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RESEARCH ARTICLE

SOFT TISSUE MANAGEMENT AROUND DENTAL IMPLANTS – A REVIEW

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ABSTRACT

Peri-implant soft tissue management is a critical determinant of long-term dental implant success, influencing esthetics, biological stability, and patient comfort. While early implantology prioritized osseointegration, contemporary evidence emphasizes the importance of keratinized mucosa width, mucosal thickness, and soft tissue contour in preventing inflammation, marginal bone loss, and mucosal recession. Autogenous grafts such as free gingival grafts (FGG) and subepithelial connective tissue grafts (SCTG) remain the gold standard for soft tissue augmentation, whereas acellular dermal matrices, collagen scaffolds, and platelet-rich fibrin (PRF) provide effective alternatives with reduced morbidity. Proper surgical technique, including meticulous flap design, vascular preservation, and biologically guided prosthetic planning, is essential for maintaining peri-implant tissue health. Digital technologies, minimally invasive approaches, and phenotype-based planning further enhance esthetic and functional outcomes. Integrating these strategies ensures predictable long-term stability, optimal esthetic results, and improved patient satisfaction, highlighting soft tissue management as a cornerstone of modern implant therapy.

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INTRODUCTION

The replacement of missing teeth has been a longstanding goal in dentistry. As early as 2000 BC, ancient civilizations like the Chinese and Mayans used bamboo pegs and seashell fragments as primitive implants (1). These early efforts reflected a persistent desire to restore function and esthetics.Modern implantology began in the 20th century with metallic implants such as vitallium and stainless steel, which often failed due to poor biocompatibility (2). A breakthrough occurred in the 1950s when Brånemark discovered osseointegration—the direct bond between bone and titanium (3). His research in the 1960s confirmed titanium's long-term stability, and by the 1980s, osseointegrated implants became a reliable treatment modality (4). Initially, success was defined by implant stability and survival rates exceeding 90% over ten years (5). By the 1990s, esthetic outcomes—especially in the anterior maxilla—gained importance. Clinicians recognized that even stable implants could fail esthetically due to mucosal recession or poor gingival contours (6), expanding the definition of success to include biological and esthetic factors.Early implant systems overlooked soft tissue biology, leading to marginal bone loss and mucosal recession (7). Research showed that insufficient keratinized mucosa and thin biotypes increased inflammation and discomfort. Berglundh and Lindhe (1996) demonstrated that peri-implant mucosa forms a protective seal akin to the dentogingival junction (8), while Wennström and Derks (2009) highlighted its role in comfort and plaque control (9). By the 2000s, soft tissue quality was recognized as vital for esthetic and biological success. Buser *et al*. (2004) emphasized the importance of mucosal stability, biotype, and papilla preservation (10). The mucosa not only prevents microbial invasion (11) but also supports gingival contours and functional resilience (12). Thick, keratinized tissue correlates with reduced bone loss and better esthetics (13).Challenges persist due to post-extraction resorption, thin biotypes, and prior periodontal disease (14,15). The below table encloses the types of soft tissue defects encountered in implants. Surgical advances have improved soft tissue outcomes. Autogenous grafts like FGG and SCTG remain gold standards (16), while biomaterials such as acellular dermal matrices offer reduced morbidity (17). Microsurgical tools, papilla preservation flaps, and biologically active adjuncts like PRF and growth factors further enhance healing and regeneration (18,19).Professional consensus underscores the importance of soft tissue management. The AAP (2020) links inadequate keratinized mucosa to peri-implant disease (20), and the EAO (2021) supports augmentation for improved stability and esthetics (21). Systematic reviews confirm its role in long-term health and patient satisfaction (22). Implantology has evolved from a focus on osseointegration to a

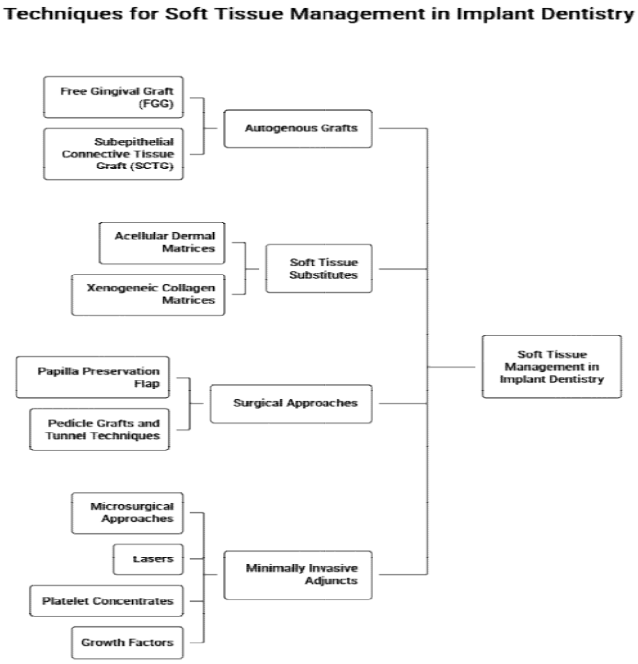
comprehensive approach integrating biological, functional, and esthetic harmony. Peri-implant soft tissue management is now central to achieving predictable, long-lasting outcomes.

Review

Peri-Implant Soft Tissue: Anatomy, Significance, and Clinical Management: Peri-implant soft tissues are critical for long-term implant success, forming a biological seal that protects against microbial invasion and mechanical trauma (31). Unlike gingiva around natural teeth, peri-implant mucosa has parallel or circular collagen fibers, fewer fibroblasts, and lacks direct insertion into titanium, resulting in weaker attachment (32). Reduced vascularity, due to the absence of a periodontal ligament, further limits regenerative potential. The supracrestal tissue ("biologic width") averages 3–4 mm, with ~2 mm junctional epithelium and 1–1.5 mm connective tissue, but lower vascularity renders it less resilient.

The peri-implant phenotype—comprising keratinized mucosa width (KMW), mucosal tissue thickness (MTT), supracrestal tissue height (STH), and underlying bone—guides surgical and restorative planning (33). A KMW ≥2 mm improves plaque control, reduces inflammation, and enhances comfort, though meticulous hygiene can maintain health even with narrower mucosa (34). MTT >2 mm reduces marginal bone loss, masks metallic abutments, and improves esthetics, while thin mucosa (<2 mm) increases crestal bone loss risk (37). STH, typically 3–4 mm, is essential for biological and esthetic stability, with insufficient vertical dimensions predisposing to marginal bone loss (40,41). The importance of peri-implant soft tissues has evolved from a secondary consideration to a central determinant of implant success. While osseointegration remains the biological foundation of implant stability (12), it is now recognized that the surrounding mucosa governs long-term health and appearance. The peri-implant mucosa acts as a protective barrier that mimics the natural junctional epithelium, preventing microbial ingress and crestal bone resorption (42). Adequate keratinized mucosa enhances patient comfort, plaque control, and resistance to inflammation, while sufficient thickness ensures color blending and esthetic integration with adjacent dentition (43).

From a biological standpoint, peri-implant soft tissues differ fundamentally from the periodontal structures of natural teeth. The absence of the periodontal ligament results in a mucosal seal that is more fragile and less resistant to apical bacterial migration (40). Maintenance of the average vertical dimension of 3–4 mm—analogous to the biologic width—is vital to prevent bone loss, while a soft tissue thickness of at least 2 mm correlates strongly with reduced resorption and improved esthetic predictability (17). Clinically, successful implant therapy necessitates precise soft tissue management. Strategies include autogenous grafting, the use of soft tissue substitutes, surgical flap modification, and biologically driven adjuncts. Autogenous grafts remain the gold standard due to their predictable outcomes. Free gingival grafts (FGG) effectively increase the width of keratinized mucosa, enhancing hygiene and comfort, though they may cause donor-site morbidity and color mismatch (44). Subepithelial connective tissue grafts (SCTG) are widely regarded as the most reliable technique for augmenting mucosal thickness and achieving superior esthetic results, albeit at the cost of longer surgical time and increased morbidity (45). To mitigate the limitations of autogenous grafting, soft tissue substitutes such as acellular dermal matrices and xenogeneic collagen scaffolds have been developed. These materials eliminate the need for a donor site, reducing postoperative discomfort while achieving satisfactory, though slightly less predictable, augmentation (46,47). Refined surgical approaches also play an essential role, particularly in esthetic regions. Techniques such as papilla preservation, pedicle flaps, and tunneling help maintain vascularity, minimize scarring, and preserve natural gingival architecture (48). When combined with grafts or substitutes, these approaches yield improved esthetic integration and patient satisfaction. The advent of minimally invasive and biologically enhanced procedures has further advanced soft tissue management. Microsurgical methods allow precise tissue manipulation with superior healing outcomes, while laser-assisted techniques aid in decontamination and reshaping with minimal trauma. Biologic adjuncts, including platelet concentrates like PRF and PRP, promote angiogenesis and soft tissue maturation (49). Growth factors such as enamel matrix derivatives and recombinant PDGF are also being explored for their regenerative potential and ability to improve mucosal stability (50). Overall, the peri-implant soft tissues are now recognized as a critical component in ensuring the biological integrity, esthetic harmony, and functional longevity of dental implants. Their management requires a thorough understanding of anatomical nuances, biological behavior, and evolving surgical innovations that collectively contribute to the modern concept of comprehensive implant care.



Soft Tissue Management During Different Stages of Surgical Placement of Dental Implants: Soft tissue augmentation may be performed at various stages of implant therapy—before placement, during implant surgery, at second-stage exposure, or following prosthetic loading. Each stage offers unique opportunities to enhance the peri-implant soft tissue environment based on the defect type, tissue biotype, and esthetic requirements. The attached gingiva, a firm and resilient tissue bound to the periosteum, contributes to long-term peri-implant health by providing resistance against mechanical trauma and microbial invasion. Its width and thickness can be augmented through procedures such as apically positioned flaps or subepithelial connective tissue grafts, ensuring stability and favorable esthetic outcomes (51).

Before Implant Placement: Soft tissue augmentation before implant placement is recommended when significant mucogingival or alveolar deficiencies are present, particularly in long-standing edentulous areas. In such cases, both hard and soft tissue regeneration should ideally be performed prior to implant insertion, as deficiencies in one can affect the other. Scarred or inelastic tissues from prior surgery may compromise primary closure during guided bone regeneration (GBR). To optimize healing and reduce the need for multiple interventions, procedures to enhance the width of attached gingiva—such as free gingival grafts (FGG)—can be performed before implant placement (52). The free gingival graft, introduced by Sullivan and Atkins (1968), remains a reliable technique for increasing keratinized mucosa width and thickness around teeth and implants.(44) Though effective, it requires careful case selection, as donor site availability is limited and postoperative color mismatch may occur. Healing typically requires several months before subsequent procedures can be performed.(53) Clinical cases have demonstrated that pre-surgical soft tissue augmentation with FGG facilitates primary closure in vertical bone augmentation, thereby improving both esthetic and functional outcomes (54).

Type Of Soft Tissue Defect	Features	Key Authors	Clinical Relevance
1. Mucosal Recession around Implants	Apical migration of peri-implant mucosal margin; exposed abutment/crown	Fu & Wang, 2011	Leads to esthetic compromise in anterior zone; exposes implant components; affects patient satisfaction.
2. Thin Peri-implant Biotype / Tissue Thickness < 2 mm	Thin mucosa is more prone to mechanical stress and transparency (gray shine-through)	Linkevicius *et al*., 2010	Increases susceptibility to recession, poor esthetics, bacterial penetration, and long-term tissue instability.
3. Lack of Keratinized Mucosa (KM < 2 mm)	Reduced or absent keratinized band around implant collar	Wennström & Derks, 2012)	Causes plaque accumulation, inflammation, pain on brushing, and increased incidence of peri-implant mucositis.
4. Buccal Contour Deficiency / Soft Tissue Volume Loss	Flattened or concave buccal profile due to ridge resorption or thin tissues	Chu *et al*., 2012	Affects emergence profile, facial esthetics, and creates shadows/dark triangles in smile zone.
5. Scarring or Non-keratinized Mobile Tissue	Post-surgical scarring or unstable vestibular tissue around implant	Buser *et al*., 2004	Leads to reduced biomechanical seal, discomfort during oral hygiene, and vulnerability to tissue breakdown.
6. Peri-implant Mucositis-related Soft Tissue Inflammation	Soft tissue redness, swelling, BOP without bone loss	Berglundh *et al*., 2018	Reversible, but if untreated → evolves into peri-implantitis, threatening implant survival.
7. Soft Tissue Dehiscence Following Immediate Implant Placement	Soft tissue collapse after extraction → implant placed too buccally or thin flap	Tarnow *et al*., 2014	Leads to severe recession, compromised esthetics, and need for secondary soft tissue grafting.

During Implant Placement: The success of implant surgery depends greatly on precise flap design and tissue handling. Proper flap design ensures optimal access, visibility, vascular integrity, and tension-free closure. It should avoid placing incisions over bony defects and preserve blood supply to minimize postoperative complications. Kleinheinz *et al*. (2005) highlighted that mid-crestal incisions in edentulous ridges and limited vertical releasing incisions in the anterior region optimize vascular preservation (56).

Two main surgical approaches are employed:

- Flapped approach: Provides excellent visibility and access, making it suitable for simultaneous bone augmentation but may disrupt vascularity and risk crestal bone loss.
- Flapless approach: Minimally invasive, preserving blood supply and reducing morbidity but offering limited visibility and access.

The choice of technique should balance surgical control with biological preservation and esthetic requirements (54).

During Second-Stage Surgery: Soft tissue deficiencies are frequently addressed during the second stage, once osseointegration is achieved. The apically positioned flap is an effective method to increase keratinized mucosa without requiring a second donor site, though it does not enhance soft tissue thickness. Free gingival grafts are also used at this stage to improve mucosal stability around implants; however, the use of palatal donor tissue often results in color mismatch. A modified approach utilizing buccal keratinized gingiva as the donor has shown superior esthetic results but requires careful tissue selection to prevent adjacent recession (54). The rotated pedicle flap, introduced by Harvey in 1970, offers another alternative for increasing keratinized mucosa. Similarly, the rotated connective tissue graft provides additional thickness while maintaining adequate vascularity to ensure graft survival. In cases requiring extensive augmentation, the vascularized interpositional periosteal connective tissue flap (VIP-CT) has shown success in increasing keratinized mucosa during second-stage procedures, promoting better vascularization and predictable healing (57).

After Implant Loading: Following prosthetic loading, soft tissue deficiencies or recession may develop, particularly in thin biotypes. Recession increases with age and is influenced by traumatic brushing, inflammation, and lack of bone support. These changes compromise esthetics and patient comfort. Autogenous connective tissue grafts, combined with coronally advanced flaps, remain the gold standard for post-loading correction, providing increased thickness, root coverage, and stable esthetic outcomes. Clinical studies have shown approximately 66% root coverage at six months using this method (58). Acellular dermal matrix (ADM) allografts, introduced in dentistry in 1996, serve as an alternative to autogenous grafts. These scaffolds promote cellular repopulation without requiring a donor site, thereby minimizing morbidity. ADM has demonstrated favorable outcomes in increasing tissue thickness and improving color match, making it a viable substitute in cases where autogenous grafting is contraindicated (59).

Role of Prosthesis: The prosthesis is integral to peri-implant soft tissue stability and long-term success. An appropriately contoured prosthesis preserves the mucosal seal, maintains biologic width, and facilitates plaque control through ideal emergence profiles and contact point positioning. Belser *et al*. emphasized the influence of prosthetic design on soft tissue architecture and papilla formation, particularly in esthetic areas.(21) Choquet *et al*. found that a bone crest-to-contact point distance ≤5 mm is critical for papilla preservation. Material selection and shade matching also affect optical harmony between peri-implant mucosa and adjacent gingiva, as demonstrated by Park *et al*.(22) Functionally, occlusal design must prevent mechanical overload to avoid bone loss and prosthetic complications. Therefore, the prosthesis should be considered an active biological component that complements surgical and soft tissue management for achieving long-term esthetic and functional success (60).

DISCUSSION

The success of implant therapy is no longer judged solely by osseointegration but by the harmonious integration of the implant with surrounding hard and soft tissues. Peri-implant soft tissue health, architecture, and phenotype have emerged as major determinants of both functional stability and esthetic excellence. The structural differences between peri-implant mucosa and natural gingiva play a decisive role in clinical outcomes, influencing the susceptibility of implants to inflammation, bone loss, and esthetic failure. Histologic observations by Berglundh and Lindhe (1991) demonstrated that the peri-implant mucosa lacks the periodontal ligament and its associated vascular network, resulting in a hypovascular, hypocellular connective tissue zone (8). The collagen fibers around implants run parallel to the surface rather than inserting perpendicularly as they do into the cementum of natural teeth, which weakens the connective attachment and makes the mucosal seal more vulnerable to disruption. Consequently, even minor microbial or mechanical insults can precipitate apical spread of inflammation, leading to marginal bone loss. Understanding these anatomic and biological differences has led to the evolution of modern soft tissue management strategies designed to protect the mucosal barrier and maintain long-term implant stability (23,24). The concept of supracrestal gingival tissue (SGT), previously termed “biologic width,” has been extensively studied. Around implants, it measures approximately 3–4 mm, comprising about 2 mm of junctional epithelium and 1–1.5 mm of connective tissue (24). Although these dimensions are comparable to natural dentition, peri-implant tissues exhibit lower resilience due to reduced vascularity and altered fiber orientation. This structural limitation explains why the peri-implant mucosa is more susceptible to mucositis and peri-implantitis when oral hygiene is inadequate. The peri-implant phenotype, encompassing keratinized mucosa width (KMW), mucosal tissue thickness (MTT), and supracrestal tissue height (STH), has

recently gained recognition as a predictive factor for esthetic and biological outcomes (25). A thick labial phenotype, characterized by a wide zone of keratinized mucosa and a thick mucosal layer, provides superior resistance to trauma, less recession, and better color stability. Conversely, thin phenotypes, particularly with a reduced buccal bone plate, are associated with higher rates of mucosal recession and esthetic compromise. Studies have shown that soft tissue augmentation, whether before or after implant placement, can effectively modify thin phenotypes, thereby improving long-term predictability and patient satisfaction (25). The importance of an adequate keratinized mucosa width (KMW) around implants has been debated for decades. Clinical studies demonstrate that a KMW ≥2 mm is associated with improved plaque control, reduced bleeding on probing, and lower mucosal inflammation (28). Wennström and Derks (2009) confirmed that implants with narrow or absent keratinized mucosa tend to exhibit higher plaque accumulation and discomfort during brushing, leading to chronic inflammation. Conversely, adequate keratinization enhances patient comfort, facilitates oral hygiene, and improves the mechanical resilience of the mucosal margin (37). However, some reports suggest that meticulous hygiene may compensate for limited KMW, indicating that individual patient compliance plays a modifying role (38). Mucosal tissue thickness (MTT) has a direct correlation with crestal bone stability. Linkevicius *et al*. (2009) observed that implants with mucosal thickness <2 mm exhibited significantly greater marginal bone loss compared to those with thicker soft tissues. This is attributed to the close proximity of the microgap and bacterial leakage to the crestal bone in thin mucosa, initiating bone remodeling and loss (39). Therefore, several authors recommend soft tissue grafting to achieve at least 2 mm of mucosal thickness before or during implant placement. Thicker mucosa not only enhances esthetic blending and reduces gray metal shine-through but also provides a more stable soft tissue seal resistant to bacterial insult (40).

Similarly, supracrestal tissue height (STH) represents the vertical soft tissue dimension extending from the mucosal margin to the bone crest. Studies by Abrahamsson *et al*. (1996) demonstrated that peri-implant STH tends to be 1–1.5 mm greater than that of natural teeth and is directly associated with papilla volume and interproximal esthetics (41). Inadequate STH during implant placement predisposes to early crestal bone loss and esthetic disharmony, emphasizing the need for careful preoperative assessment of interproximal space morphology (42). Soft tissue management can be performed at multiple stages of implant therapy—before placement, during surgery, at the second stage, or after loading—depending on clinical needs and patient anatomy. Pre-surgical augmentation is particularly indicated in long-standing edentulous ridges or scarred areas with limited elasticity. The Free Gingival Graft (FGG), described by Sullivan and Atkins (1968), remains a predictable method for increasing keratinized mucosa width prior to implant placement (44,53). Case studies have shown that performing soft and hard tissue augmentation simultaneously during extraction or ridge preservation phases can shorten treatment time and improve healing outcomes (54). During implant placement, meticulous flap design plays a crucial role in preserving soft tissue architecture and vascularity. Kleinheinz *et al*. (2005) emphasized that mid-crestal incisions in edentulous ridges and minimal vertical releases preserve the posterior-to-anterior blood flow essential for healing (55,56). The choice between flapped and flapless approaches depends on visibility requirements and tissue biotype. While flapped techniques permit direct visualization and contour modification, flapless surgery preserves vascularity and reduces morbidity, making it suitable for thick biotypes with adequate keratinized tissue (54). In the second-stage surgery, when the implant is uncovered, soft tissue deficiencies can be corrected through apically positioned flaps, rotated pedicle flaps, or connective tissue grafts. The rotated pedicle flap, first introduced by Harvey (1970), provides an alternative to free grafts by maintaining vascular continuity and minimizing color mismatch (54). Recently, the Vascularized Interpositional Periosteal Connective Tissue Flap (VIP-CT) has been proposed as an advanced option to increase keratinized tissue zones with predictable vascular supply, improving long-term esthetic outcomes (57). After prosthetic loading, soft tissue deficiencies such as recession and translucency often become more noticeable. Studies indicate that gingival recession around implants increases with age and thin biotypes, affecting patient satisfaction. The use of Subepithelial Connective Tissue Grafts (SCTG) remains the gold standard for recession coverage and tissue thickening due to its superior vascularity and integration capacity (45,58). However, the introduction of Acellular Dermal Matrix (ADM)allografts in the late 1990s provided an alternative that eliminates donor site morbidity while achieving satisfactory esthetic outcomes (9). ADM serves as a scaffold for fibroblast and epithelial migration, supporting angiogenesis and long-term volume stability.

The prosthetic component plays an equally significant role in peri-implant soft tissue preservation. The emergence profile, contact point positioning, and restorative contour influence mucosal support and papilla formation. Belser *et al*. (2004) highlighted that a well-contoured prosthesis enhances the mucosal seal and maintains biological width (6). Choquet *et al*. (2001) demonstrated that maintaining the distance between the contact point and bone crest ≤5 mm ensures predictable papilla regeneration. Additionally, Park *et al*. (2007) utilized spectrophotometric analyses to reveal that prosthetic material and color influence light reflection through peri-implant mucosa, underscoring the importance of prosthesis design in esthetic integration (31). Collectively, these findings affirm that peri-implant soft tissue management is a multifactorial discipline integrating biology, surgical technique, and prosthetic design. The current AAP (2020) and EAO (2021) consensus reports recommend phenotype-based approaches emphasizing minimally invasive, regenerative, and biomaterial-assisted techniques to achieve both biological stability and esthetic excellence (20,21). Soft tissue augmentation is no longer an adjunct but a fundamental step in comprehensive implant therapy. Future perspectives focus on digital planning, guided surgery, and the integration of biologics such as PRF, enamel matrix derivatives, and growth factors to enhance angiogenesis and accelerate tissue maturation. Artificial intelligence and digital phenotyping tools may soon enable clinicians to predict soft tissue outcomes preoperatively, improving individualized treatment planning. In summary, peri-implant soft tissue management represents a cornerstone of modern implantology. The interplay of biologic seal integrity, adequate mucosal dimensions, and prosthetic harmony determines both the survival and success of implants. With evidence-based surgical protocols and biomaterial innovations, clinicians can achieve predictable, esthetically pleasing, and biologically stable outcomes that endure over time.

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