

OPTIMAL PLACEMENT OF DENTAL IMPLANTS: ASSESSING BONE, SOFT TISSUE, DEPTH, AND POSITION FOR LONG-TERM SUCCESS

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Abstract

The optimal placement of dental implants significantly influences their long-term functional and aesthetic success. This article consolidates evidence-based strategies, emphasizing the importance of key factors such as soft tissue thickness, keratinized tissue presence, implant depth, three-dimensional positioning, and crown material selection. Results demonstrate that a minimum soft tissue thickness of 2 mm effectively reduces marginal bone loss by up to 0.8 mm and enhances implant stability. Similarly, at least 2 mm of keratinized tissue is essential for reducing peri-implant diseases and promoting tissue health. Implant placement 3–4 mm below the gingival margin, with sufficient buccal bone support, minimizes gingival recession and supports esthetic outcomes. Zirconia crowns and polished surfaces are shown to significantly lower plaque accumulation and inflammation, enhancing peri-implant health. Furthermore, platform switching consistently reduces bone loss by 0.3–0.8 mm, particularly in mechanically stressed regions, while custom healing abutments preserve soft tissue architecture and improve integration. These findings provide a comprehensive framework for achieving predictable and sustainable outcomes in implantology, integrating advanced techniques and precise clinical parameters.

Keywords: Dental Implants; Gingiva; Connective Tissue; Tissue Thickness; Peri-Implantitis.

1. Introduction

The placement of dental implants is a cornerstone procedure in modern dentistry, addressing both functional and aesthetic rehabilitation. However, significant uncertainties persist regarding optimal positioning relative to bone and soft tissues to ensure long-term success. The oral microbiota plays a pivotal role in this context, as its composition differs markedly between periodontal patients and those with implants. Studies, including Butera et al., have demonstrated that peri-implant environments foster unique microbial ecosystems, with pathogenic shifts occurring in the presence of peri-implant mucositis or peri-implantitis. Minimally invasive systems, such as air polishing with glycine or erythritol powders, have shown promise in the long-term maintenance of implant health and in

managing early-stage complications like mucositis [1].

Implant stability is crucial for successful osseointegration and the long-term retention of bone. Factors such as bone quality, soft tissue health, implant design, and placement techniques interact in complex ways to influence outcomes. Recent advancements in biomimicry—mimicking the natural biology of tissues and bones—have brought transformative insights, particularly in implant surface treatments and custom abutment designs. This approach aims to harmonize implant integration with the natural anatomy and physiology of the peri-implant environment, further improving success rates. Despite technological progress, the classification and management of peri-implant diseases remain essential. The 2023 Herrera classification offers a comprehensive framework for diagnosing and treating peri-

implant conditions, emphasizing the importance of early detection and personalized care. These insights highlight the need for precise placement parameters, supported by evidence-based guidelines, to address gaps in the current literature [2].

This article aims to consolidate current knowledge and provide a systematic review of evidence-based strategies for the optimal placement of dental implants. By integrating concepts such as microbiota modulation, biomimicry, and minimally invasive techniques, this work seeks to enhance the predictability and success of dental implant procedures, improving patient outcomes and satisfaction.

2. Stability of Soft Tissue around Dental Implants

Stability of the soft tissue surrounding a dental implant is a fundamental factor in achieving both functional and aesthetic success. Soft tissue thickness plays a crucial role in protecting the implant and maintaining healthy peri-implant tissues. Ensuring adequate soft tissue coverage is essential for long-term stability and prevention of complications. Keratinized tissue is another critical element in maintaining peri-implant health. The presence of a sufficient band of keratinized tissue around the implant helps protect the underlying bone and supports the stability of the soft tissue, reducing the risk of inflammation and other complications. The choice of crown material and surface finish is also significant in promoting healthy peri-implant tissues. Lastly, the depth and positioning of the implant are vital in supporting gingival health and achieving a successful prosthetic outcome.

2.1 Soft tissue thickness

The management of soft tissue is crucial for the success of dental implants. Adequate gingival thickness significantly contributes to implant stability and the preservation of crestal bone. Studies indicate that a soft tissue thickness of at least 2 mm is ideal for maintaining peri-implant health and preventing bone resorption. Proper manipulation and management of the soft tissue during implant placement are

essential to ensure predictable long-term outcomes [3]. The thickness of soft tissue plays a pivotal role in the changes observed in crestal bone around dental implants. According to a systematic review by Linkevicius et al. [4], a minimum gingival tissue thickness of 2 mm is necessary to prevent significant crestal bone loss. The study found that when the soft tissue was less than 2 mm thick, crestal bone loss of up to 1.45 mm could occur. This indicates that thicker soft tissue not only enhances the aesthetic outcomes but also contributes significantly to the stability and preservation of the crestal bone, ultimately leading to better long-term success of dental implants. A study by Tavelli et al. [5] conducted a systematic review and network meta-analysis to evaluate the impact of soft tissue thickness on peri-implant health. The study found that increasing the soft tissue thickness around implants significantly reduced the incidence of peri-implantitis and other complications. Specifically, a minimum soft tissue thickness of 2 mm was identified as critical for maintaining healthy peri-implant conditions and preventing marginal bone loss. The influence of soft tissue thickness on marginal bone levels around dental implants is a critical factor for implant success. A systematic review with meta-analysis and trial-sequential analysis conducted by Bressan et al. [6] evaluated this relationship extensively. The study found that a thicker soft tissue (greater than 2 mm) around dental implants significantly reduces marginal bone loss compared to thinner tissues. Specifically, implants surrounded by thicker soft tissue showed an average marginal bone loss reduction of 0.3 mm over five years. Soft tissue considerations are paramount in the development of implant sites, as highlighted by Geurs et al. [7]. Their review discusses the significance of ensuring adequate soft tissue thickness and quality for successful implant integration and long-term stability.

2.2 Keratinized Tissue

The presence of keratinized mucosa around dental implants is essential for maintaining peri-implant health and ensuring long-term

stability. Chung et al. [8] highlighted the importance of adequate keratinized tissue, showing that implants surrounded by sufficient keratinized mucosa exhibited reduced signs of peri-implantitis and improved overall outcomes. This finding underscores the protective role of keratinized tissue in peri-implant health. Bouri et al. [9] demonstrated that a wider band of keratinized mucosa is beneficial for maintaining the health of peri-implant tissues. Their study found that implants with a keratinized mucosa width of at least 2 mm had significantly lower rates of inflammation and bone loss, indicating that sufficient keratinized tissue is crucial for preventing peri-implant complications. Warrer et al. [10] evaluated the role of keratinized tissue in the success of dental implants. They concluded that implants with adequate keratinized tissue were less prone to peri-implant mucositis and exhibited better long-term stability, highlighting the necessity of ensuring sufficient keratinized tissue during implant placement. A systematic review by

Schrott et al. [11] compiled evidence on the impact of keratinized mucosa on peri-implant health. The review concluded that adequate keratinized mucosa is crucial for preventing peri-implant diseases and ensuring the longevity of dental implants. Berglundh et al. [12] explored the influence of keratinized mucosa on the long-term stability of dental implants. Their findings indicated that implants with a surrounding band of keratinized mucosa had lower incidences of peri-implantitis and better preservation of crestal bone levels, emphasizing the critical role of keratinized tissue in maintaining implant success. Thicker keratinized tissue contributes to reduced marginal bone loss, lower incidence of peri-implantitis, and overall improved stability and aesthetics of dental implants. Additionally, excellent substitutes for autogenous connective tissue grafts, such as the mucoderm membrane (see Fig. 1), have shown promising results in comparison studies [13].

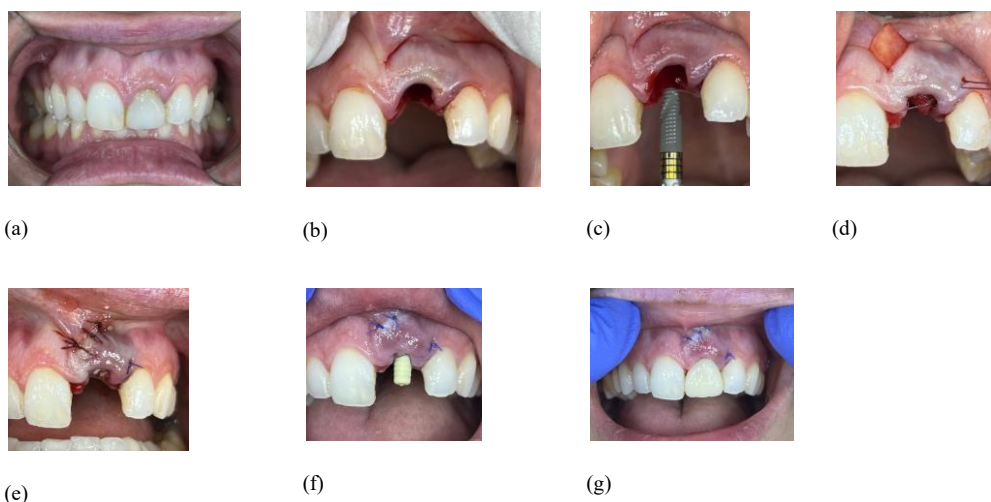


Figure 1. This Series of images documenting the surgical intervention for a vertically fractured central incisor. **(a)** Preoperative image of the natural tooth exhibiting a vertical fracture in the palatal region. **(b)** Post-extraction image of the central incisor, showing the incision design for a tunnel graft with mucoderm membrane. **(c)** Image capturing the placement of a Neodent Helix

GM 3.5x13 implant. **(d)** Image illustrating the placement of the mucoderm membrane through the tunnel. **(e)** Immediate postoperative image following the procedure. **(f)** Postoperative image taken 24 hours later. **(g)** Postoperative image taken 24 hours later with the temporary tooth in place.

2.3 Crown Material and Surface Finish

The material and surface finish of dental implant crowns significantly impact the long-term success of implants. According to Tawse-Smith et al. [14], different crown materials, such as zirconia and metal-ceramic, affect the durability and aesthetic outcomes of dental implants. Their study found that zirconia crowns demonstrated superior resistance to fracture and better aesthetic results compared to metal-ceramic crowns. Additionally, the study highlighted that polished surfaces on implant crowns reduced plaque accumulation and improved peri-implant health compared to glazed surfaces. Similarly, Bahadırli et al. [15] reported that different crown materials influence the durability and aesthetic outcomes of dental implants. The study emphasized that polished surfaces on implant crowns are more effective in reducing plaque accumulation and enhancing peri-implant health than glazed surfaces. Further Chankhore et al. [16] conducted a comprehensive review on prosthetic design factors influencing peri-implant disease, with a particular focus on the materials used for implant crowns. The study highlights the differences between various materials, such as ceramics, zirconia, and metals, analyzing their impact on peri-implant tissue health. Zirconia crowns are identified as a favorable option due to their high biocompatibility, fracture resistance, and lower plaque accumulation compared to other materials. Patel et al. [17] also evaluated various crown materials, including zirconia, metal-ceramic, and all-ceramic, for their durability, aesthetics, and impact on peri-implant health. Their study found that zirconia crowns offered superior aesthetic outcomes and fracture resistance compared to metal-ceramic crowns. Additionally, polished surfaces on implant crowns were shown to decrease plaque accumulation and enhance peri-implant health compared to glazed surfaces, leading to fewer cases of peri-implantitis and other complications.

2.4 Implant Depth and Positioning for Gingival Health and Prosthetic Success

In the esthetic zone, the precision of implant placement is critical not only for achieving

prosthetic success but also for maintaining healthy peri-implant soft tissues. The study by Testori et al. [18] details specific criteria for positioning both single and multiple implants to optimize outcomes. They emphasize that maintaining a buccal bone thickness of at least 2 mm and positioning the implant 3 to 4 mm apical to the future gingival margin are crucial for preventing gingival recession and ensuring long-term soft tissue stability. A systematic review conducted by Chen and Buser [19] provides insight into the esthetic outcomes following immediate and early implant placement in the anterior maxilla. This review underscores the significance of proper 3D positioning, particularly in the buccal-palatal dimension, to preserve peri-implant mucosa. They found that maintaining a minimum buccal bone thickness of 1.5 to 2 mm is essential for supporting the soft tissue and preventing mucosal recession. Hartlev et al. [20] explored the relationship between implant positioning and patient satisfaction in cases of immediate placement and provisionalization of single-tooth implants. Their study revealed that precise vertical and horizontal positioning, along with the use of a definitive individual abutment, significantly contributes to high patient satisfaction and favorable esthetic outcomes. Specifically, implants positioned 2 to 3 mm below the gingival margin and centered within the alveolar ridge were associated with stable soft tissue contours and a natural emergence profile. The research by Carpentieri et al. [21] on the hierarchy of restorative space required for different types of dental implant prostheses emphasizes the importance of vertical implant positioning. Their findings suggest that an implant positioned too deeply can result in an insufficient emergence profile, leading to compromised gingival health and esthetics. They recommend positioning the implant crestally or slightly subcrestally (1 to 2 mm) to ensure adequate restorative space and maintain healthy soft tissue around the implant. Gomez-Meda et al. [22] introduced the concept of the esthetic biological contour, which focuses on designing the emergence profile of the implant

restoration. They found that implants positioned too buccally or too shallowly can lead to gingival recession and an unnatural contour. The impact of 3D implant positioning on the emergence profile is further elaborated by Esquivel et al. [23]. Their study shows that implants placed 3 to 4 mm apical to the gingival margin with a slight lingual tilt ensure an optimal emergence profile and support healthy soft tissue. Norcia et al. [24] discussed the “root way” technique for implant positioning, which is particularly effective in post-extractive surgery. This technique involves aligning the implant with the original root position, ensuring that the gingival contour is preserved. The study reports that implants placed using this technique showed superior soft tissue outcomes, with minimal gingival recession and a more natural contour. Chu et al. [25] provided clinical guidelines on achieving an ideal restorative emergence profile for single-tooth implants. They highlight the importance of maintaining a minimum distance of 1.5 to 2 mm from the adjacent teeth and ensuring that the implant is positioned 3 mm below the gingival margin to achieve a natural and stable gingival margin. Saleh et al. [26] offered an overview of the prosthetic-biologic connection, emphasizing how the depth and position of the implant affect the interface between the prosthesis and surrounding soft tissues. Finally, Wu et al. [27] investigated the effect of implant length and insertion depth on the primary stability of short dental implants. They found that implants inserted 1 to 2 mm subcrestally showed increased primary stability, which is crucial for the success of short implants. However, the study also cautions that excessive insertion depth, particularly beyond 3 mm, can compromise peri-implant soft tissue health, leading to increased risk of peri-implantitis.

3. Crestal Bone Stability: Key Considerations for Optimal Maintenance

Achieving and maintaining crestal bone stability is essential for the long-term success of dental implants. This section of the article explores several critical factors that contribute to preserving the bone around the implant,

ensuring both functional and aesthetic outcomes. One of the fundamental aspects discussed is the macroscopic design of the implant itself. The shape and structure of the implant play a crucial role in how the bone adapts and integrates with the implant, influencing the overall stability and health of the peri-implant bone. Additionally, the design of the implant-abutment connection is another vital consideration. The way in which the abutment connects to the implant can significantly impact crestal bone levels. Innovations such as platform switching, where the abutment is narrower than the implant platform, have been shown to reduce bone resorption by minimizing stress at the bone-implant interface.

3.1 Macroscopic Implant Design and its Impact on Crestal Bone Stability

Stavropoulos et al. [28] investigated the impact of osteotomy preparation on the osseointegration of immediately loaded, tapered dental implants. The study emphasizes the differences in implant shapes, particularly focusing on tapered versus parallel-walled designs. Tapered implants, which mimic the natural root shape, are shown to have advantages in achieving primary stability, especially in cases of compromised bone density or immediate loading protocols. The authors highlight that the shape of the implant plays a crucial role in its ability to integrate effectively, with tapered designs offering better bone-to-implant contact and initial stability compared to parallel-walled implants. This enhanced stability is particularly beneficial for immediate loading, as it allows for a quicker and more secure integration into the bone. Al-Johany et al. [29] propose a classification scheme for dental implants based on their length and diameter, emphasizing the significance of these parameters in implant stability. They recommend a standard diameter of 3.75 mm to 4.2 mm for most cases, as it offers an optimal balance between stability and crestal bone preservation. The article also stresses that longer implants provide better load distribution, which is crucial for bone stability. Niroomand et al. [30] discuss how

topology optimization can be employed to design more stable dental implants. Their research suggests that implants with pronounced threads and a slightly tapered body are most effective for bone integration in immediate loading situations. Pettersson and Sennerby [31] conducted a 5-year retrospective study focusing on the clinical performance of Replace Select Tapered dental implants. The authors found that these implants demonstrated a high survival rate over the 5-year period, with minimal marginal bone loss and favorable clinical outcomes. The study supports the use of tapered implants for their predictable performance and effectiveness in diverse clinical situations. Moradi et al. [32] conducted a multi-objective design optimization of dental implant geometrical parameters, concluding that a design with deep threads and a tapered body offers better stress distribution and increased stability, which is critical for the success of delayed loading. Rigotti et al. [33], in their systematic review, emphasize the importance of implant thread design in stress distribution, noting that deeper, more aggressive threads are beneficial in low-density bone, as they increase primary stability and improve bone retention. Additionally, these implants are particularly effective in immediate loading procedures, where high initial stability is required. Steigenga et al. [34] explore the relationship between implant design and long-term implant success, concluding that implants with a tapered shape and deep threads are preferable in low-density bone situations, especially for delayed loading. This design not only improves primary stability but also minimizes crestal bone resorption by distributing masticatory forces more evenly. Callan [35] highlights that implant design selection must consider the patient's systemic and oral health, recommending tapered implants with pronounced threads for situations where immediate loading is anticipated. The tapered shape facilitates insertion and increases stability, which is crucial in patients with healing issues or low bone density. Finally, Laleman and Lambert [36] review how

implant connection and abutment selection influence peri-implant health, emphasizing that an implant design with a wider diameter at the alveolar crest and a broad platform internal connection is ideal for preserving crestal bone and ensuring implant longevity.

3.2 Implant Connection Design and its Impact on Crestal Bone Stability

The design of the implant-abutment connection plays a crucial role in the long-term success of dental implants, particularly in maintaining crestal bone stability. Laleman and Lambert [36] highlight that the type of connection between the implant and abutment can predispose implants to peri-implant diseases, which are closely linked to bone loss. Their review suggests that conical connections, particularly those with a Morse taper, provide superior stability compared to traditional external hexagonal connections, which are no longer preferred due to their higher susceptibility to microgap formation and bacterial infiltration. Do et al. [37] conducted a systematic review that identified risk factors associated with late implant failures, emphasizing the importance of connection design. The study also pointed out that the conical connection's self-locking mechanism enhances the seal at the implant-abutment interface, reducing micro-movements that could lead to bone loss. Alberti et al. [38] focused on the mechanical resistance of 2.9-mm-diameter implants with Morse taper connections, concluding that these implants are highly resistant to mechanical stresses. The study reinforces the notion that Morse taper connections, particularly those with an angle of approximately 11-12 degrees, offer optimal stability and reduce the risk of crestal bone loss. Lee et al. [39] used finite element analysis to study the biomechanical effects of different implant connection types on microgap formation and fatigue failure. The results indicated that internal conical connections significantly reduced microgap formation compared to external hexagonal connections. Szyszkowski and Kozakiewicz [40] conducted a long-term observational study comparing the effects of internal cone

and internal hex connections on bone around dental implants. Their findings suggest that internal cone connections result in less bone loss over time compared to internal hex connections. Koutouzis [41] discusses how the implant-abutment connection contributes to peri-implant diseases, particularly focusing on the advantages of conical connections. The review emphasizes that conical connections reduce the risk of peri-implantitis by minimizing the microgap and enhancing the mechanical stability of the implant-abutment interface. This is crucial for long-term crestal bone preservation. Block [42] provides evidence-based criteria for an ideal implant-abutment connection, advocating for the use of conical connections with a Morse taper.

3.3 Platform Switching and Marginal Bone Preservation: Evidence and Recommendations

The preservation of marginal bone levels around dental implants is critical for long-term success. Platform switching, which involves using an abutment with a smaller diameter than the implant platform, has been shown to reduce crestal bone loss. In a study by Salamanca et al. [43], a one-year retrospective analysis compared platform switching with platform matching. The study included a total of 120 implants placed in 60 patients, and the results indicated that the group using platform switching experienced less than 0.2 mm of marginal bone loss, compared to 0.8 mm in the platform matching group. This significant difference highlights the protective effect of platform switching on the peri-implant bone. Linkevicius et al. [44] investigated the impact of vertical soft tissue thickness on crestal bone changes around implants. They measured the soft tissue thickness in 100 patients and divided them into two groups: those with a soft tissue thickness of less than 2 mm and those with more than 2 mm. The results showed that patients with thinner soft tissues experienced 0.9 mm of bone loss, while those with thicker tissues had less than 0.3 mm of bone loss, suggesting that thicker soft tissues contribute to bone preservation when combined with platform switching. In the multicenter

randomized clinical trial conducted by Rocha et al. [45], 200 implants were placed in the posterior mandible of 100 patients. After three years, the platform switching group showed an average bone loss of 0.4 mm, compared to 1.0 mm in the platform matching group. This study emphasized the long-term benefits of platform switching in reducing crestal bone resorption, particularly in the posterior mandible, where mechanical forces are higher. Furthermore, Gupta et al. [46] conducted a systematic review that included 15 studies with over 1,500 implants. The review found that platform switching reduced bone loss by an average of 0.5 mm compared to platform matching, with the protective effect being most pronounced in implants placed in the esthetic zone. This study reinforced the idea that platform switching is an effective strategy for minimizing crestal bone loss and ensuring better long-term outcomes.

3.4 Impact of Implant Surface Texture on Bone and Gingival Behavior: Rough vs. Polished Surfaces

Albrektsson et al. [47] conducted a pioneering study on the effects of surface roughness on the osseointegration of dental implants. Their findings showed that rougher surfaces promote better bone-to-implant contact (BIC), with rates reaching up to 70-80% in rough-surfaced implants compared to 30-50% in smooth ones. They concluded that surface topography plays a significant role in accelerating bone healing and enhancing the overall stability of the implant. Regarding gingival health, the study suggested that polished surfaces tend to cause less plaque accumulation, which is critical in maintaining healthy peri-implant soft tissues. However, while polished surfaces reduce the likelihood of inflammation and bacterial colonization, they do not encourage soft tissue attachment as effectively as rough surfaces, which can lead to long-term gingival recession [45]. Thus, although polished surfaces may help prevent peri-implantitis, they might not provide the best environment for soft tissue stability. Buser et al. [48] investigated the healing process of rough-surfaced implants compared to smooth-surfaced ones. Their

study found that implants with a moderately rough surface significantly increased early bone apposition. On the other hand, smooth or polished surfaces were found to be beneficial for the soft tissue around the neck of the implant. Polished surfaces at the implant collar are known to reduce irritation to the gingiva, resulting in better mucosal health. However, this comes at the cost of less effective soft tissue attachment, potentially leading to minor soft tissue recession over time. They highlighted that while rough surfaces enhance osseointegration, smooth surfaces around the implant collar can improve soft tissue health by reducing peri-implant inflammation. In their study, rough surfaces reduced peri-implant soft tissue recession by up to 0.6 mm compared to polished collars. However, they also noted that implants with vertical polished collars led to greater soft tissue recession and bone loss, approximately 0.2-0.5 mm more than implants with rough collars [49]. The same research group argued that smooth collars should be avoided as they fail to provide the necessary attachment to the peri-implant mucosa, potentially leading to bacterial infiltration and tissue breakdown. Instead, a moderately rough collar provides both bone stability and sufficient soft tissue attachment, minimizing recession and enhancing overall peri-implant health. Various studies compared the clinical outcomes of rough versus smooth dental implant surfaces in terms of bone regeneration and soft tissue response. It was found that rough surfaces improve BIC percentages, with rough implants showing 75-80% compared to 50-60% for smooth implants. However, smooth surfaces around the neck of the implant were shown to have an advantage in reducing the risk of bacterial colonization and gingival inflammation [50]. The authors stressed that while smooth surfaces at the implant neck reduce plaque accumulation and inflammation, they do not encourage as strong an attachment to the peri-implant soft tissue. This may result in soft tissue recession over time. Therefore, a balance must be struck: rough surfaces for better bone integration and moderately smooth

surfaces to maintain gingival health without compromising soft tissue attachment.

3.5 Role of Custom Healing Abutments in Implant Dentistry

Custom healing abutments have emerged as a crucial innovation in modern implant dentistry, significantly enhancing both the aesthetic and functional outcomes of dental implants. These abutments, designed to mimic the natural anatomy of the surrounding soft tissues, contribute to optimal peri-implant healing and tissue integration. Unlike standard prefabricated abutments, custom healing abutments are tailored to the patient's unique anatomical features, allowing for better tissue contouring and reduced complications during the prosthetic phase. Research consistently shows that custom abutments provide superior soft tissue management, reducing the risk of gingival recession and promoting long-term implant stability. Chokaree et al. [51] explore how custom healing abutments contribute to peri-implant tissue health by evaluating various biomaterials such as PEEK, PMMA, titanium, and zirconia. The authors emphasize that custom abutments allow for better soft tissue contouring, reduce the need for additional surgeries, and promote a more natural emergence profile compared to standard abutments. The authors advocate for the use of materials like zirconia for aesthetic regions due to their favorable tissue responses and PEEK for its flexibility in provisional restorations. Lertwongpaisan et al. [52] examined the effects of custom titanium healing abutments on soft tissue architecture following immediate implant placement in posterior teeth. The study found that titanium abutments preserve soft tissue dimensions and minimize gingival recession over time. Their analysis focused on measuring gingival margin distance and volume, using digital scans to evaluate changes over 6 months post-surgery. The research concludes that custom titanium abutments play a critical role in stabilizing peri-implant tissues, particularly in areas of immediate loading. The use of these abutments allowed for greater soft tissue preservation, which is essential for long-term implant

success, particularly in functionally demanding regions like posterior teeth. In a pilot study, Rapone et al. [53] explored the use of digitally designed custom healing abutments fabricated via CAD/CAM technology to stabilize peri-implant soft tissues. The study included 40 patients and compared the outcomes of those who received customized abutments against those with standard abutments. The results showed a significant improvement in soft tissue stability and architecture in the test group over five years. The use of CAD/CAM technology to create these abutments ensures precision in soft tissue contouring, leading to reduced post-operative adjustments and improved long-term outcomes (Fig. 2).



Figure 2. This figure illustrates the process of implant placement in a case with significant bone and soft tissue deficiency. The image shows the lateral incisor and the right canine with a large defect of bone and gingiva, for which implants and a Straumann mucoderm membrane were placed. Custom healing abutments milled in transparent PMMA were affixed to the implants, secured with a suspensory 4-0 Vicryl suture [51].

El-Danasory et al. [54] present a detailed dental technique for creating custom healing abutments using CAD-CAM technology. Their research demonstrates that CAD-CAM abutments significantly enhance the efficiency of the treatment process by minimizing the number of clinical visits required. Akin et al. [53] investigated the benefits of using custom healing abutments in immediate posterior implant placements. They found that the use of these abutments improved soft tissue healing and helped maintain gingival architecture, which is often compromised in immediate placements. The study underscores the importance of custom abutments in managing soft tissue healing in posterior regions, where

immediate loading is common. The authors recommend the routine use of custom abutments for posterior implants to prevent soft tissue collapse and promote long-term stability. Perez et al. [56] conducted a randomized clinical trial comparing the effects of standard versus customized healing abutments on peri-implant tissue changes when used alongside simultaneous bone grafting. The study found that customized healing abutments significantly influence gingival tissue health and stability around immediate implants. The use of custom abutments was shown to promote better soft tissue contour and adaptation, improving both the esthetic outcomes and functional integration. These abutments helped maintain tissue volume and supported soft tissue maturation more effectively than standard abutments. Gomez-Meda et al. [57] introduce the concept of the "esthetic biological contour," which is achieved through the use of custom healing abutments. The authors propose that these abutments allow for the creation of a soft tissue contour that mimics the natural emergence profile of the tooth, enhancing both the aesthetic and functional outcomes of implant restorations. The results demonstrate that the use of custom abutments significantly reduces the need for additional surgical interventions to achieve a desirable tissue profile. Tešlak et al. [58] focuses on the development of custom anatomical healing abutments using cone-beam computed tomography (CBCT). The research indicates that CBCT-based custom abutments provide a more accurate fit, reducing the likelihood of soft tissue irritation and enhancing the overall success of the implant. Menchini-Fabris et al. [59] evaluated the impact of using immediate implants combined with customized healing abutments in periodontally compromised post-extraction sockets. The retrospective study focused on how the tailored design of healing abutments influences soft tissue adaptation and stability. The authors found that customized abutments significantly promote better gingival tissue contour and maturation in compromised sockets, helping to achieve

optimal esthetic and functional outcomes. Fernandes et al. [60] conducted a prospective randomized clinical trial to assess the effect of customized healing abutments on peri-implant tissue changes at immediate implant sites in the maxilla. The study specifically evaluated the linear and volumetric changes of the gingival tissue following the placement of customized abutments in post-extraction sockets. The results indicated that these customized abutments played a significant role in preserving soft tissue volume and architecture, enhancing gingival contour compared to standard healing abutments. Chokaree et al. [61] conducted a randomized controlled trial to compare the effects of customized and prefabricated healing abutments on peri-implant soft tissue and bone in immediate implant sites. The study found that customized healing abutments had a favorable influence on soft tissue adaptation and bone preservation around immediate implants. Specifically, the use of customized abutments promoted better soft tissue contour and reduced bone loss when compared to prefabricated abutments. Lenz et al. [62] conducted a systematic review to assess peri-implant outcomes associated with the use of customized healing abutments in immediate implant placements. The review aimed to evaluate the influence of these abutments on soft tissue health, bone stability, and overall esthetic results. This improved tissue contour supports better esthetic outcomes and preserves peri-implant bone levels, reducing the risk of bone loss and improving the long-term stability of immediate implants.

3.6 Importance of Biologic Width in Peri-Implant Health and Prosthetic Design

Biologic width refers to the combined dimension of the epithelial and connective tissue attachment around a tooth or dental implant. It serves as a natural protective barrier that helps maintain healthy peri-implant tissues by preventing bacterial invasion. In dental implants, the biologic width is typically composed of the junctional epithelium and the connective tissue attachment. Zheng et al. [63] emphasize the critical role of the biological

width in soft tissue integration around dental implants. According to the authors, the biological width, typically measuring between 2 to 4 mm, forms a protective barrier that shields peri-implant tissues from bacterial invasion. Romanos et al. [64] conducted an observational cohort study to investigate the impact of implant diameter on the success and survival rates of dental implants, with a specific focus on its relationship to the biological width. It was found that wider implant diameters provided greater initial stability and were less prone to micromovement, which is crucial for osseointegration, especially in cases of immediate loading. Esfahrood et al. [65] provided an updated review on the concept of biological width around dental implants, emphasizing how implant diameter and size can significantly affect peri-implant tissue health. The review found that implant diameter directly influences the establishment of biological width, as a larger implant diameter can alter the soft tissue's dimensions and response. This change may result in increased pressure on the surrounding tissues and affect their ability to maintain a stable seal around the implant. Implants placed too deeply or with an excessively wide diameter may disrupt the natural formation of the biological width, potentially leading to bone resorption and soft tissue recession. Linkevicius and Apse [66] conducted an evidence-based review examining the concept of biological width around dental implants, highlighting its importance in maintaining peri-implant tissue health and stability. The authors found that wider implant diameters may disrupt the natural establishment of biological width, potentially leading to bone remodeling and soft tissue recession. Makigusa [67] conducted a histologic comparison of the biological width between natural teeth and dental implants, examining how this width influences bone preservation. The study highlighted that biological width, which consists of the junctional epithelium and connective tissue attachment, differs significantly in its structure and dimensions around teeth versus implants.

Sun et al. [68] conducted a retrospective study investigating the effect of initial biological width on marginal bone loss around dental implants. The research demonstrated that inadequate biological width can trigger the body's attempt to reestablish a protective barrier, often resulting in the downward movement of the bone crest around the implant to create sufficient space for soft tissue attachment, which in turn contributes to marginal bone loss over time. Dhir [69] explores the importance of the biological width in implant dentistry and how failure to respect this width can result in adverse tissue reactions. The article emphasizes that when this biological width is violated—such as by placing implants too deeply or positioning restorations too close to the soft tissue—it can disrupt the natural soft tissue seal. Yeung [70] provides an overview of the biological principles underlying soft tissue management in implant dentistry, emphasizing the importance of maintaining a healthy soft tissue barrier around dental implants. When the biological width is not respected, particularly during implant placement or restoration, there can be adverse reactions in the soft tissue. This violation can lead to inflammation, soft tissue recession, and potential bone loss, as the body attempts to reestablish the appropriate width to create a stable seal around the implant.

4. Conclusion

The success of dental implants hinges on meticulous planning and precise execution, particularly regarding the thickness of soft and keratinized tissue, the depth and position of the implant, and the materials used for crowns. Custom abutments and platform switching are pivotal innovations that significantly enhance long-term stability and peri-implant health. The integration of these factors results in

predictable and sustainable outcomes, greatly improving patient satisfaction and the overall success of dental implants. To proactively address potential complications, dental professionals should adopt a multidisciplinary approach that incorporates regular monitoring and maintenance protocols tailored to each patient's individual risk factors. This includes the use of natural adjuncts, such as antimicrobial agents and biofilm-reducing substances, as part of routine care to minimize the risk of mucositis and peri-implantitis. Additionally, leveraging advancements in digital planning tools, such as CBCT imaging and CAD/CAM technology, can further enhance the precision of implant placement and prosthetic design. As technology and materials continue to evolve, the establishment of standardized, evidence-based guidelines remains essential. Proactive education for clinicians and patients on the importance of personalized care, alongside the integration of innovative strategies, will ensure the longevity and success of dental implants while setting new benchmarks for quality and patient satisfaction in implantology.

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