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# Periodontal Tissue Response to Crown Margin Placement: A Comparative Evaluation of Prosthodontic Designs

## ABSTRACT

This comprehensive review examines the influence of crown margin placement and prosthodontic design on periodontal tissue response, emphasizing the biological principles that govern longterm restorative success. The periodontal tissues are highly sensitive to restorative interventions, and their stability depends on respect for the natural soft tissue attachment and the careful positioning of restoration margins. Evidence consistently shows that supragingival margin placement offers the most favorable clinical outcomes due to reduced plaque accumulation, greater accessibility for oral hygiene, and minimal disruption to gingival architecture. Equigingival margins may also perform satisfactorily when precisely adapted, while subgingival margins remain useful for esthetic and structural purposes but carry a greater risk of inflammation and loss of attachment. Prosthodontic factors such as margin geometry, emergence profile, restorative material, and fabrication technique further influence periodontal behavior by affecting surface smoothness, bacterial adhesion, and soft tissue compatibility. Integrating digital technologies, minimally invasive restorative approaches, and biologically driven preparation concepts enhances marginal accuracy and supports periodontal preservation. The findings reinforce the importance of individualized treatment planning based on tissue phenotype, esthetic requirements, and clinical needs to achieve optimal functional and periodontal outcomes.

## 1. INTRODUCTION

The interrelationship between prosthodontic restorations and periodontal health has long been recognized as a critical determinant of longterm clinical success. Restorative margins that encroach upon or disrupt periodontal tissues can lead to inflammation, attachment loss, and structural instability, whereas welldesigned restorations enhance function while preserving softtissue equilibrium. The periodontal tissues comprising the gingiva, periodontal ligament, cementum, and alveolar bone are highly responsive to restorative interventions, and even minor deviations in margin placement or contour can initiate pathological changes. This sensitivity is particularly evident around the supracrestal tissue attachment (STA), previously termed "biologic width," which represents the physiological dimension required for softtissue stability and is a pivotal reference point in restorative dentistry. Contemporary evidence underscores that any restorative margin violating this dimension risks provoking chronic inflammation, gingival recession, or bone resorption, thereby compromising both periodontal and prosthodontic prognosis[1] .

The biological concept of STA has undergone refinement in recent years, emphasizing its structural composition and functional significance in restorative planning. Supracrestal tissue attachment must remain undisturbed to maintain periodontal health, and clinicians must understand its dimensions and variability across individuals. Updated literature highlights that restorative procedures must respect this anatomical requirement and avoid subgingival intrusion unless clinically justified. Deviations from this principle can jeopardize soft tissue integrity and esthetic outcomes, particularly in the anterior region where marginal discrepancies are more visible and biologically consequential[2] . Similarly, management strategies such as crown lengthening have been explored to reestablish an adequate STA when restorative requirements mandate deeper margin placement. Crown lengthening facilitates the placement of margins without biologic width violation; however, its indications, limitations, and esthetic implications must be carefully weighed in clinical decisionmaking[3] .

The positioning of crown margins, whether supragingival, equigingival, or subgingival, plays a central role in determining the periodontal response. Subgingival margins, although often necessary for esthetic or structural reasons, are associated with increased plaque retention, higher inflammatory marker expression, and more frequent bleeding on probing. Systematic assessments have demonstrated that procedures such as deep margin elevation (DME) can mitigate some periodontal risks when appropriately executed, allowing clinicians to modify subgingival defects coronally and reduce invasive surgical requirements[4]. Recent advances in restorative protocols have expanded the use of DME, offering greater predictability in achieving biologically compatible margins and improving restorative access in deep cervical areas. Comparative analyses suggest that decisions between crown lengthening and DME should be guided by prognosis, periodontal biotype, and anticipated functional demands[6].

As restorative philosophies evolve, DME has received increased attention for its minimally invasive potential, particularly in complex posterior restorations. Scoping reviews highlight its utility in elevating deeply placed margins to a more accessible supragingival position, reducing risks associated with subgingival restorative manipulation[7]. Likewise, evidencebased evaluations have demonstrated that DME positively influences marginal integrity and microleakage when performed with appropriate adhesive protocols, ultimately contributing to improved gingival outcomes[8]. Recent narrative reviews further emphasize the importance of strict procedural adherence, material selection, and biomechanical considerations to ensure favorable periodontal responses following DME[9].

In addition to restorative and preparatory techniques, emerging evidence indicates that interproximal restorations also significantly impact periodontal conditions. A quasiexperimental study revealed that even conservative restorative interventions can modify cytokine profiles and alter inflammatory responses within the gingival sulcus,underscoring the delicate equilibrium of periodontal tissues and the need for biologically respectful restorative design[10]. Based on these considerations, this review synthesizes contemporary evidence to provide a comprehensive understanding of periodontal tissue responses to crown margin placement and prosthodontic margin designs.

## Objectives

1. To critically evaluate how supragingival, equigingival, and subgingival crown margin placements influence periodontal health and tissue stability
2. To compare contemporary prosthodontic design approaches, including margin geometry, material selection, and restorative techniques, in relation to their periodontal consequences

# 2. METHODOLOGY

This comprehensive review adopts an integrative narrative approach to examine periodontal tissue responses to various crown margin placements and prosthodontic design features. Relevant scientific and clinical literature was gathered from major academic databases and authoritative periodontal–prosthodontic sources, to ensure conceptual relevance and high scholarly quality. The extracted evidence was organized into thematic clusters, including biological tissue reactions, prosthodontic margin design parameters, materialrelated influences, and clinical procedural determinants. These themes were synthesized through descriptive mapping, comparative evaluation, and integrative interpretation to provide a unified understanding of how margin placement affects periodontal health. Figure 1 illustrates the methodological framework guiding this review. It outlines the steps of literature exploration, thematic grouping of biological and prosthetic factors, synthesis through narrative comparison, and integration into consolidated insights on periodontal responses to crown margin placement.

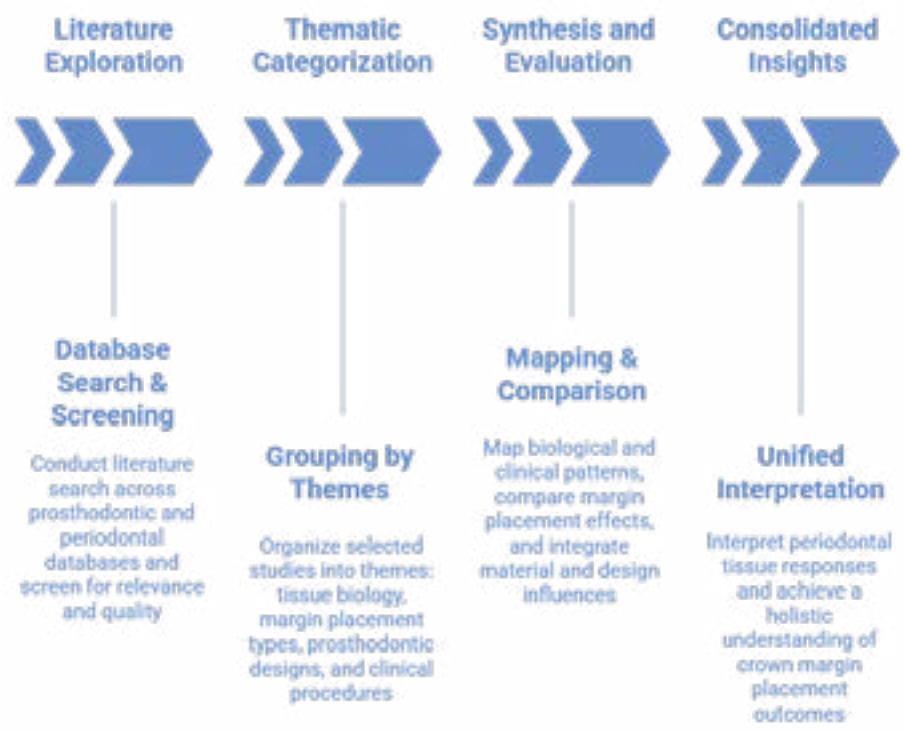


Figure 1. Methodological Framework for the Comprehensive Review

# RESULTS

## Periodontal Tissue Response to Different Crown Margin Placements Supragingival Margins

Evidence from recent clinical trials demonstrated that supragingival margins consistently supported superior periodontal outcomes due to reduced plaque retention and minimal sulcular trauma. A prospective controlled trial evaluating deepmargin elevation combined with CAD/CAM partial restorations reported stable periodontal indices when margins were moved coronally into a supragingival position, reinforcing the biological compatibility of this approach[11] . The findings summarized in Table 1 show that supragingival margins exhibit the lowest inflammation scores and minimal changes in probing depth, contributing to stable gingival architecture. These results were corroborated by longterm evaluations of proximal box elevation procedures, which demonstrated stable periodontal conditions and minimal inflammatory changes when margins were kept above the sulcus[12] .

Table 1. Periodontal Outcomes Associated with Supragingival, Equigingival, and Subgingival

| Margin Type | Periodontal Outcome Summary |
|---|---|
| Supragingival | Lowest inflammation, stable PD, minimal sulcular trauma[11,12] |
| Equigingival | Acceptable periodontal stability if margins are smooth and well-adapted[12,13] |

## Equigingival Margins

Although historically approached with caution, equigingival margins presented clinically acceptable periodontal responses when their adaptation and smoothness were precisely controlled. Threeyear observations of indirect resin composite restorations indicated that equigingival placements demonstrated stable bleedingonprobing values and acceptable plaque indices when restoration contours conformed closely to natural supragingival anatomy[12] . Systematic evaluations further highlighted that equigingival margins avoided deep sulcular intrusion and maintained periodontal parameters within physiologic limits, provided that finish lines were wellpolished and free of overhangs[13] . These patterns are detailed within Table 1, reinforcing their suitability in esthetically sensitive regions.

## Subgingival Margins

Subgingival margin placement was associated with the highest periodontal risk, including increased gingival inflammation, expression of inflammatory biomarkers, and potential violation of the supracrestal tissue attachment. Systematic reviews have concluded that deeper cervical margins significantly elevate probing depth, bleedingon-probing, and plaque retention due to limited accessibility for hygiene maintenance[13,14] . Nonetheless, controlled use of deep margin elevation procedures has been shown to reduce the need for subgingival positioning by repositioning defective margins coronally, thereby mitigating periodontal compromise[11] .

## Influence of Prosthodontic Design Features on Periodontal Outcomes Margin Geometry

Margin geometry demonstrated a significant influence on periodontal behavior. Clinical evaluations of vertical preparation and chamfer margin designs indicated reduced softtissue inflammation due to improved marginal integrity and reduced overhang formation[15] . Retrospective evidence up to five years confirmed that vertical techniques yielded favorable periodontal stability by promoting natural soft-tissue adaptation around zirconia and PFM restorations. The comparative performance of various margin geometries is summarized in Table 2.

Table 2. Impact of Margin Geometry on Periodontal Outcomes

| Margin Design | Periodontal Effect |
|---|---|
| Chamfer | Reduced inflammation, good marginal adaptation[15] |
| Vertical/BOPT | Stable gingival contours, high softtissue compatibility[16,17] |

## Emergence Profile and Crown Contour

Anatomically guided emergence profiles minimized gingival displacement, reduced plaque stagnation, and preserved gingival zenith patterns. Longterm prospective studies evaluating biologically oriented preparation techniques (BOPT) demonstrated high patient satisfaction and favorable periodontal behavior when emergence contours were precisely controlled[17] . Vertical preparation crowns also promoted a more harmonious softtissue line, reducing inflammation and enhancing mucogingival stability[16,17] .

## Material Type and Surface Microstructure

Material selection exerted a significant effect on bacterial adhesion and gingival response. Zirconia and lithium disilicate crowns exhibited smoother surfaces and lower plaque accumulation compared to metalceramic restorations[18] . These findings are outlined in Table 3, indicating that polished monolithic zirconia restorations provided the most favorable softtissue integration.

Table 3. Influence of Material Type and Surface Microstructure on Periodontal Behavior

| Material | Gingival Response |
|---|---|
| Monolithic Zirconia | Lowest plaque adhesion, stable soft-tissue architecture[16,18] |
| Lithium Disili-cate | Good surface smoothness, acceptable plaque levels [16] |

### Fabrication Technique

Digital CAD/CAM fabrication enhanced marginal precision, reducing gaps that predispose to plaque retention and inflammation. Prospective clinical studies demonstrated that monolithic zirconia crowns fabricated through fulldigital workflows maintained periodontal stability over three years, with minimal BOP and recession values[18] . Digital volumetricev-

aluations further confirmed stable periodontal contours around BOPT restorations fabricated with digital protocols[19].

## Clinical Procedures Affecting Periodontal Response

Respecting the supracrestal tissue attachment was critical for preserving periodontal stability. Studies emphasized that excessive subgingival extension during preparation predisposed tissues to inflammation, destabilized the biological seal, and increased the risk of gingival recession[20]. Vertical preparation techniques promoted minimal invasion of the sulcus and helped preserve tissue height[16].

## Gingival Retraction Methods

Evidence revealed that mechanical and chemical retraction techniques varied in their influence on sulcular epithelium. Minimally traumatic methods maintained softtissue health and reduced postoperative inflammation compared to aggressive displacement protocols[15].

## Impression vs. Digital Scanning

Digital scanning reduced sulcular trauma and eliminated the need for aggressive retraction, contributing to better short- and longterm periodontal outcomes. Prospective clinical studies confirmed reduced bleeding and improved tissue stability when digital workflows were used[18,19].

## Cementation and Adhesive Protocols

Excess cement remained a major contributor to postoperative inflammation, particularly with subgingival margins. Resin cements required meticulous removal to prevent plaque accumulation and subsequent tissue damage[11].

Table 4. Clinical Procedures Influencing Periodontal Outcomes

| Clinical Procedure | Effect on Periodontal Tissues |
|---|---|
| Tooth Preparation Depth | Risk of STA violation, increased inflammation[16,20] |
| Gingival Retraction | Traumadependent inflammation levels[15] |
| Digital Scanning | Lower sulcular trauma, improved tissue stability[18,19] |

## Evidence from Key Comparative Studies

Comparative trials consistently demonstrated several universal trends: deeper margins increased inflammatory burden; precise and welladapted margins minimized attachment loss; and materials with smoother surfaces improved tissue integration. BOPT restorations produced stable periodontal contours and higher softtissue time[17,19]compatibility over . However, heterogeneity in operator technique and margin placement depth created gaps in longterm evidence. The biological principles summarized by supracrestal tissue attachment literature further reinforced the necessity of preserving this dimension during all restorative procedures[20].

# DISCUSSION

The synthesized evidence illustrates that periodontal physiology remains the primary determinant of tissueresponse to restorative margin placement, confirming foundational concepts regarding the supracrestal tissue attachment and its critical role in maintaining gingival stability. Classical periodontal principles emphasize that disruption or invasion of this biological dimension leads to inflammation, connective tissue breakdown, and potential bone remodeling, making biologic width preservation essential for restorative success[21]. Epidemiological observations have similarly demonstrated that defective margins, overhangs, and inappropriate finish line placement increase the risk of periodontal attachment loss, reinforcing the longrecognized interplay between restorative design and periodontal breakdown[22]. These principles provide the physiological framework for interpreting recent clinical findings and underscore the importance of biologically respectful restorative planning. Clinically, the choice of margin position must be tailored to anatomical demands, functional considerations, and esthetic priorities. Supragingival margins consistently demonstrate superior periodontal compatibility, particularly in patients with favorable periodontal thickness and controlled plaque levels. Conversely, subgingival margins, although often necessary for esthetic concealment or management of deep caries, carry higher biological risk because of their proximity to the delicate epithelial and connective tissue attachments[23]. Modern restorative protocols such as deep margin elevation have emerged to address these challenges by elevating deep cervical margins coronally, thereby reducing sulcular manipulation while improving restorative access and minimizing the likelihood of biologic width violation[24]. This evolving approach reflects a shift toward minimally invasive methods that respect periodontal architecture while still optimizing restorative function.

Margin geometry also plays a pivotal role in determining periodontal stability. Vertical preparation concepts, particularly those associated with the biologically oriented preparation technique (BOPT), have been shown to facilitate harmonious gingival adaptation by guiding natural softtissue reshaping around the restoration[25]. This represents a significant departure from traditional horizontal finish lines, which depend heavily on mechanical precision and may be more susceptible to marginal discrepancies. The shift toward biologically driven preparation reflects a broader paradigm shift within prosthodontics, integrating periodontal science more closely into restorative strategy.

Periodontal phenotype emerges as another critical variable influencing tissue behavior. Thin biotypes are more vulnerable to recession, softtissue collapse, and inflammatory complications following subgingival intervention, while thick biotypes demonstrate greater resilience and stability[26]. As such, accurate evaluation of phenotype should precede any restorative procedure, guiding the clinician in selecting margin depth, impression technique, retraction method, and even the restorative material to ensure longterm success.

Balancing esthetics, function, and biology remains one of the most significant challenges in modern restorative dentistry. Techniques such as deep margin elevation and minimally invasive adhesive protocols allow clinicians to achieve esthetic goals while preserving the biological seal. These approaches support gingival symmetry, maintain the gingival zenith, and prevent longterm recession, making them particularly valuable in the esthetic zone[27,28]. Such methods mirror the broader movement in dentistry toward patient-centered, biologically integrated restorative philosophies.

Technological advancements have further enhanced the precision and predictability of restorative procedures. CAD/CAM fabrication systems offer improved marginal accuracy, while digital impression techniques minimize sulcular trauma, leading to reduced postoperative inflammation and more stable periodontal contours[29] . Digital tissue profiling also enables highly accurate emergence profile design, improving softtissue integration and reducing periodontal risk.

Despite these advances, the existing literature presents notable limitations. Variability in methodology, operator expertise, and followup duration complicates direct comparison across studies and restricts the generalizability of outcomes. Shortterm evaluation remains common, limiting understanding of longterm periodontal behavior, especially around subgingival and vertical preparation margins[27–29] . Future research should prioritize standardized protocols, longterm followup, and phenotypebased comparative analyses to clarify optimal restorative strategies.

Collectively, current evidence highlights a distinct paradigm shift from purely mechanical restorative approaches toward biologically oriented design principles. This evolution underscores the importance for prosthodontists to integrate biological understanding, esthetic considerations, and functional demands to ensure predictable, longlasting periodontal health[30] .

# CONCLUSION

The collective evidence demonstrates that crown margin placement exerts a decisive influence on periodontal tissue behavior, underscoring the importance of biologically respectful restorative planning in achieving longterm clinical success. Supragingival margins consistently emerge as the most favorable option due to their minimal impact on plaque accumulation, ease of maintenance, and reduced risk of violating the supracrestal tissue attachment, thereby supporting periodontal stability. Conversely, subgingival margins, while often necessary for esthetic or structural indications, require exceptional precision in preparation, contouring, and finishing to prevent sulcular irritation, inflammatory responses, and subsequent attachment loss. The role of prosthodontic design is equally critical, as margin geometry, emergence profile, and restorative material selection collectively determine the degree of soft tissue compatibility and microbial adhesion. Advances in high-strength ceramics, digital workflows, and CAD/CAM fabrication have enhanced marginal accuracy and surface smoothness, contributing to improved periodontal outcomes when used appropriately. Nevertheless, achieving optimal results requires more than technical proficiency; it demands thoughtful integration of esthetic expectations, biomechanical requirements, and the biological limitations of the periodontal apparatus. Central to this approach is individualized treatment planning that considers the patient's periodontal phenotype, as thin and thick biotypes exhibit distinctly different susceptibilities to gingival recession and inflammatory changes. Customized retraction techniques, tailored preparation depths, and carefully selected adhesive strategies further contribute to maintaining tissue health around restorations. As restorative dentistry continues to shift toward minimally invasive, biologically oriented concepts, clinicians are encouraged to adopt approaches that respect tissue integrity while delivering esthetic and functional excellence. Ultimately, successful management of crown margins depends on harmonizing scientific principleswith clinical judgment, ensuring that restorative interventions support both periodontal preservation and longterm prosthodontic success.

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