Journal of Dental Sciences 19 (2024) 1348—1358

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Journal of Dental Sciences

Review article

Soft tissue management around dental implant in esthetic zone — the current concepts and novel techniques

Teresa Chanting Sun [a,b*†], Tsung-Kai Chang [c†]

[a] *Department of Periodontology, Mackay Memorial Hospital, Taipei, Taiwan*
[b] *Department of Periodontology, School of Dentistry, National Defense Medical Center and Tri-Service General Hospital, Taipei, Taiwan*
[c] *Department of Prosthodontics, Mackay Memorial Hospital, Taipei, Taiwan*

Received 17 February 2024; Final revision received 2 March 2024
Available online 28 March 2024

KEYWORDS
Peri-implant soft tissue;
Periodontal plastic surgery;
Autogenous grafts;
Soft tissue substitutes;
Emergence profile;
Dental implant

Abstract It has been said, 'Bone sets the tone, but tissue is the issue.' In the field of implantology, while significant breakthroughs have been achieved in hard tissue regeneration, clinicians find it more challenging to handle soft tissue complications around dental implants. Successfully managing soft tissue around dental implants requires clinicians to have comprehensive knowledge of proper implant placement, prosthetic design and tissue management, and a high level of surgical skills for soft tissue augmentation and grafting. Autogenous gingival grafts can be utilized in various clinical situations, providing surgeons with great potential and freedom to enhance the quality and quantity of peri-implant soft tissue. Emerging trends, such as digital tools for treatment planning, minimally invasive surgical approaches, and innovative biomaterials, can also contribute to a more pleasing outcome. By elucidating these multifaceted considerations, this review will serve as a valuable resource for clinicians aiming to achieve functional and aesthetic excellence in implant-based oral rehabilitation.

* Corresponding author. Department of Periodontology, Mackay Memorial Hospital, No. 92, Zhongshan North Road Section 2, Taipei City 104217, Taiwan.
E-mail address: teresasun2015@gmail.com (T.C. Sun).
† These two authors contributed equally as the first author to this study.

https://doi.org/10.1016/j.jds.2024.03.003

Introduction

The field of implant dentistry has undergone significant advancements since Dr. Brånemark's pioneering application of dental implants in the 1960s.[1] In today's modern dentistry, an increasing number of patients are choosing dental implants to replace missing teeth, with expectations extending beyond the functional success of osteointegration to reach the ultimate esthetic goal-dental implants with a natural tooth appearance. Consequently, alongside hard tissue augmentation, soft tissue management around dental implants and the stability of soft tissue have become central topics in discussion aimed at achieving optimal function, aesthetics, and the enduring maintenance of dental implants.[2–5]

Understanding the features of the periodontium around natural teeth and peri-implant soft tissue involves recognizing both similarities and differences. The periodontium surrounding natural dentition is comprised of four key tissues: the periodontal ligament (PDL), cementum, alveolar bone, and gingiva. The gingival tissue consists of the oral epithelium (OE), oral sulcular epithelium (OSE), junctional epithelium (JE) and connective tissue attachment, with the JE serving as the primary defense against bacterial invasion.[6] Collectively, the periodontium functions to support the tooth, protecting it against oral microflora and attach the tooth to the alveolar bone with strong physical barrier to environmental challenges.[7]

Dental implants differ from natural dentition in that there is no periodontal ligament, and the direct structural and functional integration between the implant fixture and the surrounding alveolar bone is defined as osteointegration.[1] Despite this distinction, the soft tissue interface between dental implants and the surrounding gingival tissue shares structural similarities with dentogingival junctions around natural teeth, including the presence of junctional epithelial attachment and sulcular spaces. However, notable differences arise. Around natural dentition, gingival fibers run perpendicular to the tooth's long axis, attaching to and occasionally penetrating the tooth's structure. Conversely, in implants, these fibers run parallel to the implant's long axis and do not penetrate its surface. Additionally, while natural teeth boast nine different types of supracrestal fibers enhancing attachment, dental implants typically have only two, potentially resulting in less mechanical resistance in connective tissue adhesion with implants compared to natural teeth.[8–11] Moreover, when compared to natural dentition, it was found that implants exhibit a lower number of blood vessels, relying solely on the large supraperiosteal blood vessel on the outer surface of the alveolar ridge for the peri-implant mucosa's vascular system.[12]

In summary, although certain characteristics are shared between the gingiva around natural teeth and dental implants, distinctions exist in connective tissue composition, collagen fiber arrangement, and vascular structures in the compartment apical to the barrier epithelium. This article aims to comprehensively review the current understanding of peri-implant soft tissue and the importance of soft tissues management around dental implant, both surgically and prosthetically. It will serve as a valuable resource for clinicians aiming to achieve functional and aesthetic excellence in implant-based oral rehabilitation.

How does peri-implant soft tissue play its important role?

The importance of the presence of keratinized mucosa (KM) and attached gingiva around dental implants has been supported by some researchers, while others proposed it might not be a necessity.[13,14] In an animal study, Warrer et al.[15] examined the influence of plaque accumulation on attachment loss and recession around implants placed in areas lacking KM. They concluded that implants without KM exhibited more recession and attachment loss compared to those with KM. The absence of KM around implants increases the susceptibility of the peri-implant site to more tissue destruction.

On the other side, Wennstrom et al.[16] conducted a human study evaluating the soft tissue conditions around dental implants in relation to the width of masticatory mucosa with the opposite results. The study failed to support the concept that the lack of an attached portion of masticatory mucosa may jeopardize the maintenance of soft tissue health around dental implants. However, other review articles[17,18] indicate an association between inadequate width of keratinized gingiva (KG) (<2 mm) with peri-implant mucositis, which is more prone in the group of patients with erratic maintenance compliance.[19]

In 2020, Gustavo Avila-Ortiz et al.[20] further proposed the concept of the peri-implant phenotype, which includes a soft tissue component constituted by the peri-implant keratinized mucosa width (KMW), the mucosal thickness (MT), and the supracrestal tissue height (STH), as well as an osseous component, characterized by the peri-implant bone thickness (PBT). They concluded that further research is necessary to determine the minimum amount of KMW, MT, STH, and PBT required to achieve optimal short- and long-term outcomes, including the maintenance of peri-implant health, function and esthetics in specific clinical scenarios.

The surgical technique of soft tissue management around dental implants

When the soft tissue volume is inadequate, modification of the peri-implant soft tissue phenotype is sometime necessary. Soft tissue reconstruction can be achieved through various flap design technique to manipulate the soft tissue around dental implants. In cases where the soft tissue volume is insufficient, soft tissue augmentation can be performed by utilizing autogenous soft tissue grafts or soft tissue substitutes in conjunction with the flap approach. The efficacy of peri-implant soft tissue phenotype modification therapy in augmenting peri-implant soft tissue phenotype and its association with peri-implant health has been investigated through previous systematic reviews.[4,21,22]

Flap design technique

One of the earliest techniques is the "vestibular extension operations". The concept was primarily designed to extend the depth of the vestibular sulcus,[23] and consequently, the

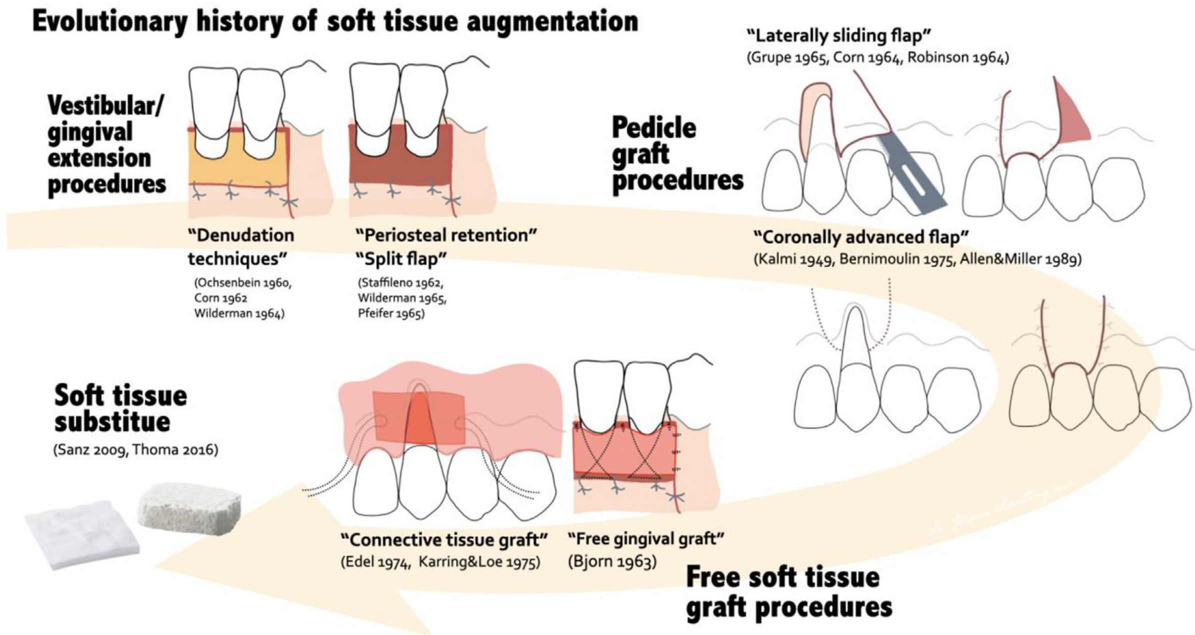

Figure 1 The evolutionary history of soft tissue augmentation around natural dentition, the techniques has been further applied to soft tissue management around dental implants.

newly generated keratinized tissue covers the exposed periosteum or bony surface. The Apically Repositioned Flap was later proposed for the purpose of repositioning the attached gingiva around natural dentition,[24] and this technique can further be utilized around dental implants (Fig. 1).[4]

The Roll flap Technique, first developed by Abrams in 1980,[25] was initially designed to correct ridge defects. The modified roll flap technique was subsequently applied to dental implants, employing a pedicle flap that includes part of the connective tissue rotated from the palate and then folded under into a pouch created on the buccal side of the dental implants.[26–29] In 1995, Palacci described a technique to create papilla-like soft tissue formation between adjacent implants. This involved raising a full thickness flap with crestal and vertical incisions to displace attached gingiva buccally at the time of implant's second stage. After connecting healing abutments, excess buccal attached gingiva was dissected into pedicles with semilunar incisions. The pedicle was then further rotated at 90-degree angle into the palatal direction and fixed and sutured in place in between the healing abutments.[30] The benefit of utilizing the flap techniques for soft tissue management is to create better soft tissue contour without a second surgical site (Fig. 2).

Autogenous graft

The pedicle-displaced flap and free soft tissue grafts have become the most commonly used techniques to manage 'insufficient' gingival dimensions, mainly because of the higher predictability of the treatment result. Unlike the pedicle-displaced flap, which has its based left attached to the original site, free soft grafts are freed from their bed and completely removed. After transplantation, the graft body is entirely separated from the original donor site. The most common autogenous free soft graft procedure is the free gingival graft and subepithelial connective tissue graft.[4,21,22]

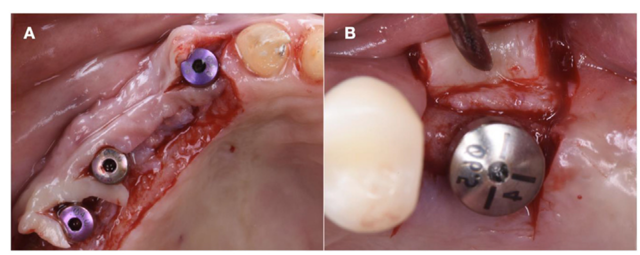

Figure 2 Flap techniques for soft tissue management around dental implants. (A) The Palacci flap technique (B) The roll flap technique.

Autogenous graft - free gingival graft

In 1963, Bjorn[31] first described the use of free gingival grafts in periodontal therapy, and Sullivan and Atkins[32,33] further discussed the principles of successful grafting. The free gingival graft procedure includes two important steps. First, prepare the recipient site, which is able to form "capillary outgrowths" to vascularize the graft. Adequate hemostasis before grafting is also essential to prevent hematomas and dead space between the graft and recipient bed. Secondly, donor tissues are usually taken from the maxillary palatal region lingual to the bicuspids and molars, but they could also be harvested from the edentulous ridge, attached gingiva or maxillary tuberosity. Scarred, fatty, or glandular tissues should be removed to avoid the possibility of vascularization blockage.

The third key point is immobilization of the graft, which is necessary to enhance and maintain capillary ingrowths during the healing process. Lastly, graft thickness plays a crucial role in the outcome of the procedure, influencing its contraction, survival, and esthetic result. Primary contraction occurs immediately after the graft is taken from the donor area, and secondary contraction takes place during the stage where the graft integrates into the recipient bed. Thicker grafts have greater primary contraction due to the larger amount of elastic lamina propria but demonstrate less secondary contraction which is stable after integration with an immobile recipient bed. Once integrated, thicker grafts are better able to withstand functional stresses. Currently, the free gingival graft (FGG) is considered one of the standard approaches for soft tissue augmentation around dental implants for non-esthetic zone (Fig. 3).

Autogenous graft- subepithelial connective tissue graft

The usage of free gingival grafts has a long history with promising postoperative results. However, there are several limitations to this procedure: (1) It is challenging to increase a significant amount of soft tissue when the thickness is severely limited. (2) Esthetic concern arises after the healing of the epithelized graft. The graft does not easily blend in with the surrounding soft tissue, and the surface texture and color often differ. Additionally, scar tissue may form relatively easy.

In 1975, Drs. Thorkild Karring, Niklaus P. Lang & Harald Löe[34] introduced the use of the subepithelial connective tissue graft (CTG). This experiment played an important role as a breakthrough in the field of periodontal plastic surgery. In this animal study, free grafts of subepithelial connective tissue harvested from either the keratinized gingiva (test group) or the non-keratinized alveolar mucosa (control group) were transplanted into areas of the alveolar mucosa. After 3—4 weeks, the transplants were exposed by de-epithelialization of the overlying tissue. At the end of the study, the gingival connective tissue grafts (test group) were covered with keratinized epithelium, displaying the same characteristics as those of normal gingival epithelium. While in the control group, the alveolar mucosa transplants were covered with non-keratinized epithelium. This indicated that gingival connective tissue regulates the differentiation of the overlying epithelium and is capable of inducing the formation of a keratinized gingival epithelium.

The application of the subepithelial connective tissue graft demonstrates its potential to provide excellent esthetic results and a high success rate, further advancing the development of the field of periodontal plastic and microsurgery. Langer and Langer, in their 1985 publication,[35] described the step-by-step procedure of the subepithelial free connective tissue graft for obtaining dental root coverage. The authors stated that the use of the graft enhances esthetics through color match and also avoids the 'keloid' healing appearance associated with free gingival grafts. In 1985, Peter B. Raetzke[36] described a variation of the traditional subepithelial connective tissue graft by minimizing recipient site exposure. The author called it the 'envelope' technique, where instead of making two vertical releasing incisions to facilitate graft placement, an envelope pouch was created by undermining partial thickness incisions around the denuded root surface. For the treatment of multiple recession sites, variation of techniques, including the tunnel technique proposed by Allen,[37] Bruno,[38] and Zabalegui,[39] and the VISTA technique of Dr. Homa Zadeh,[40] have shown the trend of a minimally invasive and microsurgical approach in modern mucogingival plastic surgery (Fig. 4).

Soft tissue substitute

Autogenous grafts have been preferred for soft tissue augmentation with promising result in increasing keratinized tissue and gingival thickness around dental implants.[4] However, there are some disadvantage to these techniques. First, it requires a second surgical donor site, which can be associated with increased patient morbidity, such as postoperative bleeding, tissue necrosis, and discomfort. Secondly, there is limited availability of autogenous grafts due to anatomical limitations.[41,42] To overcome the shortcomings of autogenous grafts, there is increasing popularity in utilizing alternative materials such as acellular dermal matrix or xenogeneic collagen matrices.

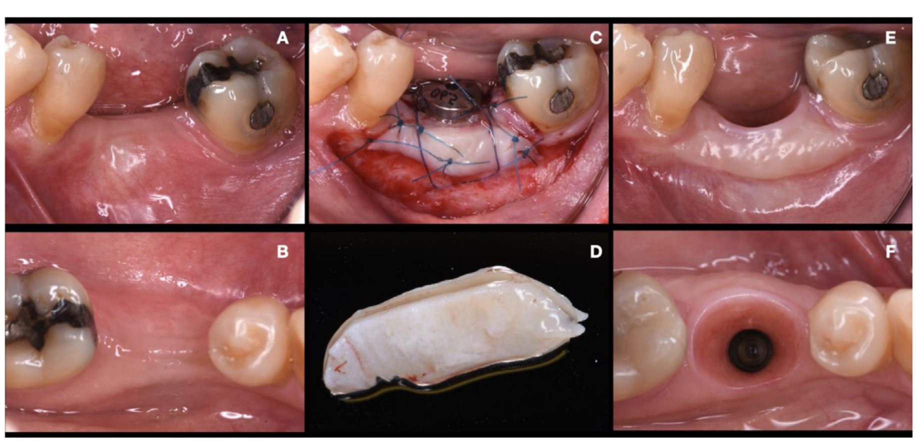

Figure 3 Free gingival graft surgical procedure to increase the width of keratinized mucosa around dental implants (A and B) Clinical presentation at baseline (C) Stabilization of free gingival graft at recipient bed (D) Free gingival graft harvest from palate (E and F) Twelve-month outcomes, notice the significant increased width of soft tissue and keratinized tissue.

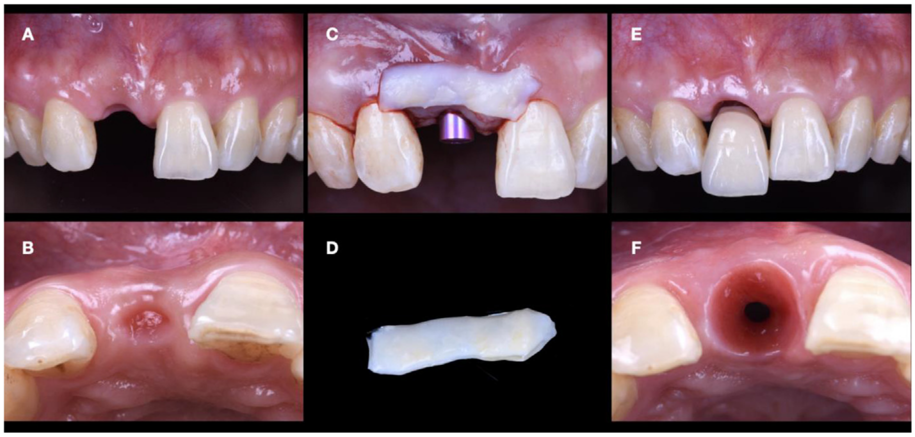

Figure 4 Connective tissue graft surgical procedure around dental implant to increase the peri-implant soft tissue thickness (A and B) Clinical presentation at baseline (C and D) Connective tissue graft harvest from palate ready to be inserted into recipient bed (E and F) Twelve-month outcomes, notice the significant increased width of peri-implant soft tissue and improved esthetic.

Acellular dermal matrix (ADM) is an allograft obtained from human donor skin that undergone a decellularization process to remove the epidermis and cellular components. It comprises a structurally integrated basement membrane complex (BMC) and extracellular matrix (ECM), which serve as a scaffold to support cellular migration and revascularization from surrounding host tissue.[43,44] A randomized clinical trial has shown similar short-term outcomes when compared ADM to CTG in terms of peri-implant mucosal thickness, width of keratinized mucosa, and Patient-Reported Outcome Measures (PROMs), but long-term data still require further investigation.[45] A recent systematic review collected relevant data up to July 2020, focusing on the efficacy of acellular dermal matrix (ADM) in increasing the soft tissue thickness (STT) and keratinized mucosa width (KMW) around dental implants. A meta-analysis was performed on six clinical studies, which showed that acellular dermal matrix significantly increased the STT and KMW around dental implants, and it showed comparable results to the control groups, including autogenous tissue augmentation sites.[46]

One of the xenogeneic collagen matrices, Mucograft®, is a non-cross-linked resorbable porcine bilayer collagen matrix (CM). It has a thin, cell-occlusive superior later of dense collagen with a smooth texture that allows for tissue adherence and a thick, porous bottom placed against the host tissue aids in clot formation to support cell ingrowth and tissue integration.[47] Randomized clinical trials have shown the potential of using CM to increase the width of keratinized tissue and gingival thickness around dental implants, with the advantage of shorter surgical time, lower post-operative pain and morbidity, and better color match with surrounding tissue.[48,49]

A recently introduced volume-stable collagen matrix (VCMX), Fibrogide®, is a porcine, porous, resorbable and volume-stable collagen matrix designed for soft-tissue regeneration. It is made of cross-linking collagen, providing volume stability, and its porous layer promotes angiogenesis and ingrowth of fibroblast for the integration of new connective tissue under submerged healing.[50–52] Preclinical and clinical studies have shown promising results for soft tissue volume gain without significant adverse effects. Further long-term studies are required to confirm the results for soft-tissue volume gain around dental implants.[51–55]

When comparing the efficacy of surgical procedures using soft tissue substitutes and autogenous grafts for soft tissue augmentation around dental implants, systematic reviews supported that both autogenous grafts and soft tissue substitutes can be used to increase keratinized mucosa width (KMW) and mucosal thickness (MT).[4,56,57] A meta-analysis study by Tavelli et al.[4] showed that the utilization of autogenous grafts and soft tissue substitutes resulted in a significant increase in KMW or MT when compared to non-augmented sites. The results from the systematic review and meta-analyses by Montero et al.[56] demonstrated that autogenous soft tissue grafts are more effective than soft tissue substitutes for the augmentation of peri-implant KM. However, a meta-analysis by Thoma et al.[57] showed that soft tissue substitutes, compared to autogenous grafts, significantly improve Patient-Reported Outcome Measures (PROMs) following soft tissue augmentation at implant sites. Therefore, the current evidence suggests that soft tissue substitutes can potentially be a valid alternative to minimized invasiveness in soft tissue augmentation at dental implant sites, and future research is required to further support the efficacy and longevity of the outcomes (Fig. 5) (Table 1).

Management of peri-implant soft tissue at prosthetic phase

Achieving a successful esthetic outcome for implant-supported restoration involves not only the surgical phase but also the crucial prosthetic phase.[58] Prosthetic considerations include both the design of the implant restoration and the management of peri-implant soft tissues. During the surgical phase, the healing abutment is usually used as a transitional device. Therefore, a narrow and round gingival profile is formed after the surgical phase, and this key operational region extends from the circumferential implant neck to the gingival cervical area. For the prosthodontist, this area is crucial for managing

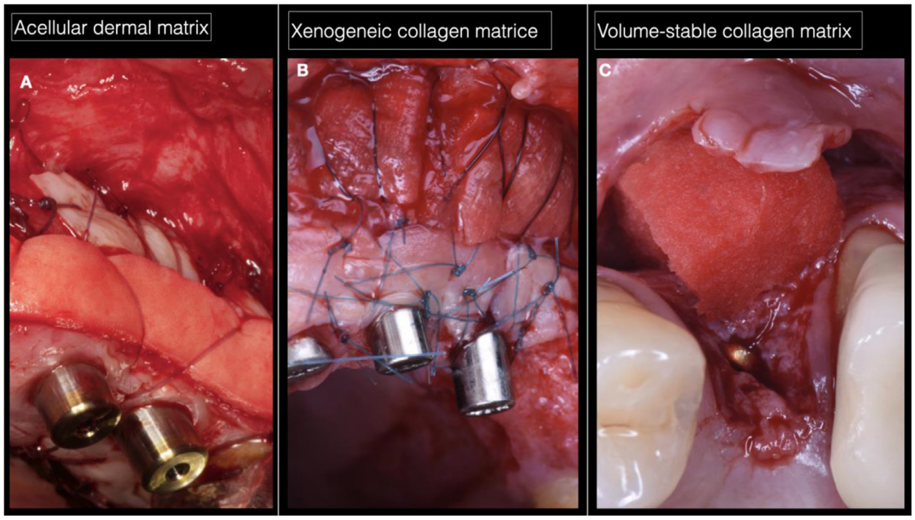

Figure 5 Application of the soft tissue substitutes for soft tissue management around dental implants (A) Combination use of acellular dermal matrix and free gingival graft to increase keratinized mucosa for extensive soft tissue deficiency (B) Combination use of xenogeneic collagen matrix and free gingival graft to increase keratinized mucosa for extensive soft tissue deficiency (C) Application of volume-stable collagen matrix to increase peri-implant soft tissue thickness.

the soft tissue and finalizing the ideal gingival position before fabricating the definitive prosthesis. It determines whether the implant-supported restoration appears natural or not. The customized modification of the implant abutment-crown contour is known as the emergence profile design.

Design of the emergence profile

An esthetic implant-supported restoration, emerging through the surrounding tissues to appear natural, requires a seamless transition from the circumferential implant fixture head to the correct cervical tooth

Table 1 The following table summarized the techniques and clinical consideration for soft tissue management during surgical and prosthetic phase.

Surgical Phase			Prosthetic Phase	
Technique		Clinical consideration	Technique	
Flap design	• Apically repositioned flap • Roll flap technique • Palacci flap	• Flap management to create better soft tissue contour • Suitable for small amount of soft tissue deficiency correction	Implant position and design of the emergence profile	• Critical and subcritical contour[59] • Esthetic biological contour concept[60]
Autogenous grafts	• Free gingival graft	• Mainly used for non- esthetic zone • Highest amount of KMW gain • Required 2nd surgical site		
	• Connective tissue graft ⇒ Donor sites (Palate, Tuberosity) ⇒ Receipt sites preparation technique (CAF, Envelope pouch, Tunnel, VISTA)	• Indicated for esthetic zone • Highest amount of MT, STH gain for esthetic zone • Required 2nd surgical site	Soft tissue conditioning with provisional prosthesis and transition to the final restoration	• Conventional impression (individualized impression coping technique) • Digital impression ⇒ Individualized scanbody technique ⇒ 3D printed cast technique ⇒ "Best -fit" algorithm technique
Soft tissue substitutes	• Acellular dermal matrix • Xenogeneic collagen matrix • Volume- stable collagen matrix	• Possible to use as alternatives to autogenous soft tissue grafts • Efficacy and long- term stability study still required		

Abbreviations: CAF, Coronally advanced flap; VISTA, Vestibular Incision Subperiosteal Tunnel Access; KMW, keratinized mucosa width; MT, mucosal thickness; STH, supracrestal tissue height.

anatomy. The emergence profile (EP) often needs customized modification for a natural appearance. If designed properly, the abutment emergence will be structured harmoniously to support the free gingival margin and papilla while providing sufficient space for the biological width.[58]

Several concepts have been proposed for designing a proper emergence profile. Su et al. first focused on two distinct zones: the critical contour and the subcritical contour. The critical contour refers to the area of the implant abutment and crown located immediately apical to the gingival margin, determining the zenith and labial gingival marginal level. The subcritical contour is located apical to the critical contour and extends further to the implant neck, allowing the establishment of the proper cervical contour of the restoration.[59]

The esthetic biological contour concept (EBC) was later proposed by Gomez-Meda et al.[60] It suggests that the subgingival contour of the implant restoration is composed of three zones: the Esthetic Zone (E zone), the Bounded Zone (B zone) and the Crestal Zone (C Zone). The E Zone, also termed the critical zone, should have designs matching the gingival contour of the crown morphology of the missing tooth or the contralateral tooth to emulate the natural appearance of the dentition. The B Zone serves as the transition between the E and C zones, and its contour is influenced by the quantity of the soft tissue and the implant position. The C Zone is located immediately coronally to the implant platform, and its design influences crestal stability. The contours should be straight or slightly concave to avoid excess pressure on surrounding tissue to minimize bone remodeling (Fig. 6).

The relationship between implant position and soft tissue profile

As the critical contours of the final restoration (E Zone) are mostly predetermined by aesthetics and function, the implant position becomes the determining factor for the contour of the emergence profile in the transition zone. To achieve a gradual and harmonious transition from the implant platform to the esthetic zone, several publications emphasize the importance of the ideal implant position, which is undeniably necessary for a pleasing mucosal marginal level. The ideal implant position can be summarized as follows: (1) 3.0–4.0 mm in an apico-coronal position from the soft tissue crest; (2) slightly palatal to the incisal edge, with 2 mm of facial bone; and (3) the mesio-distal space with at least 1.5 mm between the implant and adjacent teeth, and a 3-mm space between implants.[59,61]

With an ideal implant position, the emergence profile design is narrow at the implant platform and follows an 'S' curve shape that enlarges to reach the free gingival margin.[62] When the implant position is too shallow (less than 2 mm apical to the future gingival margin of the restoration), it leads to insufficient 'running room'. The excessive flare in the restoration outline of the abutment will result in a ridge-lap design, compromising plaque control and sometimes creating esthetic challenges to restore.[63]

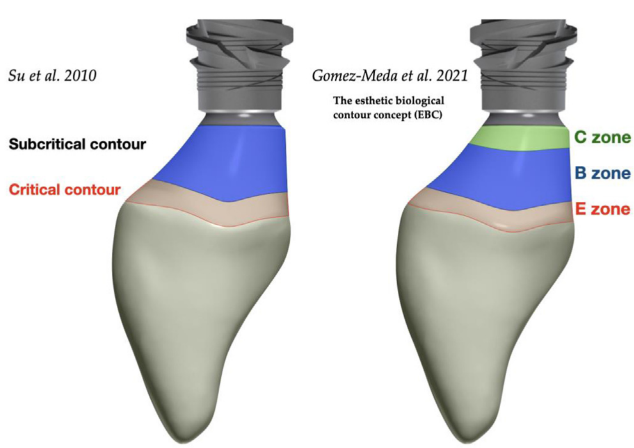

Figure 6 The proposed concept for design of the emergence profile.

Soft tissue conditioning utilizing provisional prosthesis

Provisional restoration is a valuable tool for managing the soft tissue to achieve the ideal emergence profile. It serves as a prototype, enabling prosthodontist to assess the gingival contour, including the gingival margin level and zenith, labial profile, and papilla support.[64] The use of provisional restoration is now widely accepted as an effective method of developing the desired soft tissue architecture.[65,66]

A randomized clinical trial by Furze et al. demonstrated that implant-supported provisionals can enhance the final esthetic outcome of the peri-implant mucosa. In their study, implant prosthesis restored with provisional restoration showed statistically significant higher modPES scores compared to the group without provisional restorations.[67] Therefore, the use of provisional restorations is strongly recommended, despite being more costly and time-consuming during the soft tissue conditioning phase.

Soft tissue management of provisional restoration is performed by inducing pressure to guide the soft tissue remodeling and to 'squeeze' the tissue to optimize the emergence profile.[68] After placing the provisional restoration, a slight blanching of the mucosa should be immediately observed, which should only be moderate and should disappear within 15 min. Utilizing screw-retained provisional restorations whenever possible is recommended for proper soft tissue management and removability.[62,68]

When fabricating the provisional prosthesis, determining the facial E zone contour is the first step in the conditioning process.[58] It is established by contrasting the tooth contour and mimicking the proper gingival line. Provisional material is added extraorally by outlining the expected contour with a red pencil. The facial B zone contour will be flat or concave, influenced by the quantity of the soft tissue. If the soft tissue is mildly insufficient, applying gentle pressure might be helpful to support the mucosa. The C Zone design in this area should be straight or slightly concave to avoid excess pressure on the surrounding tissue.

The interproximal E zone contours are determined by the papilla height. The B zone contour, following the E zone contour, should not exert excessive pressure on the surrounding soft tissue, adopting a straight or concave contour. If there is a loss of papilla height, an exclusive increase of the E zone contour could be considered. Inducing pressure to B zone (increasing the convexity of the contour) may apply pressure to 'squeeze' the papilla and promote a coronal papillary displacement of 0.5 mm—1.0 mm.[59] Also, it can be designed to create long interproximal contacts and a squarer tooth shape for the restoration. The C Zone design in this area remains straight or slightly concave to avoid excess pressure on surrounding tissue.

The palatal E zone contour smoothly links between mesial and distal interproximal contours. The B zone contour should provide sufficient support to the gingiva, featuring a mild convexity, while the C zone remains straight or slightly concave.

After each adjustment, thorough polishing of the provisional restoration surface should always be performed, followed by disinfection with steam, to minimize the risk of bacterial plaque accumulation and enhance favorable epithelial cell adhesion.[68,69] A minimum interval of 15 days between each adjustment is suggested to allow sufficient time for revascularization and soft tissue maturation. It should be at least 1 month before the final impression is made. In esthetic zone, a waiting period of at least 3 months is considered adequate for a more favorable outcome (Fig. 7).

Transition from provisional prosthesis to the final restoration-the conventional and digital technique

When the soft tissue has been optimally conditioned by provisional restoration, and the peri-implant mucosa has matured, preservation of the correct contour of soft tissue is essential for the definitive restoration. Simultaneously, the accurate transfer of subgingival contours is crucial information for the dental technician to fabricate the definitive restoration. The following techniques can easily be used to transfer the created emergence profile to the final master cast: (1) using an individualized impression coping that has the same tissue profile as the provisional restoration (Fig. 7), and (2) implant digital impression.[70]

Conventional methods to achieve the same subgingival soft-tissue contours involve using an individualized impression coping that has the same tissue profile as the provisional restoration.[70] More recently, implant digital impressions have been introduced through the application of scan bodies. To prevent soft tissue collapse during intraoral scanning, the "Individualized Scanbody Technique" have been proposed by Joda et al.[71] While this method helps confirm the soft tissue margin, it is important to note that the contour of subgingival area cannot be fully captured.

Other digital impression techniques rely on the 'best fit' algorithm to superimpose the provisional restoration digital impression over the full-arch digital impression.[72–74] Through this method, a single file containing the implant position, peri-implant mucosa, and emergence profile can be obtained. Additionally, by applying CAD/CAM technology, 3D printed casts with soft tissue replica can be created to precisely transfer the conditioned emergence profile that facilitate the fabrication of the definitive restoration (Fig. 8).[75]

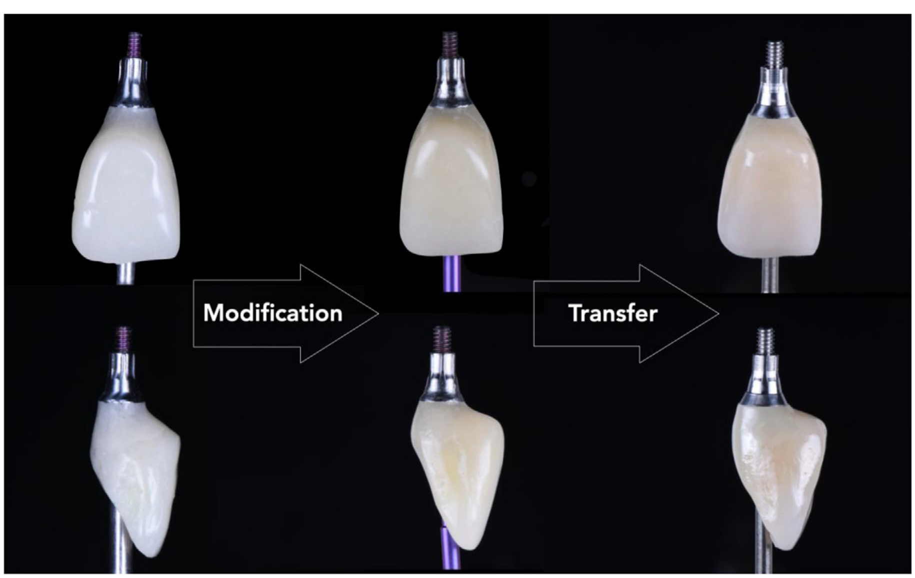

Figure 7 The workflow of soft tissue conditioning utilizing provisional prosthesis. The clinical photos indicate the transition from the initial set of provisional prosthesis (left) to modified final provisional prothesis (middle) then the outline is then transferred to the final prosthesis (right).

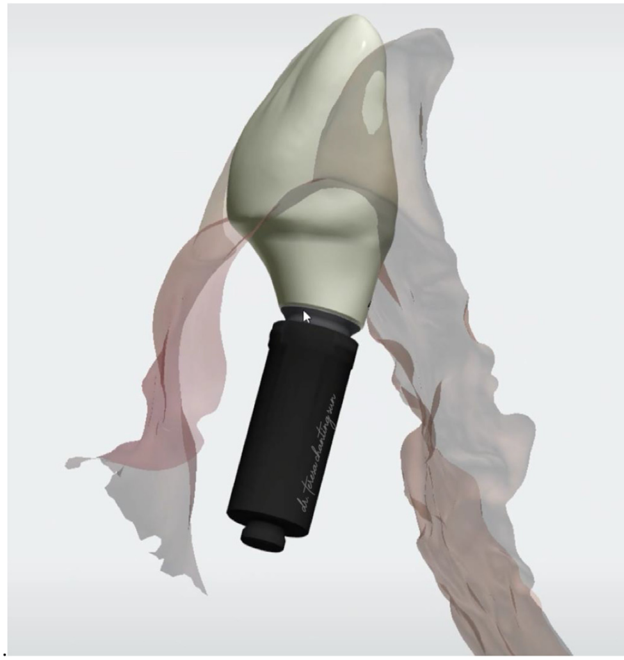

Figure 8 Digital work flow- Computer aided design (CAD) for design of the emergence profile for the implant final crown.

Conclusions

As demonstrated in this review, there are many periodontal plastic surgical techniques that can be used for soft tissue management around dental implants. Surgeons can choose a suitable technique for improving the pink esthetic around dental implants not only by increasing the "quality" but also by enhancing the "quantity" to achieve a long-term stable esthetic outcome. Furthermore, utilizing provisional restoration for soft tissue conditioning at prosthetic phase and precisely transferring the contour to the final restoration are key points to achieve the esthetic outcome for implant-supported restoration.

Declaration of competing interest

The authors declare no conflict of interest.

References

1. Brånemark PI. Osseointegration and its experimental background. *J Prosthet Dent* 1983;50:399—410.
2. Bassetti RG, Stähli A, Bassetti MA, Sculean A. Soft tissue augmentation procedures at second-stage surgery: a systematic review. *Clin Oral Invest* 2016;20:1369—87.
3. Giannobile WV, Jung RE, Schwarz F. Evidence-based knowledge on the aesthetics and maintenance of peri-implant soft tissues: osteology Foundation Consensus Report Part 1-Effects of soft tissue augmentation procedures on the maintenance of peri-implant soft tissue health. *Clin Oral Implants Res* 2018; 29(Suppl 15):7—10.
4. Tavelli L, Barootchi S, Avila-Ortiz G, Urban IA, Giannobile WV, Wang HL. Peri-implant soft tissue phenotype modification and its impact on peri-implant health: a systematic review and network meta-analysis. *J Periodontol* 2021;92:21—44.
5. Thoma DS, Mühlemann S, Jung RE. Critical soft-tissue dimensions with dental implants and treatment concepts. *Periodontol 2000* 2014;66:106—18.
6. Schroeder HE, Theilade J. Electron microscopy of normal human gingival epithelium. *J Periodontal Res* 1966;1:95—119.
7. Melcher AH. On the repair potential of periodontal tissues. *J Periodontol* 1976;47:256—60.
8. Gould TR, Brunette DM, Westbury L. The attachment mechanism of epithelial cells to titanium in vitro. *J Periodontal Res* 1981;16:611—6.
9. Gould TR, Westbury L, Brunette DM. Ultrastructural study of the attachment of human gingiva to titanium in vivo. *J Prosthet Dent* 1984;52:418—20.
10. Jansen JA, de Wijn JR, Wolters-Lutgerhorst JM, van Mullem PJ. Ultrastructural study of epithelial cell attachment to implant materials. *J Dent Res* 1985;64:891—6.
11. Moon IS, Berglundh T, Abrahamsson I, Linder E, Lindhe J. The barrier between the keratinized mucosa and the dental implant. An experimental study in the dog. *J Clin Periodontol* 1999;26:658—63.
12. Berglundh T, Lindhe J, Jonsson K, Ericsson I. The topography of the vascular systems in the periodontal and peri-implant tissues in the dog. *J Clin Periodontol* 1994;21:189—93.
13. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *Int J Oral Maxillofac Implants* 1986;1:11—25.
14. Strub JR, Gaberthüel TW, Grunder U. The role of attached gingiva in the health of peri-implant tissue in dogs. 1. Clinical findings. *Int J Periodontics Restor Dent* 1991;11:317—33.
15. Warrer K, Buser D, Lang NP, Karring T. Plaque-induced peri-implantitis in the presence or absence of keratinized mucosa. An experimental study in monkeys. *Clin Oral Implants Res* 1995;6:131—8.
16. Wennström JL, Bengazi F, Lekholm U. The influence of the masticatory mucosa on the peri-implant soft tissue condition. *Clin Oral Implants Res* 1994;5:1—8.
17. Gobbato L, Avila-Ortiz G, Sohrabi K, Wang CW, Karimbux N. The effect of keratinized mucosa width on peri-implant health: a systematic review. *Int J Oral Maxillofac Implants* 2013;28: 1536—45.
18. Lin GH, Chan HL, Wang HL. The significance of keratinized mucosa on implant health: a systematic review. *J Periodontol* 2013;84:1755—67.
19. Monje A, Blasi G. Significance of keratinized mucosa/gingiva on peri-implant and adjacent periodontal conditions in erratic maintenance compliers. *J Periodontol* 2019;90:445—53.
20. Avila-Ortiz G, Gonzalez-Martin O, Couso-Queiruga E, Wang HL. The peri-implant phenotype. *J Periodontol* 2020;91:283—8.
21. Cairo F, Barbato L, Selvaggi F, Baielli MG, Piattelli A, Chambrone L. Surgical procedures for soft tissue augmentation at implant sites. A systematic review and meta-analysis of randomized controlled trials. *Clin Implant Dent Relat Res* 2019;21:1262—70.
22. Thoma DS, Buranawat B, Hämmerle CH, Held U, Jung RE. Efficacy of soft tissue augmentation around dental implants and in partially edentulous areas: a systematic review. *J Clin Periodontol* 2014;41(Suppl 15):S77—91.
23. Bohannan HM. Studies in the alteration of vestibular depth I. Complete denudation. *J Periodontol* 1962;33:120—8.
24. Friedman N. Mucogingival surgery: the apically repositioned flap. *J Periodontol* 1962;33:328—40.
25. Abrams L. Augmentation of the deformed residual edentulous ridge for fixed prosthesis. *Comp Cont Educ Gen Dent* 1980;1: 205—13.
26. Barone R, Clauser C, Prato GP. Localized soft tissue ridge augmentation at phase 2 implant surgery: a case report. *Int J Periodontics Restor Dent* 1999;19:141—5.

27. Man Y, Wu Q, Wang T, Gong P, Gong T, Qu Y. Split pedicle roll envelope technique around implants and pontics: a prospective case series study. *Int J Oral Maxillofac Surg* 2015;44: 1295–301.
28. Park SH, Wang HL. Pouch roll technique for implant soft tissue augmentation: a variation of the modified roll technique. *Int J Periodontics Restor Dent* 2012;32:e116–21.
29. Nemcovsky CE, Artzi Z. Split palatal flap. I. A surgical approach for primary soft tissue healing in ridge augmentation procedures: technique and clinical results. *Int J Periodontics Restor Dent* 1999;19:175–81.
30. Palacci P. *Optimal implant positioning & soft tissue management for the brånemark system*. Quintessence Publishing Company, 1995.
31. B H. Free transplantation of gingiva propria [abstract] In: symposium in periodontology in Malmö. *Odontol Revy* 1963;14: 321–3.
32. Sullivan HC, Atkins JH. Free autogenous gingival grafts. I. Principles of successful grafting. *Periodontics* 1968;6: 121–9.
33. Sullivan HC, Atkins JH. Free autogenous gingival grafts. 3. Utilization of grafts in the treatment of gingival recession. *Periodontics* 1968;6:152–60.
34. Karring T, Lang NP, Löe H. The role of gingival connective tissue in determining epithelial differentiation. *J Periodontal Res* 1975;10:1–11.
35. Langer B, Langer L. Subepithelial connective tissue graft technique for root coverage. *J Periodontol* 1985;56:715–20.
36. Raetzke PB. Covering localized areas of root exposure employing the "envelope" technique. *J Periodontol* 1985;56: 397–402.
37. Allen AL. Use of the supraperiosteal envelope in soft tissue grafting for root coverage. I. Rationale and technique. *Int J Periodontics Restor Dent* 1994;14:216–27.
38. Bruno JF. Connective tissue graft technique assuring wide root coverage. *Int J Periodontics Restor Dent* 1994;14:126–37.
39. Zabalegui I, Sicilia A, Cambra J, Gil J, Sanz M. Treatment of multiple adjacent gingival recessions with the tunnel subepithelial connective tissue graft: a clinical report. *Int J Periodontics Restor Dent* 1999;19:199–206.
40. Zadeh HH. Minimally invasive treatment of maxillary anterior gingival recession defects by vestibular incision subperiosteal tunnel access and platelet-derived growth factor BB. *Int J Periodontics Restor Dent* 2011;31:653–60.
41. Chackartchi T, Romanos GE, Sculean A. Soft tissue-related complications and management around dental implants. *Periodontol* 2000 2019;81:124–38.
42. Griffin TJ, Cheung WS, Zavras AI, Damoulis PD. Postoperative complications following gingival augmentation procedures. *J Periodontol* 2006;77:2070–9.
43. Scarano A, Barros RR, Iezzi G, Piattelli A, Novaes Jr AB. Acellular dermal matrix graft for gingival augmentation: a preliminary clinical, histologic, and ultrastructural evaluation. *J Periodontol* 2009;80:253–9.
44. Wei PC, Laurell L, Lingen MW, Geivelis M. Acellular dermal matrix allografts to achieve increased attached gingiva. Part 2. A histological comparative study. *J Periodontol* 2002;73: 257–65.
45. Hutton CG, Johnson GK, Barwacz CA, Allareddy V, Avila-Ortiz G. Comparison of two different surgical approaches to increase peri-implant mucosal thickness: a randomized controlled clinical trial. *J Periodontol* 2018;89:807–14.
46. Yaghini J, Mogharehabed A, Feizi A, Afshari Z. Efficacy of acellular dermal matrix in soft tissue augmentation around dental implants: a systematic review and meta-analysis. *J Oral Implantol* 2022;49:197–205.
47. Nevins M, Nevins ML, Kim SW, Schupbach P, Kim DM. The use of mucograft collagen matrix to augment the zone of keratinized tissue around teeth: a pilot study. *Int J Periodontics Restor Dent* 2011;31:367–73.
48. Cairo F, Barbato L, Tonelli P, Batalocco G, Pagavino G, Nieri M. Xenogeneic collagen matrix versus connective tissue graft for buccal soft tissue augmentation at implant site. A randomized, controlled clinical trial. *J Clin Periodontol* 2017;44:769–76.
49. Lorenzo R, García V, Orsini M, Martin C, Sanz M. Clinical efficacy of a xenogeneic collagen matrix in augmenting keratinized mucosa around implants: a randomized controlled prospective clinical trial. *Clin Oral Implants Res* 2012;23: 316–24.
50. Mathes SH, Wohlwend L, Uebersax L, et al. A bioreactor test system to mimic the biological and mechanical environment of oral soft tissues and to evaluate substitutes for connective tissue grafts. *Biotechnol Bioeng* 2010;107:1029–39.
51. Thoma DS, Villar CC, Cochran DL, Hämmerle CH, Jung RE. Tissue integration of collagen-based matrices: an experimental study in mice. *Clin Oral Implants Res* 2012;23:1333–9.
52. Ferrantino L, Bosshardt D, Nevins M, Santoro G, Simion M, Kim D. Tissue integration of a volume-stable collagen matrix in an experimental soft tissue augmentation model. *Int J Periodontics Restor Dent* 2016;36:807–15.
53. Thoma DS, Naenni N, Benic GI, Hämmerle CH, Jung RE. Soft tissue volume augmentation at dental implant sites using a volume stable three-dimensional collagen matrix - histological outcomes of a preclinical study. *J Clin Periodontol* 2017;44: 185–94.
54. Thoma DS, Zeltner M, Hilbe M, Hämmerle CH, Hüsler J, Jung RE. Randomized controlled clinical study evaluating effectiveness and safety of a volume-stable collagen matrix compared to autogenous connective tissue grafts for soft tissue augmentation at implant sites. *J Clin Periodontol* 2016;43:874–85.
55. Zeltner M, Jung RE, Hämmerle CH, Hüsler J, Thoma DS. Randomized controlled clinical study comparing a volume-stable collagen matrix to autogenous connective tissue grafts for soft tissue augmentation at implant sites: linear volumetric soft tissue changes up to 3 months. *J Clin Periodontol* 2017;44: 446–53.
56. Montero E, Molina A, Matesanz P, Monje A, Sanz-Sánchez I, Herrera D. Efficacy of soft tissue substitutes, in comparison with autogenous grafts, in surgical procedures aiming to increase the peri-implant keratinized mucosa: a systematic review. *Clin Oral Implants Res* 2022;33(Suppl 23):32–46.
57. Thoma DS, Strauss FJ, Mancini L, Gasser TJW, Jung RE. Minimal invasiveness in soft tissue augmentation at dental implants: a systematic review and meta-analysis of patient-reported outcome measures. *Periodontol* 2000 2023;91:182–98.
58. González-Martín O, Lee E, Weisgold A, Veltri M, Su H. Contour Management of implant restorations for optimal emergence profiles. Guidelines for immediate and delayed provisional restorations. *Int J Periodontics Restor Dent* 2020;40:61–70.
59. Su H, Gonzalez-Martin O, Weisgold A, Lee E. Considerations of implant abutment and crown contour: critical contour and subcritical contour. *Int J Periodontics Restor Dent* 2010;30: 335–43.
60. Gomez-Meda R, Esquivel J, Blatz MB. The esthetic biological contour concept for implant restoration emergence profile design. *J Esthetic Restor Dent* 2021;33:173–84.
61. Chu SJ, Kan JY, Lee EA, et al. Restorative emergence profile for single-tooth implants in healthy periodontal patients: clinical guidelines and decision-making strategies. *Int J Periodontics Restor Dent* 2019;40:19–29.
62. Schoenbaum TR, Swift Jr EJ. Abutment emergence contours for single-unit implants. *J Esthetic Restor Dent* 2015;27:1–3.
63. Esquivel J, Meda RG, Blatz MB. The impact of 3D implant position on emergence profile design. *Int J Periodontics Restor Dent* 2021;41:79–86.

64. Martin WC, Pollini A, Morton D. The influence of restorative procedures on esthetic outcomes in implant dentistry: a systematic review. *Int J Oral Maxillofac Implants* 2014;29(Suppl):142—54.
65. Furze D, Byrne A, Alam S, Wittneben JG. Esthetic outcome of implant supported crowns with and without peri-implant conditioning using provisional fixed prosthesis: a randomized controlled clinical trial. *Clin Implant Dent Relat Res* 2016;18:1153—62.
66. Steigmann M, Monje A, Chan HL, Wang HL. Emergence profile design based on implant position in the esthetic zone. *Int J Periodontics Restor Dent* 2014;34:559—63.
67. Furze D, Byrne A, Alam S, Brägger U, Wismeijer D, Wittneben JG. Influence of the fixed implant-supported provisional phase on the esthetic final outcome of implant-supported crowns: 3-year results of a randomized controlled clinical trial. *Clin Implant Dent Relat Res* 2019;21:649—55.
68. Wittneben JG, Buser D, Belser UC, Brägger U. Peri-implant soft tissue conditioning with provisional restorations in the esthetic zone: the dynamic compression technique. *Int J Periodontics Restor Dent* 2013;33:447—55.
69. Luchinskaya D, Du R, Owens DM, Tarnow D, Bittner N. Various surface treatments to implant provisional restorations and their effect on epithelial cell adhesion: a comparative in vitro study. *Implant Dent* 2017;26:12—23.
70. Elian N, Tabourian G, Jalbout ZN, et al. Accurate transfer of peri-implant soft tissue emergence profile from the provisional crown to the final prosthesis using an emergence profile cast. *J Esthetic Restor Dent* 2007;19:306—14. ; discussion 15.
71. Joda T, Wittneben JG, Brägger U. Digital implant impressions with the "Individualized Scanbody Technique" for emergence profile support. *Clin Oral Implants Res* 2014;25:395—7.
72. Monaco C, Evangelisti E, Scotti R, Mignani G, Zucchelli G. A fully digital approach to replicate peri-implant soft tissue contours and emergence profile in the esthetic zone. *Clin Oral Implants Res* 2016;27:1511—4.
73. Monaco C, Scheda L, Baldissara P, Zucchelli G. Implant digital impression in the esthetic area. *J Prosthodont* 2019;28:536—40.
74. Sasada Y, Huynh-Ba G, Funakoshi E. Transferring subgingival contours around implants and the intaglio surface of the pontic to definitive digital casts by using an intraoral scanner: a technique. *J Prosthet Dent* 2020;123:210—4.
75. Doliveux S, Jamjoom FZ, Nadra M, Gallucci GO, Hamilton A. Fabrication technique for a custom implant emergence profile on 3D printed casts. *J Prosthet Dent* 2020;123:571—5.