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Soft tissue grafting to improve the attached mucosa at dental implants: A review of the literature and proposal of a decision tree

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Background: Scientific data and clinical observations appear to indicate that an adequate width of attached mucosa may facilitate oral hygiene procedures thus preventing peri-implant inflammation and tissue breakdown (eg, biologic complications). Consequently, in order to avoid biologic complications and improve long-term prognosis, soft tissue conditions should be carefully evaluated when implant therapy is planned. At present the necessity and time-point for soft tissue grafting (eg, prior to or during implant placement or after healing) is still controversially discussed while clinical recommendations are vague. **Objectives:** To provide a review of the literature on the role of attached mucosa to maintain peri-implant health, and to propose a decision tree which may help the clinician to select the appropriate surgical technique for increasing the width of attached mucosa. **Results:** The available data indicate that ideally, soft tissue conditions should be optimized by various grafting procedures either before or during implant placement or as part of stage-two surgery. In cases, where, despite insufficient peri-implant soft tissue condition (ie, lack of attached mucosa or movements caused by buccal frena), implants have been uncovered and/or loaded, or in cases where biologic complications are already present (eg, mucositis, peri-implantitis), the treatment appears to be more difficult and less predictable. **Conclusion:** Soft tissue grafting may be important to prevent peri-implant tissue breakdown and should be considered when dental implants are placed. The presented decision tree may help the clinician to select the appropriate grafting technique. *(Quintessence Int 2015;46:499–510; doi: 10.3290/j.qi.a33688)*

Key words: peri-implant keratinized attached mucosa, peri-implantitis, soft tissue recession

The soft tissue around teeth is subdivided by definition into gingiva and mobile alveolar mucosa. The borderline between alveolar mucosa and gingiva is termed the mucogingival junction (Fig 1). The gingival width can vary inter-individually between 1 mm and 9 mm.[1] In contrast, the terminology of the peri-implant soft tissue in the literature is inconsistent.

There are various reasons to distinguish the peri-implant mucosa from the gingiva around teeth:

- The periodontal fibers in teeth run perpendicular to the root surface and insert into the root cementum (Sharpey's fibers), while the peri-implant connective tissue fibers run in a parallel direction to the implant or abutment surface and do not attach to the implant.[2,3]

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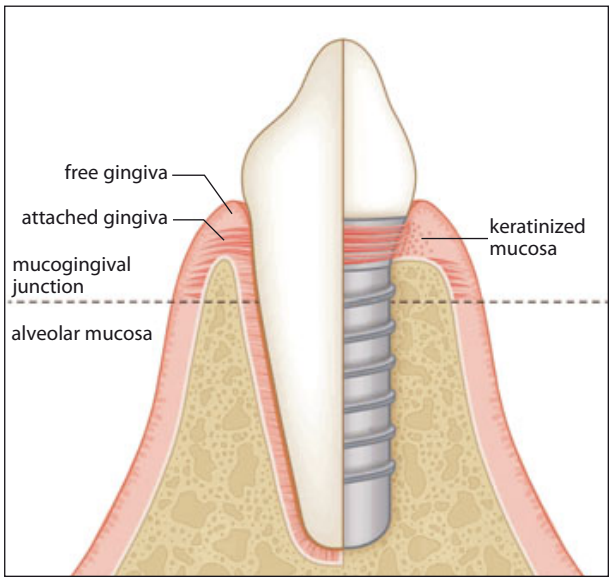


Fig 1 Schematic illustration of soft tissue structures around teeth and implants.

- The peri-implant connective tissue consists of a lower number of fibroblasts and a greater amount of collagen fibers and has a comparable structure to that of scar tissue.[2,4]
- The junctional epithelium around dental implants is more permeable than that around teeth.[5]
- The gingiva has a higher number of blood vessels compared to peri-implant mucosa.[6]

It seems that the presence of non-elastic collagen fibers in the underlying connective tissue is responsible for the existence of keratinized tissues while most fibers from the periodontal ligament space are non-elastic (eg, collagen) fibers. Therefore, around teeth, even following its complete surgical excision, a narrow band of gingiva will, in most cases, reform.[7] In contrast, implants can be surrounded by keratinized mucosa (KM) as well as by mobile alveolar mucosa.[8] An experimental study in monkeys revealed that the specificity of epithelium (keratinized or non-keratinized epithelium) appears to be influenced by the type of the underlying connective tissue;[9] ie, the connective tissue, harvested from an area covered by keratinized epithelium and transplanted into an area covered by non-keratinized epithelium, has the potential to induce keratinization.[9,10] However, in some cases, despite the presence of keratinization, the peri-implant mucosa is not attached to the underlying bone. This can occur in cases of slightly higher located peri-implant soft tissue, when the junction between KM and lining mucosa is situated more coronally in relation to the peri-implant bone margin.[8]

At present the necessity and time-point for soft tissue grafting (eg, prior to or during implant placement or after healing) are still controversially discussed in the literature, and clinical recommendations are vague.

The purposes of this article are to present a review of the literature on the role of the attached mucosa (AM) in the maintenance of peri-implant health, and to propose a decision tree which may help the clinician to select the appropriate surgical technique for increasing the width of AM.

REVIEW OF THE LITERATURE

The role of a certain width of keratinized tissue (KT) for preserving periodontal health is still controversially discussed in the literature. Observations from a clinical study have indicated that, even with supervised oral hygiene, all sites with < 2 mm of KT showed clinical signs of inflammation, whereas 80% of sites showing ≥ 2 mm of KT and attached tissue remained healthy. Based on these findings, the authors have concluded that ≥ 2 mm of KT is necessary to maintain the health of periodontal tissues.[11]

On the other hand, another investigation including 16 subjects has failed to show any differences in terms of clinical signs of inflammation, irrespective of whether the soft tissue surrounding the teeth displayed a band of KT width varying from < 1 mm to ≥ 2 mm.[12] Thus, at present, it is generally accepted that, around natural teeth, the presence of a certain width of attached gingiva is not necessary to maintain periodontal health.[13-15]

However, around dental implants, the potential role of an adequate width of keratinized/attached mucosa (KAM) on the long-term clinical stability is still a matter of debate.[16-28] In two human studies in totally edentulous patients, reconstructed with screw-retained fixed partial dentures, no correlation between implant success and the presence of KAM was detected.[16,21] Two

other human studies failed to support the concept that an adequate width of KM is essential in order to maintain a clinical healthy peri-implant soft tissue condition.[17,26] Moreover, in a study in dogs, no differences could be detected in terms of gingival recession or loss of attachment, independent of the presence or absence of AM and the width of KM. Grafting of gingival tissue increased the width of KAM, but did not additionally improve the condition of peri-implant soft tissue.[24] On the other hand, three earlier studies have indicated that the absence of KAM around dental implants increases the susceptibility of inflammation and adverse peri-implant soft and hard tissue reactions.[18,25,28] Accordingly, based on the limited evidence present at that time, earlier reviews identified insufficient reliable evidence regarding an association between the absence of KM and peri-implant disease.[19,20,23] In contrast, very recent publications suggest that the absence of an adequate width of KAM around dental implants may lead to increased levels of plaque accumulation,[29-33] higher rates of mucositis,[29,31,32,34,35] higher risk of peri-implant alveolar bone loss,[34,36] as well as soft tissue recession [29,32,33,36,37] and clinical attachment loss.[37] In addition, the width of peri-implant KAM seems to have an influence on immunologic parameters.[35,38] Therefore, by implication, better outcomes in terms of soft and hard tissue stability and esthetics might be expected in the presence of an adequate width of peri-implant KAM. Only one retrospective study reported on low incidences of peri-implant diseases over long periods in patients enrolled in a maintenance program, independent of the absence or presence of KAM (Table 1).[39] Nevertheless, recent reviews even concluded that the lack of an adequate width of KAM around dental implants is associated with more plaque accumulation, inflammation, soft tissue recession, and attachment loss (Table 2).[40-43] Additionally, there is evidence that in contrast to the attached gingiva, the peri-implant mucosa appears to have less capacity for an inflammatory response against external irritations (plaque accumulation).[44] Furthermore, there is evidence that tissue breakdown may progress faster at dental implants than at teeth.[45]

In many clinical situations following teeth extractions, horizontal and vertical bone resorption occurs due to the inactivity atrophy.[46-48] This process is often accompanied by a coronal displacement of the mucogingival junction.[49,50] Since implant surgery frequently includes one-stage or two-stage bone augmentation procedures, an additional displacement of the mucogingival junction may occur.[51,52] Therefore, in order to optimize the width of KAM, different soft tissue augmentation protocols have been suggested:

- as preliminary pre-implantation intervention before implant placement
- as part of the implant placement surgery
- as part of the stage-two surgery (re-entry)
- when the implant is already uncovered and eventually loaded.

The first three of the above-mentioned protocols seem to result in more predictable outcomes, compared to interventions after loading. In most cases in which an intervention at the peri-implant soft tissue is required after loading, esthetic problems or biologic complications like mucositis or peri-implantitis are already present. Moreover, the data on the indication of various surgical soft tissue augmentation techniques depending on the existing soft tissue (connective tissue graft [CTG], free gingival graft [FGG], combination of both) are scarce.[53-56]

Decision tree for peri-implant soft tissue augmentation

Basically, two different peri-implant soft tissue augmentation methods can be applied:

- enlargement of KM width by means of an apically positioned flap/vestibuloplasty (in combination with a FGG)
- gain of soft tissue volume using a subepithelial CTG or soft tissue replacement graft.

The concept of using autogenous CTGs or FGGs to enlarge the width of KT is well documented in the periodontal literature.[10,49,57,58] A retrospective investigation has shown that using FGGs, an average increase of

Table 1 Studies on the influence of a functionally adequate zone of keratinized/attached mucosa (KAM) around dental implants

Study	Correlation between implant success and the presence of KM	No correlation between implant success and the presence of KM	Study design
Adell et al[16]		No correlation between implant success and the presence of KM (implants with smooth surfaces)	Human study
Lekholm et al[21]		No correlation between implant success and the presence of KM (implants with smooth surfaces)	Human study
Zarb and Schmitt[28]	Increased levels of plaque and inflammation around implants in the absence of KM		Human study
Strub et al[24]		Grafting of gingival tissue increased the width of KAM but otherwise did not improve the condition of the peri-implant soft tissue (implants with smooth surfaces)	Animal study (dog)
Wennström et al[26]		An adequate width of KM is not essential in order to maintain a clinical healthy soft tissue condition at dental implants (implants with smooth surfaces)	Human study
Warrer et al[25]	Absence of KM around implants increases the susceptibility of the peri-implant region to plaque-induced tissue destruction		Animal study (monkey)
Bengazi et al[17]		An adequate width of KM is not essential in order to maintain a clinical healthy soft tissue condition at dental implants	Human study
Block et al[18]	Absence of KM around implants is correlated to adverse reactions of soft and hard tissue		Human study
Roos-Jansaker et al[22]		No association between the absence of KM around implants and peri-implant disease	Human study
Chung et al[31]	Absence of adequate KM or AM around implants was associated with higher plaque accumulation and mucositis but not with more alveolar bone loss		Human study
Artzi et al[30]	Significantly higher mucositis rates around implants with absence of adequate KM		Human study
Bouri et al[34]	Increased width of KM around implants is associated with lower mean alveolar bone loss and improved indices of soft tissue health		Human study
Zigdon and Machtei[38]	KM around implants affects both the clinical and immunologic parameters		Human study
Schrott et al[33]	Despite good oral hygiene/maintenance therapy, implants with less than 2 mm of peri-implant KM were more prone to plaque accumulation and bleeding as well as soft-tissue recession		Human study
Adibrad et al[29]	Absence of adequate KM around implants was associated with higher plaque accumulation, mucositis, BOP, and mucosal recession		Human study
Kim et al[36]	From the aspect of long-term maintenance and management, as well as for the area requiring esthetics, the presence of an appropriate amount of keratinized gingiva is required		Human study
Crespi et al[32]	Less width of KM is significantly associated with more mucositis, more plaque accumulation, and more mucosal recession		Human study
Malo et al[37]	The absence of a residual band of KM ≥ 6 mm wide in the vestibular-lingual aspect in patients rehabilitated in the complete edentulous mandible with flapless guided implant surgery may be associated with clinical attachment loss and a higher incidence of dehiscences		Human study
Boynuegri et al[35]	Adequate band of KM was related with less plaque accumulation and mucosal inflammation as well as pro-inflammatory mediator		Human study
Frisch et al[39]		Low incidence of peri-implant diseases over long periods can be expected in patients attending supportive post-implant therapy programs, independent of the absence or presence of KM	Human study

BOP, bleeding on probing.

Table 2 Reviews on the influence of a functionally adequate zone of keratinized/attached mucosa (KAM) around dental implants

	Correlation between implant success and the presence of KM	No correlation between implant success and the presence of KM	Review design
Schou et al[23]		No correlation between implant success and the presence of KM	Narrative review
Esposito et al[19]		Insufficient reliable evidence whether the increase of width of KAM is beneficial to patients or not	Cochrane review
Heitz-Mayfield[20]		No association between the absence of KM and peri-implant disease	Systematic review
Greenstein and Cavallaro[40]	The need for KM is patient specific, and at the present there is no method to reliably predict who would benefit from tissue augmentation		Narrative review
Wennström and Derks[27]	Despite the absence of strong associations between absence/presence of KM and peri-implant health, it is recommended to maximize efforts to preserve existing KM during the treatment procedures		Systematic review
Gobbato et al[43]	Reduced KAM around dental implants appears to be associated with clinical parameters indicative of inflammation and poor oral hygiene		Systematic review
Lin et al[41]	Lack of adequate KM around dental implants is associated with more plaque accumulation, tissue inflammation, mucosal recession, and attachment loss		Systematic review
Brito et al[42]	The presence of an adequate zone of KM may be necessary because it was shown to be related to better peri-implant tissue health		Systematic review

4.2 mm of KT can be obtained. The gain of KT measured at 1 year after surgery was, to its greatest extent, maintained up to a period of 10 to 25 years.[59] The mean loss of KT was minimal and amounted to an average of 0.7 to 0.8 mm. Based on these results, it can thus be anticipated that no clinically relevant resorptions of KT have to be expected after the first year following the use of FGGs.[59]

However, at implants that have been loaded despite an insufficient peri-implant soft tissue environment, four different clinical situations can be distinguished (Figs 2 and 3):

- The width of KM at the buccal aspect of the implant measures ≥ 2 mm.
- The width of KM at the buccal aspect of the implant measures < 2 mm (presence or absence of a frenulum low inserting) (Fig 4).
- The width of KM at the buccal aspect of the implant measures < 2 mm and a soft tissue recession can be distinguished (ie, the rough implant surface is visible). The peri-implant mucosa is thin, and no frenulum pull is visible (Fig 5).
- No or minimal width of KM at the lingual aspect of the implant in the mandible.

There are few data available in the literature reporting on the enlargement of KM and/or soft tissue thickening in already loaded dental implants with soft tissue recessions and/or slight peri-implant bone resorption. One RCT compared the outcomes in terms of peri-implant KM gain following either vestibuloplasty combined with the application of a FGG to vestibuloplasty alone. Sixty-four patients with 64 implants presenting KM of < 1.5 mm and showing signs of peri-implant mucositis were randomly treated with one of the two treatment modalities. The results clearly showed that the application of a FGG was more predictable for enhancing the width of the AM compared with vestibuloplasty alone.[53]

A prospective cohort study has evaluated in 10 patients the outcomes following coverage of soft tissue dehiscences at single-implant restorations. Treatment consisted of coronally advanced flap (CAF) combined with a subepithelial connective graft. The mean recession coverage measured 70% at 3 months and 66% at 6 months following therapy.[54] A recent prospective pilot study reported on the results following recession coverage at 16 dental implants by means of CAF and CTG harvested from the maxillary tuberosity.

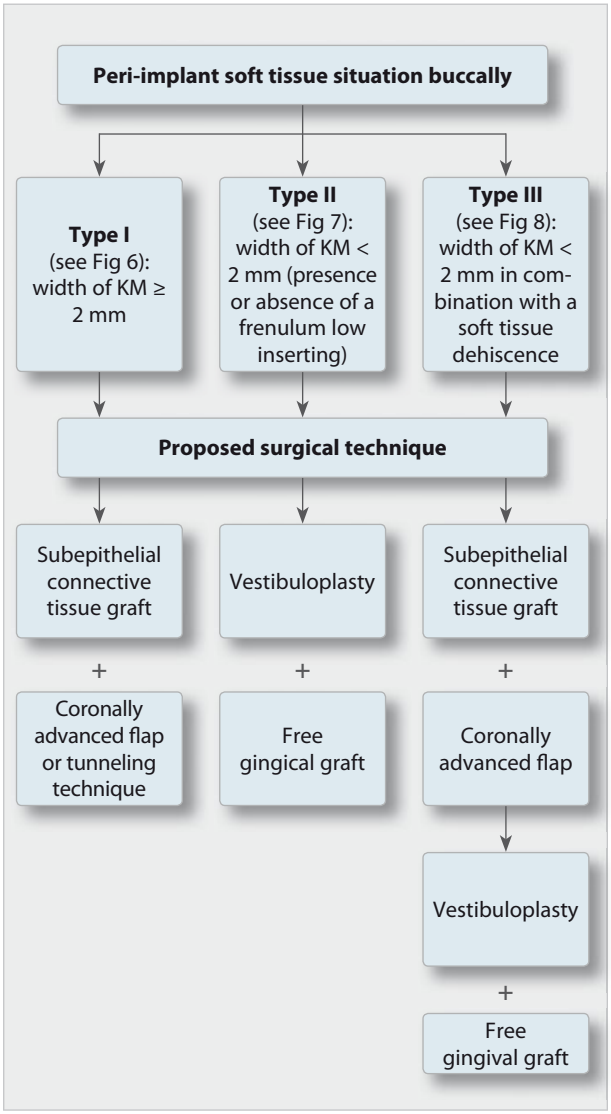


Fig 2 Decision tree for the surgical intervention of loaded implants (already uncovered and/or loaded implants) according the existing soft tissue conditions at the buccal aspects.

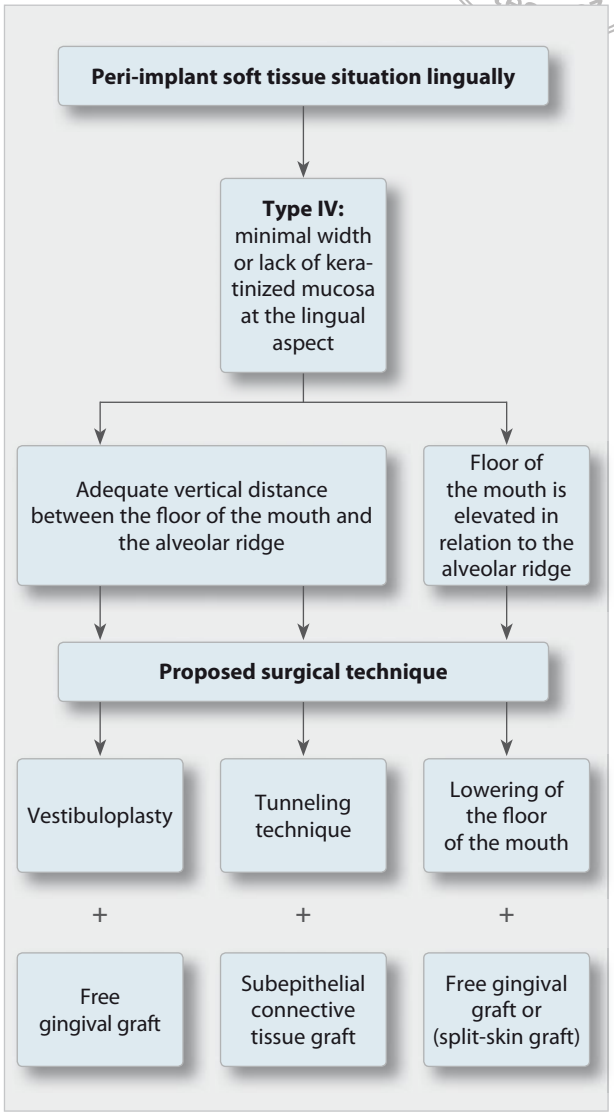


Fig 3 Decision tree for the surgical intervention of loaded implants (already uncovered and/or loaded implants) according the existing soft tissue conditions at the lingual aspects.

At 1 year following therapy, mean recession coverage amounted to 89.6%.[55] However, neither of the publications reported the height of KT at baseline and at final evaluation.

The highest values in terms of soft tissue recession coverage were reported in a cohort study including 20 patients and amounted to 96.3% at the follow-up 1 year after surgical intervention.[56] In all cases, treatment was performed by means of CAF and CTG. In that study, a significant increase of mean KT height was measured compared to baseline (baseline, 1.72 mm; 1-year follow-up, 2.3 mm). One reason for this high coverage ratio might be the combination of a CTG procedure and a mean residual height of KM at baseline of 1.72 mm.[56] This finding seems to support the use of a CTG in cases of type I, where the width of KM at the buccal aspect of the implant is ≥ 2 mm (Fig 6). Using autogenous connective tissue a shrinkage by more than 40% as well as a thickness augmentation between 0.55 and 1.18 mm have to be expected.[60] A threshold thickness at the

Figs 4a to 4d Illustration of the surgical procedure of a peri-implant soft tissue situation (type II): a 48-year-old woman with persisting inflammation and bleeding on probing in the buccal region of the implants at positions of maxillary right first and second premolar (14 and 15 according to FDI notation).

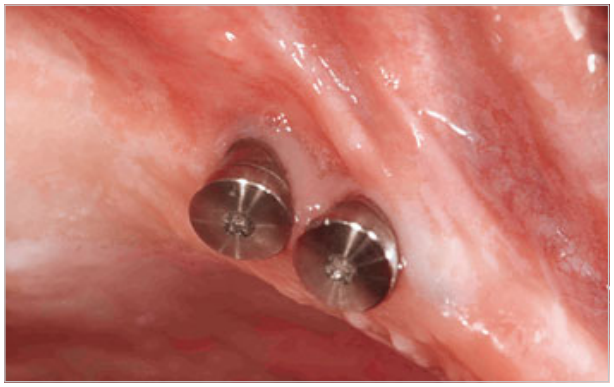


Fig 4a Initial situation with no KM existed on the buccal side of the implants 14 and 15, a low inserting frenulum was detected, and a soft tissue recession of 0.5 to 1.5 mm could be assessed.

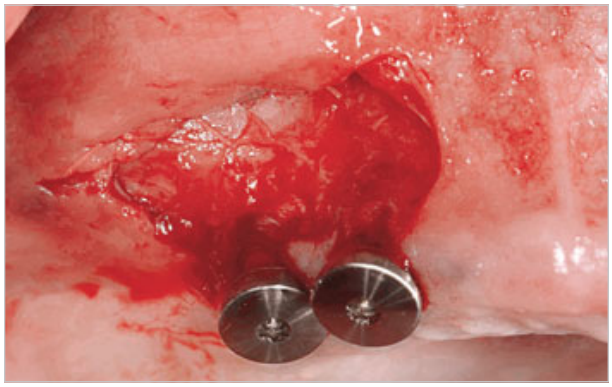


Fig 4b A sulcular incision at the implants 14 and 15 using the modified papilla preservation technique between the implants and two short vertical releasing incisions mesial 14 and regio 16 were performed.[69] Thereafter a split-thickness mucosal flap was prepared in the vestibule, whose coronal margins were sutured apically with the periosteum (Vicryl 5-0, Ethicon).

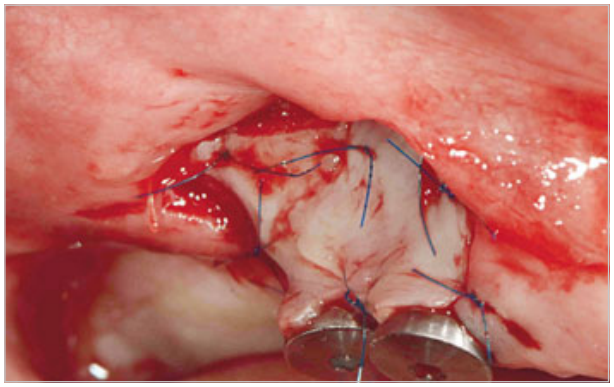


Fig 4c According to the extent of the prepared and by periosteum covered area a FGG, harvested from the palate, was fixed (Seralon 6-0, Serag). Sutures were removed postoperatively after 10 days.

Fig 4d Three months after surgery a 4 mm wide buccal cuff of KAM could be created. The soft tissue recession could be stabilized compared to the initial finding.

buccal aspect for more esthetic outcomes appears to be about 2 mm.[61-63]

In cases of a minimal amount or lack of peri-implant KM (type II) a FGG might be proposed in order to create a higher amount of KM compared to the CTG technique, which first of all increases the volume of the peri-implant soft tissue (Fig 7). A prospective clinical trial, in which the enlargement of KM at dental implants was performed using a vestibuloplasty in combination with a FGG at the stage-two surgery, recorded 1 year after surgery an average increase of 3.7 mm. Within the first year after surgery, an average resorption of 0.9 mm was detected.[64] However, a systematic review suggested a shrinkage in width of KT augmentations of more than 50% within some months after surgery.[60] In cases of a thin mucosa and a minimal width or lack of peri-implant KAM, in combination with a soft tissue recession to the extent that the rough implant surface is visible (type III), a two-stage procedure might be performed (Fig 8): first a subepithelial CTG in combination

Figs 5a to 5j Illustration of the surgical procedure of a peri-implant soft tissue situation (type III): a 53-year-old man with a symptomatic buccal soft tissue recession as well as peri-implant bone resorption at the implant 16.

Fig 5a Initial situation: Maxillary implant in the region 16 presenting a buccal soft tissue recession of 4 mm and a corresponding peri-implant bone resorption. Additionally only a minimal amount of KM was located at the buccal aspect.

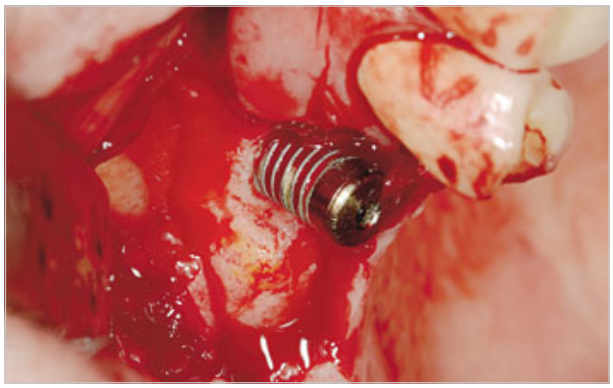


Fig 5b A crestal incision on the palatale aspect of the implant 16 with two releasing incisions mesially and distally into the vestibule were performed. A full-thickness mucoperiosteal flap was released.

Fig 5c Smoothening of the exposed rough implant surface using diamond burrs and rubber polisher (implantoplasty) and desinfection with chlorhexidine 0.2%.

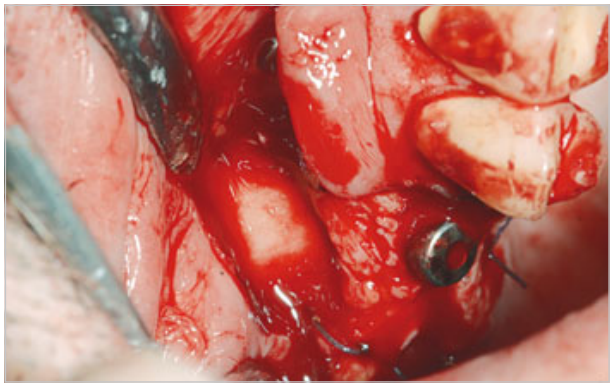


Fig 5d A subepithelial CTG, harvested from the palate, was fixed at the buccal side of the implant (Vicryl 5-0, Ethicon).

Fig 5e After horizontal periosteal incision the flap was coronally advanced and sutured (Seralon 5-0, Serag Wiessner). Sutures were removed postoperatively after 10 days.

Fig 5f Six weeks after this intervention the recession was covered and the soft tissue thickened, but the buccal soft tissue was not yet keratinized.

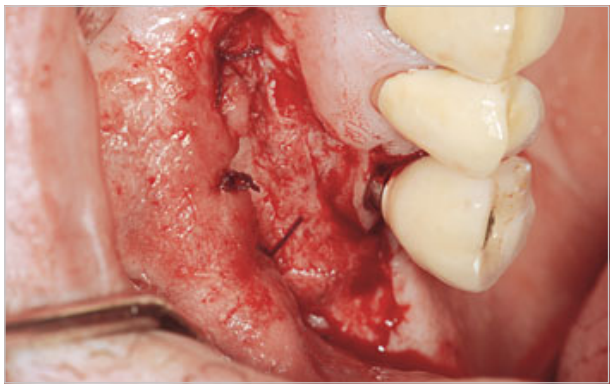


Fig 5g Three months after the first surgical intervention a vestibuloplasty in combination with a FGG was performed: A marginal incision along the mucogingival junction and two vertical releasing incisions regio 15 and 17 into the vestibule were performed. Thereafter a split-thickness mucosal flap was prepared in the vestibule, whose coronal margin was sutured apically with the underlying periosteum (Vicryl 5-0, Ethicon).

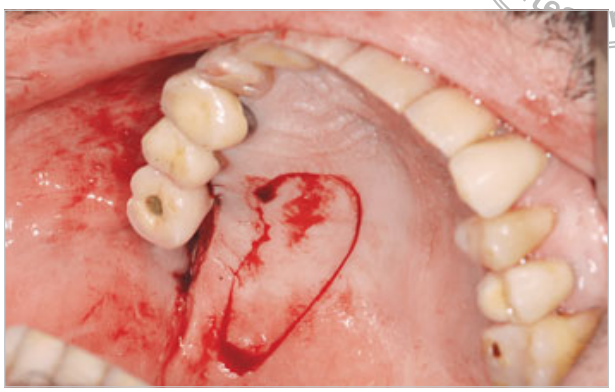


Fig 5h According to the extent of the prepared and periosteum covered area a FGG was harvested from the palate.

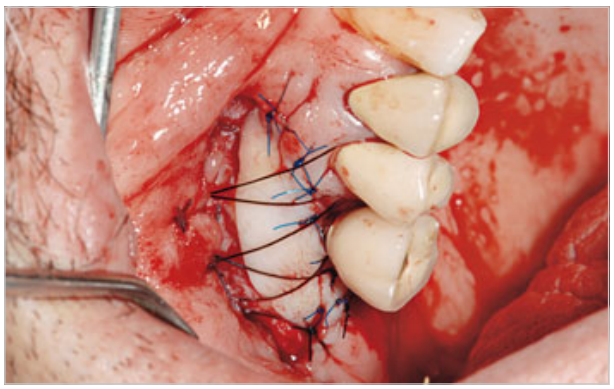


Fig 5i The FGG was fixed at the recipient side (5-0, Serag Wiessner). The cranial bottom of the FGG was not sutured, but pressed at the periosteum by mattress sutures (Ethilon 4-0, Ethicon). Sutures were removed postoperatively after 10 days.

Fig 5j Three months after the second intervention a KAM-width of 7.5 mm resulted. The soft tissue recession could be reduced significantly.

with a CAF in order to cover the dehiscence; and second, after a healing period of 3 months, a vestibuloplasty in combination with a FGG to create an adequate peri-implant cuff of KAM.

In cases of a minimal width or lack of KM at the lingual aspect of a dental implant and an adequate vertical distance between the mouth floor and the lingual mucosal margin (type IV), it might be possible to handle this situation by performing the same procedure proposed for type II (vestibuloplasty in combination with a FGG) or type I conditions (tunneling technique in combination with a CTG). If the mouth floor is elevated in relation to the alveolar ridge, the lowering of the mouth floor has to be considered.[65] The surgical lowering of the mouth floor can be combined with an FGG, or if extended with a split-skin graft.[66]

In place of a CTG or a FGG, there is now the possibility to use soft tissue replacement grafts (xenogenic collagen matrix [XCM]). Compared to autogenous soft tissue grafts, which negatively affect patient's morbid-

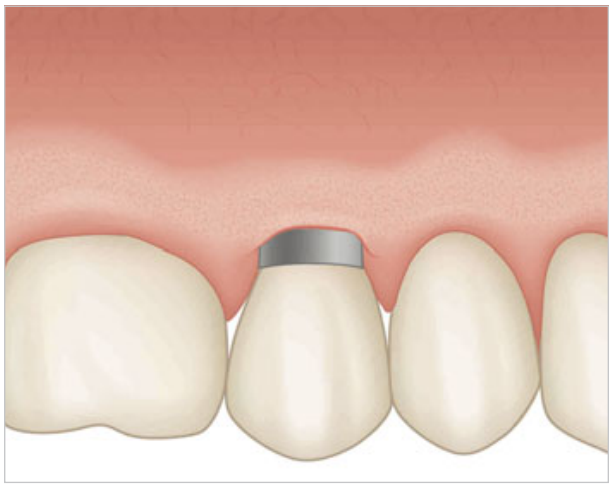


Fig 6 Type I: the width of KM at the buccal aspect of the implant is ≥ 2 mm.

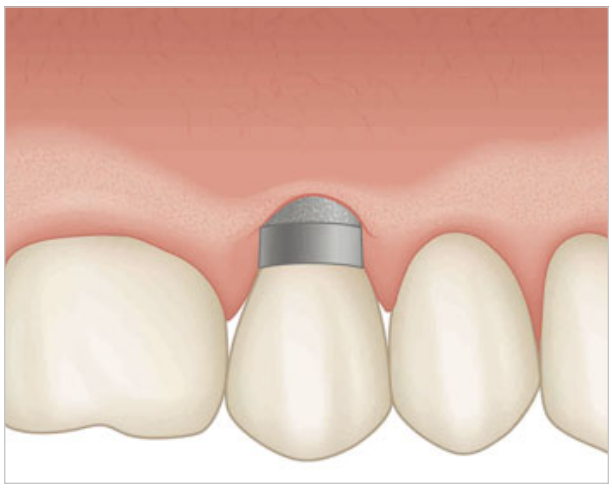
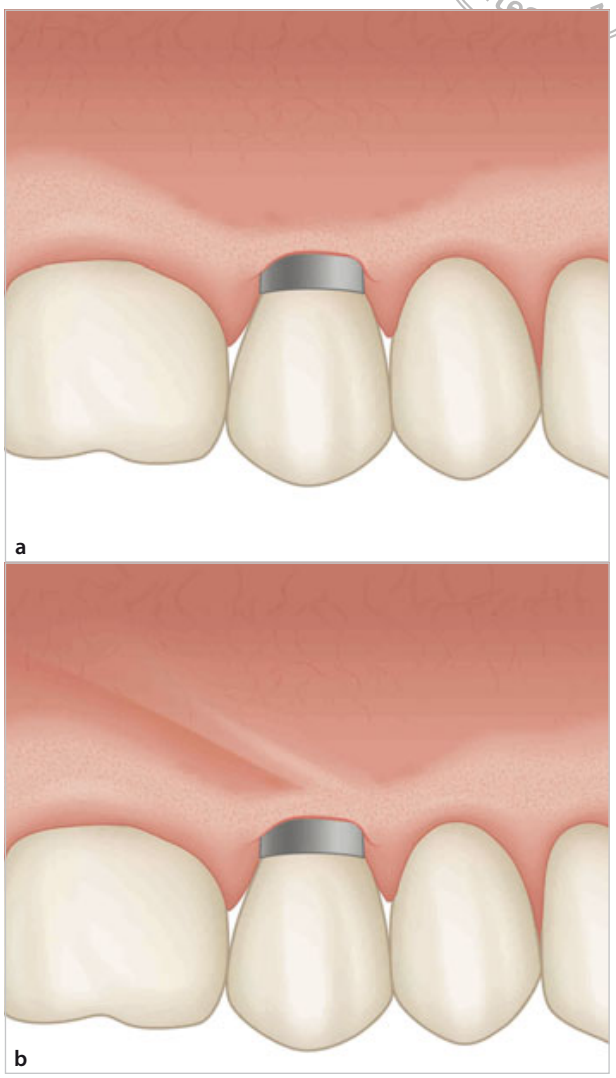


Fig 8 Type III: width of KM < 2 mm in combination with a soft tissue dehiscence.



Figs 7a and 7b Type II: width of KM < 2 mm (presence or absence of a frenulum low inserting).

ity, an additional donor site becomes unnecessary.[67] A randomized parallel-armed controlled clinical trial revealed that the use of XCM was as effective and predictable as the CTG for obtaining a zone of peri-implant KT.[68] The results of a split-mouth pilot case series indicated that around teeth XCM might be a viable alternative to a FGG. However, further investigations in evaluating the role of XCM as a viable alternative to FGG or CTG are needed.

It should be kept in mind that despite the use of soft tissue augmentation procedures, at present a *restitutio ad integrum* of peri-implantitis defects is still a difficult and unpredictable goal. Since the main aim of the treatment is to ensure long-term implant success, further clinical trials with larger cohorts are necessary to confirm the predictability of the proposed decision tree.

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