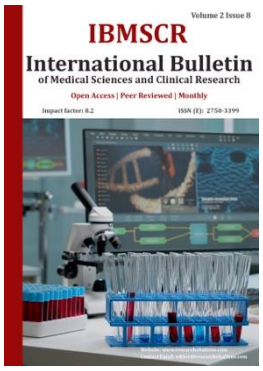

FACTORS AFFECTING PERI-IMPLANT SOFT TISSUE RECESSION AND INFLAMMATION FOLLOWING DENTAL IMPLANTATION

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Annotatsiya: Dental implantatsiyaning uzoq muddatli klinik muvaffaqiyati nafaqat implantning osseointegratsiyasi, balki peri-implant yumshoq to‘qimalarining morfologik va biologik barqarorligiga ham bog‘liq. Yumshoq to‘qimalar retsessiyasi va yallig‘lanishining rivojlanishida yumshoq to‘qima fenotipi, keratinizatsiyalangan shilliq qavat kengligi, implantning uch o‘lchamli pozitsiyasi, suyak anatomiyasi, implantatsiya vaqti hamda augmentatsiya usullari muhim rol o‘ynaydi. Mazkur ishning maqsadi dental implantatsiyadan keyingi peri-implant yumshoq to‘qimalari retsessiyasi va yallig‘lanishi bilan bog‘liq asosiy omillarni zamonaviy ilmiy adabiyotlar asosida tahlil qilishdan iborat. Adabiyotlar tahlili shuni ko‘rsatdiki, yupqa yumshoq to‘qima fenotipi, keratinizatsiyalangan shilliq qavatning yetarli emasligi, implantning noqulay joylashuvi va ayrim holatlarda immediate implantatsiya yumshoq to‘qima barqarorligiga salbiy ta’sir ko‘rsatishi mumkin. Aksincha, yetarli yumshoq to‘qima qalinligi, adekvat keratinizatsiyalangan shilliq qavat, optimal implant pozitsiyasi va klinik ko‘rsatmalar asosida bajarilgan yumshoq to‘qima augmentatsiyasi peri-implant to‘qimalar barqarorligini qo‘llab-quvvatlaydi. Zamonaviy dalillar ushbu omillarni alohida emas, balki o‘zaro bog‘liq holda baholash zarurligini ko‘rsatadi. Individual riskni oldindan baholash va unga mos davolash strategiyasini tanlash peri-implant yumshoq to‘qimalari asoratlarini kamaytirishning muhim sharti hisoblanadi.

Kalit so‘zlar: dental implantatsiya, peri-implant yumshoq to‘qimalari, yumshoq to‘qima retsessiyasi, keratinizatsiyalangan shilliq qavat, yumshoq to‘qima fenotipi, peri-implant yallig‘lanish, peri-implantit, yumshoq to‘qima augmentatsiyasi.

Аннотация: Долгосрочный клинический успех дентальной имплантации зависит не только от успешной остеоинтеграции имплантата, но и от морфологической и биологической стабильности периимплантных мягких тканей. В развитии рецессии и воспалительных изменений мягких тканей важную роль играют фенотип мягких тканей, ширина кератинизированной слизистой оболочки, трёхмерное положение имплантата, состояние костной ткани, сроки имплантации и методы аугментации. Целью настоящей работы являлся анализ основных факторов, связанных с рецессией и воспалением периимплантных мягких тканей после дентальной имплантации, на основании современных научных данных. Анализ литературы показал, что тонкий фенотип мягких тканей, недостаточная ширина кератинизированной слизистой оболочки, неблагоприятное положение имплантата и в отдельных клинических ситуациях немедленная имплантация могут отрицательно влиять на стабильность мягких тканей. Напротив, достаточная толщина мягких тканей, адекватная ширина кератинизированной слизистой оболочки, оптимальное положение имплантата и проведение мягкотканной аугментации по клиническим показаниям могут способствовать поддержанию стабильности периимплантных тканей. Современные

научные данные свидетельствуют о необходимости комплексной оценки этих факторов с учётом их взаимного влияния. Предварительная индивидуальная оценка риска и выбор соответствующей лечебной тактики являются важными условиями снижения вероятности периимплантных мягкотканных осложнений.

Ключевые слова: дентальная имплантация, периимплантные мягкие ткани, рецессия мягких тканей, кератинизированная слизистая оболочка, фенотип мягких тканей, периимплантное воспаление, периимплантит, мягкотканная аугментация.

Abstract: The long-term clinical success of dental implant therapy depends not only on successful osseointegration but also on the morphological and biological stability of the peri-implant soft tissues. The development of soft tissue recession and inflammatory changes is influenced by several factors, including the soft tissue phenotype, width of keratinized mucosa, three-dimensional implant position, hard-tissue anatomy, timing of implant placement, and soft tissue augmentation procedures. The aim of this study was to analyze the major factors associated with peri-implant soft tissue recession and inflammation following dental implant placement based on contemporary scientific evidence. The literature indicates that a thin soft tissue phenotype, inadequate keratinized mucosa, unfavorable implant positioning, and, in selected clinical situations, immediate implant placement may negatively affect soft tissue stability. In contrast, adequate soft tissue thickness, sufficient keratinized mucosa, optimal three-dimensional implant positioning, and soft tissue augmentation performed when clinically indicated may contribute to maintaining peri-implant tissue stability. Current evidence supports a comprehensive assessment of these factors rather than evaluating them individually, taking into account their potential interactions. Individualized risk assessment before treatment and selection of an appropriate treatment strategy are important for reducing the risk of peri-implant soft tissue complications.

Keywords: dental implant therapy, peri-implant soft tissue, soft tissue recession, keratinized mucosa, soft tissue phenotype, peri-implant inflammation, peri-implantitis, soft tissue augmentation.

1. Introduction

The predictability of contemporary dental implant therapy has substantially improved; however, implant survival alone does not fully describe the quality of the treatment outcome. Stable peri-implant soft tissues are essential for maintaining peri-implant health, facilitating plaque control, preserving mucosal architecture, and achieving an acceptable aesthetic result. Peri-implant soft tissue alterations may become clinically apparent as apical displacement of the mucosal margin, soft tissue dehiscence, reduced tissue volume, or inflammatory changes. These conditions are particularly relevant in the aesthetic zone, where relatively small alterations in the mucosal contour may become visible to the patient. The biological behavior of peri-implant soft tissues is determined by several interacting variables. The thickness and phenotype of the mucosa, the amount of keratinized tissue, the three-dimensional position of the implant, the condition of the facial bone, the timing of implant placement, and the need for soft tissue augmentation may all influence the final tissue architecture. Importantly, these factors should not be interpreted as independent predictors in every clinical situation. For example, the effect of a thin soft tissue phenotype may be modified by implant position and facial bone thickness, while the clinical significance of keratinized mucosa may depend on plaque control and the patient's ability to maintain adequate oral hygiene. Recent systematic

reviews have provided increasingly detailed evidence regarding the prevalence and determinants of peri-implant soft tissue alterations. Tavelli and Barootchi's 2025 AO/AAP systematic review and meta-regression analysis included 221 eligible studies and identified limited mucosal thickness, immediate implant therapy, limited keratinized mucosa, and lack of soft tissue augmentation among factors associated with different forms of peri-implant soft tissue dehiscence. The purpose of the present analysis was therefore to examine these factors as components of an interconnected clinical risk profile rather than as isolated variables.

2. Aim

The aim of this study was to critically analyze the principal factors associated with peri-implant soft tissue recession and inflammation following dental implant placement and to summarize their clinical relevance for individualized implant treatment planning.

3. Materials and Methods

The present work was designed as a literature-based analytical review. Contemporary systematic reviews, meta-analyses, cohort studies, and relevant clinical investigations concerning peri-implant soft tissue stability were considered. The analysis focused on publications addressing:

- soft tissue phenotype and mucosal thickness;
- keratinized mucosa;
- peri-implant mucosal recession and soft tissue dehiscence;
- three-dimensional implant positioning;
- timing of implant placement;
- peri-implant inflammatory conditions;
- soft tissue augmentation techniques.

Particular emphasis was placed on recent evidence syntheses because they allow findings from multiple clinical studies to be interpreted within a broader evidence framework. No original patient cohort, experimental intervention, or unpublished clinical outcome was introduced into the analysis. Accordingly, numerical findings presented in this article refer to the results reported in the cited publications and are not presented as original clinical data.

4. Results and Analytical Discussion

4.1. Peri-implant soft tissue recession is a multifactorial phenomenon

Peri-implant recession should be understood as a biological and anatomical outcome rather than as an isolated surgical complication. The 2025 AO/AAP systematic review and meta-regression analysis by Tavelli and Barootchi included 221 studies and evaluated several manifestations of peri-implant soft tissue dehiscence. The reported mean prevalence of peri-implant soft tissue dehiscence was 46.2%, whereas mucosal recession was reported with a mean prevalence of 23.1%. Importantly, the authors identified limited mucosal thickness, immediate implant therapy, limited or absent keratinized mucosa, and absence of soft tissue augmentation among relevant risk factors, depending on the specific soft tissue outcome evaluated. These findings are particularly relevant because they demonstrate that the term “peri-implant recession” encompasses clinically different manifestations. Consequently, the assessment of soft tissue stability should include both the position of the mucosal margin and the qualitative and quantitative characteristics of the surrounding tissue.

4.2. Soft tissue phenotype and mucosal thickness

The peri-implant soft tissue phenotype represents a biologically relevant component of implant-site anatomy. Reduced mucosal thickness may provide less tissue volume for maintaining a stable peri-implant mucosal contour and may increase susceptibility to soft tissue dimensional changes. The available evidence supports the relevance of mucosal thickness when assessing the risk of peri-implant soft tissue dehiscence. In the large 2025 systematic review, limited mucosal thickness was consistently identified among factors associated with several forms of soft tissue instability.

From a clinical perspective, this suggests that soft tissue evaluation should occur before implant placement rather than only after complications become clinically visible. However, mucosal thickness cannot be considered independently of the underlying hard-tissue anatomy. A thin facial bone plate, unfavorable implant position, and thin mucosal phenotype may act together and produce a greater risk of marginal tissue instability than any single characteristic considered separately.

4.3. Keratinized mucosa: protective factor or clinical marker?

The role of keratinized mucosa remains one of the more debated aspects of peri-implant tissue management. Earlier evidence syntheses have generally associated a reduced width of keratinized mucosa with greater plaque accumulation, soft tissue inflammation, mucosal recession, and marginal bone loss. An umbrella review published in 2025, which synthesized ten systematic reviews, reported significant associations between narrow keratinized mucosa and several peri-implant clinical outcomes, although the strength of evidence varied across outcomes. More recent evidence provides a more nuanced interpretation. A 2026 systematic review and meta-analysis of 12 cohort studies involving 938 patients and 2,646 implants found no statistically significant association between keratinized mucosa and the incidence of peri-implant mucositis. In contrast, the presence of keratinized mucosa and a width of at least 2 mm were associated with a lower incidence of peri-implantitis. Thus, it would be inappropriate to describe keratinized mucosa as a universal determinant of peri-implant disease. Its clinical significance appears to depend on the specific outcome under investigation and on the broader biological and behavioral context. A more appropriate interpretation is that keratinized mucosa constitutes one component of the peri-implant risk profile and may contribute to tissue stability and maintainability, particularly when combined with effective plaque control and appropriate maintenance.

4.4. Three-dimensional implant positioning

Implant positioning represents a potentially modifiable determinant of peri-implant soft tissue stability. An implant positioned excessively toward the facial aspect may compromise the available hard and soft tissue dimensions and increase the likelihood of mucosal instability. Implant depth and angulation may additionally influence the emergence profile and the relationship between the implant-supported restoration and surrounding soft tissues. Consequently, implant planning should not be reduced to identifying a sufficient volume of bone for primary stability. The desired final position of the implant should also take into consideration the future soft tissue contour and prosthetic emergence profile. Three-dimensional imaging and digital planning can facilitate this process by providing information regarding the available bone anatomy and spatial limitations. Nevertheless, digital planning should complement rather than replace direct clinical assessment of the soft tissue phenotype.

4.5. Timing of implant placement

Immediate implant placement can shorten treatment time and reduce the number of surgical interventions. Nevertheless, extraction initiates remodeling of the alveolar ridge, and the resulting anatomical changes may influence the peri-implant soft tissue contour. The relationship between immediate implant placement and soft tissue recession is therefore conditional rather than absolute. The clinical outcome depends on factors such as facial bone integrity, soft tissue phenotype, implant position, defect morphology, and the use of appropriate hard- and soft-tissue management.

The 2025 systematic review identified immediate implant therapy as a risk factor for certain forms of peri-implant soft tissue dehiscence. This finding should not be interpreted as evidence that immediate implantation is inherently inferior. Rather, it emphasizes the importance of careful patient selection and anatomical assessment when this treatment protocol is considered.

4.6. Soft tissue augmentation

Soft tissue augmentation is increasingly used to modify peri-implant tissue dimensions when the existing phenotype is considered insufficient. Evidence indicates that different augmentation techniques have different clinical objectives. A 2026 systematic review and Bayesian network meta-analysis including 48 randomized controlled trials found that an apically positioned flap combined with a free gingival graft was the most effective approach for increasing keratinized tissue width, whereas connective tissue graft-based bilaminar techniques demonstrated the strongest performance for increasing mucosal thickness. These findings have an important clinical implication: augmentation procedures should be selected according to the desired biological endpoint rather than simply according to the availability of a particular graft material. A separate 2026 systematic review of 27 randomized controlled trials also reported favorable long-term outcomes for connective tissue grafts with regard to keratinized mucosa, mucosal thickness, marginal tissue stability, and aesthetic outcomes, while collagen-based substitutes may represent alternatives when reduced donor-site morbidity is prioritized. Similarly, a 2024 systematic review comparing soft tissue substitutes with conventional grafting approaches found that free gingival grafts were more effective than substitutes for increasing keratinized mucosa around implants. Taken together, the evidence suggests that soft tissue augmentation should be viewed as a targeted intervention whose indication and technique are determined by the specific tissue deficiency.

5. Integrated Interpretation of Risk Factors

The principal contribution of the current analysis is the interpretation of peri-implant soft tissue complications as the result of interacting risk factors. A thin mucosal phenotype may become clinically more significant when accompanied by unfavorable implant positioning. Similarly, a limited zone of keratinized mucosa may be more problematic in a patient with inadequate plaque control than in a patient with excellent oral hygiene and regular maintenance. Therefore, a binary approach—such as classifying an implant site as simply “high risk” or “low risk” based on one measurement—may not adequately reflect the biological complexity of peri-implant tissue behavior. A more clinically useful framework involves evaluating:

Soft tissue phenotype → hard-tissue anatomy → implant position → surgical protocol → prosthetic emergence → maintenance.

This sequence emphasizes that prevention begins before implant placement and continues throughout the restorative and maintenance phases.

6. Clinical Implications

Based on the current evidence, peri-implant soft tissue assessment should be incorporated into implant treatment planning. The following parameters deserve particular attention:

1.Soft tissue phenotype and mucosal thickness should be assessed before surgery.

2.Keratinized mucosa should be documented as part of the peri-implant risk assessment rather than interpreted as an isolated disease predictor.

3Three-dimensional implant positioning should be planned with consideration of both bone anatomy and the anticipated soft tissue contour.

4.Immediate implant placement should be reserved for appropriately selected anatomical situations.

5.Soft tissue augmentation should be considered when a specific tissue deficiency is identified.

6.The choice of augmentation technique should correspond to the intended outcome, such as increasing keratinized tissue width or mucosal thickness.

7.Long-term supportive maintenance remains essential because anatomical tissue characteristics alone cannot compensate for inadequate plaque control.

7. Scientific Novelty

The scientific value of this analysis lies in the integrated interpretation of peri-implant soft tissue recession and inflammation. Rather than presenting keratinized mucosa, mucosal thickness, implant position, and augmentation as independent determinants, the present review considers them as interconnected components of an individualized peri-implant risk profile. This perspective is consistent with recent evidence showing that different soft tissue parameters are associated with different clinical outcomes and that the effectiveness of augmentation depends on the biological objective of treatment.

8. Limitations

This work is a literature-based analytical review and does not present original clinical data. The available evidence is characterized by heterogeneity in study design, patient populations, implant systems, surgical protocols, follow-up periods, and definitions of peri-implant soft tissue outcomes. Furthermore, associations identified in observational studies should not automatically be interpreted as causal relationships. The clinical importance of individual risk factors may vary according to patient characteristics and the combination of other local and systemic variables.

9. Conclusion

Peri-implant soft tissue recession and inflammation represent multifactorial outcomes arising from the interaction of tissue phenotype, keratinized mucosa, implant positioning, anatomical conditions, surgical timing, augmentation procedures, and long-term maintenance. Current evidence supports the relevance of mucosal thickness and implant positioning in maintaining soft tissue stability, while the role of keratinized mucosa appears to vary according to the specific peri-implant outcome being evaluated. Recent evidence also indicates that soft tissue augmentation can effectively modify tissue dimensions when the technique is appropriately matched to the clinical objective.

Accordingly, prevention of peri-implant soft tissue complications should begin with individualized preoperative risk assessment and continue through three-dimensional implant planning, appropriate soft tissue management, prosthetic rehabilitation, and supportive maintenance.

The most clinically appropriate strategy is therefore not to search for a single “protective” tissue parameter, but to identify and manage the combination of factors that determines the biological environment around each implant.

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