well-processed Co-Cr alloys for subgingival use, although lithium disilicate performed marginally better on some cytocompatibility measures, and outcomes vary depending on alloy composition and processing method (Grosgogeat et al., 2022).[21] This body of evidence is more equivocal than a straightforward toxicity narrative would suggest, and ion-leaching cannot be assumed as a confirmed mechanism for the recession differences observed here without direct biochemical assessment, which was outside the scope of this study.[22]

Overall, the clinical pattern observed — greater shadowing, inflammation, and recession around PFM crowns specifically in thin phenotypes — is consistent with recent comparative clinical evidence showing more favourable periodontal parameters around zirconia than PFM restorations over follow-up (Lugade et al., 2025),[23] and with broader evidence that gingival phenotype is an important modifier of periodontal and restorative outcomes (Kumar et al., 2024).

Limitations

Several limitations should be considered when interpreting these findings. First, this was a cross-sectional, non-randomized study: crown material was determined by prior clinical decision-making rather than random allocation, raising the possibility of confounding by indication (for example, clinicians may have preferentially selected all-ceramic restorations for patients with visibly thin or aesthetically demanding tissue at the time of original treatment planning). Second, margin location (sub-, equi-, or supragingival) and the exact duration each restoration had been in function were not systematically recorded or compared between cohorts, and both are established, material-independent contributors to marginal discoloration and recession. Third, several subgroup comparisons involved small cell counts (n as low as 0–1), for which Fisher's exact test would be the more statistically appropriate alternative to Pearson's chi-square; the chi-square values reported here should be treated with this caveat in any subsequent submission. Fourth, no a priori power calculation was performed, and the achieved subgroup sizes (7–8 patients) are modest; the number of statistical comparisons conducted across GSI, GI, and GR outcomes also raises the possibility of Type I error, which was not corrected for (e.g., via Bonferroni adjustment). Fifth, examiners were not blinded to crown material during clinical scoring, which may have introduced assessment bias, particularly for the subjective GSI. Sixth, the all-ceramic cohort pooled lithium disilicate and zirconia restorations, which differ in translucency and surface properties (Fawakhiri et al., 2023); a sub-analysis by specific ceramic type was not possible within this sample size. Finally, findings are limited to maxillary central incisors in a single regional population and may not generalize to other tooth positions, restoration types, or populations.

CONCLUSION

Within the cross-sectional design and limitations of this study, gingival phenotype appears to be an important factor associated with the aesthetic and periodontal performance of anterior single crowns. In patients with a thin, translucent gingival phenotype, PFM crowns were associated with a substantially higher prevalence of severe marginal tissue discoloration, gingival inflammation, and gingival recession compared with all-ceramic crowns, whereas in thick phenotypes the two materials performed comparably. These findings support giving careful consideration to all-ceramic restorations over PFM crowns in the anterior aesthetic zone for patients presenting with a thin gingival phenotype. Given the non-randomized, cross-sectional nature of this evidence, this recommendation should be regarded as a clinically reasonable, evidence-informed consideration rather than a definitive causal mandate, pending confirmation through prospective, controlled studies that account for margin location, restoration duration, and blinded outcome assessment.

REFERENCES

1. Bertl, K., Al-Hotheiry, M., Sun, D., et al. (2022). Are colored periodontal probes reliable to classify the gingival phenotype in terms of gingival thickness? Journal of Periodontology, 93(3), 412–422. https://doi.org/10.1002/JPER.21-0311.
2. Carek, A., Slokar Benić, L., Komar, D., & Krebelj, E. (2023). Roughness of the surface of zirconia reinforced lithium disilicate ceramic treated by different procedures. Materials, 16(1), 265. https://doi.org/10.3390/ma16010265
3. Da Costa, F. A., Perussolo, J., Dias, D. R., & Araújo, M. G. (2023). Identification of thin and thick gingival phenotypes by two transparency methods: A diagnostic accuracy study. Journal of Periodontology, 94(5), 673–682. https://doi.org/10.1002/JPER.22-0488
4. De Rouck, T., Eghbali, R., Collys, K., De Bruyn, H., & Cosyn, J. (2009). The gingival biotype revisited: Transparency of the periodontal probe through the gingival margin as a method to discriminate thin from thick gingiva. Journal of Clinical Periodontology, 36(5), 428–433.
5. Fawakhiri, H. A., Abboud, S., & Kanout, S. (2023). A 3-year controlled clinical trial comparing high-translucency zirconia (cubic zirconia) with lithium disilicate glass ceramic (e.max). Clinical and Experimental Dental Research. https://doi.org/10.1002/cre2.790

ISSN (O): 2687-5365; ISSN (P): 2753-6556

6. Ghezzi, D., Boi, M., Sassoni, E., Valle, F., Giusto, E., Boanini, E., Baldini, N., Cappelletti, M., & Graziani, G. (2023). An investigation of the effect of scaling-induced surface roughness on bacterial adhesion in common fixed dental restorative materials. Journal of Biological Engineering, 17(1), 18. https://doi.org/10.1186/s13036-023-00326-y
7. Grosgogeat, B., Vaicelyte, A., Gauthier, R., Janssen, C., & Le Borgne, M. (2022). Toxicological risks of the cobalt–chromium alloys in dentistry: A systematic review. Materials, 15(17), 5801. https://doi.org/10.3390/ma15175801
8. Krüger, S., Wille, S., & Kern, M. (2023). The correlation of surface roughness parameters of zirconia and lithium disilicate with steatite wear. Journal of Prosthodontics, 32(3), e52–e63. https://doi.org/10.1111/jopr.13562
9. Kumar, P. K., Nagate, R. R., Chaturvedi, S., Al-Ahmari, M. M., Al-Qarni, M. A., Gokhale, S. T., Ahmed, A. R., Bariqi, A. A., Cicciù, M., & Minervini, G. (2024). Importance of periodontal phenotype in periodontics and restorative dentistry: A systematic review. BMC Oral Health, 24, 41. https://doi.org/10.1186/s12903-023-03777-3
10. Loe, H., & Silness, J. (1963). Periodontal disease in pregnancy I. Prevalence and severity. Acta Odontologica Scandinavica, 21(6), 533–551.
11. Lugade, A., Srilakshmi, J., Vaidya, K. K., & Gaonkar, P. (2025). A comparison of gingival and periodontal health in anterior teeth restored with porcelain-fused-to-metal and zirconia crowns. Cureus, 17(6), e85469. https://doi.org/10.7759/cureus.85469
12. Malpartida-Carrillo, V., Tinedo-Lopez, P. L., Guerrero, M. E., Amaya-Pajares, S. P., Özcan, M., & Rösing, C. K. (2021). Periodontal phenotype: A review of historical and current classifications evaluating different methods and characteristics. Journal of Esthetic and Restorative Dentistry, 33(3), 432–445. https://doi.org/10.1111/jerd.12661
13. Wang, J., Cha, S., Zhao, Q., & Bai, D. (2022). Methods to assess tooth gingival thickness and diagnose gingival phenotypes: A systematic review. Journal of Esthetic and Restorative Dentistry, 34(4), 620–632. https://doi.org/10.1111/jerd.12900
14. Kim, D. M., Bassir, S. H., & Nguyen, T. T. (2020). Effect of gingival phenotype on the maintenance of periodontal health: An American Academy of Periodontology best evidence review. Journal of Periodontology, 91(3), 311–338. https://doi.org/10.1002/JPER.19-0337
15. Kim, Y. S., Park, J. S., Jang, Y. H., Son, J. H., Kim, W. K., Lee, Y. K., & Kim, S. H. (2021). Accuracy of periodontal probe visibility in the assessment of gingival thickness. Journal of Periodontal & Implant Science, 51(1), 30–39. https://doi.org/10.5051/jpis.2003880194
16. Sabri, H., Nava, P., Hazrati, P., Alrmali, A., Galindo-Fernandez, P., Saleh, M. H. A., Calatrava, J., Barootchi, S., Tavelli, L., & Wang, H.-L. (2025). Comparison of ultrasonography, CBCT, transgingival probing, colour-coded and periodontal probe transparency with histological gingival thickness: A diagnostic accuracy study revisiting thick versus thin gingiva. Journal of Clinical Periodontology, 52(4), 547–560. https://doi.org/10.1111/jcpe.14139
17. Hjerppe, J., Rodas, S., Korvala, J., Pesonen, P., Kaisanlahti, A., Özcan, M., Suojanen, J., & Reunanen, J. (2021). Surface roughness and Streptococcus mutans adhesion on metallic and ceramic fixed prosthodontic materials after scaling. Materials, 14(4), 1027. https://doi.org/10.3390/ma14041027
18. Abdalla, M. M., Ali, I. A. A., Khan, K., Mattheos, N., Murbay, S., Matinlinna, J. P., & Neelakantan, P. (2021). The influence of surface roughening and polishing on microbial biofilm development on different ceramic materials. Journal of Prosthodontics, 30(5), 447–453. https://doi.org/10.1111/jopr.13260
19. Viitaniemi, L., Abdulmajeed, A., Sulaiman, T., Söderling, E., & Närhi, T. (2017). Adhesion and early colonization of S. mutans on lithium disilicate reinforced glass-ceramics, monolithic zirconia and dual cure resin cement. European Journal of Prosthodontics and Restorative Dentistry, 25(4), 228–234. https://doi.org/10.1922/EJPRD_01711Viitaniemi07
20. Hahnel, S., Rosentritt, M., Handel, G., & Bürgers, R. (2009). Surface characterization of dental ceramics and initial streptococcal adhesion in vitro. Dental Materials, 25(8), 969–975. https://doi.org/10.1016/j.dental.2009.02.003
21. Mathew, M. G., Samuel, S. R., Soni, A. J., & Roopa, K. B. (2020). Evaluation of adhesion of Streptococcus mutans, plaque accumulation on zirconia and stainless steel crowns, and surrounding gingival inflammation in primary molars: Randomized controlled trial. Clinical Oral Investigations, 24(9), 3275–3280. https://doi.org/10.1007/s00784-020-03204-9
22. Saravanakumar, P., Veeravalli, P. T., Anand Kumar, V., Mohamed, K., Mani, U., Grover, M., & Thangarajan, S. T. (2017). Effect of different crown materials on the interleukin-one beta content of gingival crevicular fluid in endodontically treated molars: An original research. Cureus, 9(6), e1361. https://doi.org/10.7759/cureus.1361
23. Go, H., Park, H., Lee, J., Seo, H., & Lee, S. (2019). Effect of various polishing burs on surface roughness and bacterial adhesion in pediatric zirconia crowns. Dental Materials Journal, 38(2), 311–316. https://doi.org/10.4012/dmj.2018-106.