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REVIEW

Soft tissue augmentation procedures at second-stage surgery: a systematic review

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Abstract
Objectives The aim of this systematic review was to evaluate the efficacy of different soft tissue augmentation/correction methods in terms of increasing the peri-implant width of keratinized mucosa (KM) and/or gain of soft tissue volume during second-stage surgery.
Materials and methods Screening of two databases, MEDLINE (PubMed) and EMBASE (OVID), and hand search of related articles, were performed. Human studies reporting on soft tissue augmentation/correction methods around submucosally osseointegrated implants during second-stage surgery up to July 31, 2015 were considered. Quality assessment of the selected full-text articles was performed according to the Cochrane collaboration's tool to assess the risk of bias.
Results Overall, eight prospective studies (risk of bias: high) and two case series (risk of bias: high) were included. Depending on the surgical technique and graft material used, the enlargement of keratinized tissue (KT) ranged between −0.20 and 9.35 mm. An apically positioned partial-thickness flap/vestibuloplasty (APPTF/VP) in combination with a free gingival graft (FGG) or a xenogeneic graft material (XCM) was most effective. Applying a roll envelope flap (REF) or an APPTF in combination with a subepithelial connective tissue graft (SCTG), mean increases in soft tissue volumes of 2.41 and 3.10 mm, respectively, were achieved. Due to the heterogeneity of study designs, no meta-analysis could be performed.
Conclusions Within the limitations of this review, regarding the enlargement of peri-implant KT, the APPTF in the maxilla and the APPTF/VP in combination with FGG or XCM in the lower and upper jaw seem to provide acceptable outcomes. To augment peri-implant soft tissue volume REF in the maxilla or APPTF + SCTG in the lower and upper jaw appear to be reliable treatment options.
Clinical relevance The localization in the jaw and the clinical situation are crucial for the decision which second-stage procedure should be applied.

Keywords Second-stage surgery · Re-entry · Peri-implant keratinized mucosa · Peri-implant soft tissue volume

Introduction

The degree of bone resorption after tooth extraction can reach ~50 % of the original bone width [1–5]. Thus, with this substantial horizontal bone loss, the mucogingival line shifts coronally [6]. Due to this bone resorption, one- or two-stage surgical bone augmentation procedures are often required in implant therapy [7]. Because hard tissue augmentation requires primary wound closure, an additional displacement of the mucogingival line arises [8–10].

By definition, soft tissue around teeth is classified into gingiva and mobile mucosa. In contrast, the terminology of soft tissue around implants in the literature is inconsistent [11]. Despite many similarities, there are some differences between the mucosa around implants and the gingiva around teeth [11]:

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- The peri-implant connective tissue fibers run in a parallel direction to the implant or abutment surface and do not attach to the implant, while the periodontal fibers run perpendicular to the root surface and insert into the root cementum [12, 13].
- The peri-implant mucosa has a lower number of blood vessels compared to the gingiva [14]. While the blood supply of the gingiva around teeth derives from three sources, the periodontal ligament space, the supraalveolar plexus, and the interdental alveolar bone, the mucosa around implants lacks the supply from the periodontal ligament space [14].
- The junctional epithelium around implants is more permeable than around teeth [15].
- The peri-implant connective tissue exhibits fewer fibroblasts and a greater amount of collagen fibers [12, 16].
- The presence of non-elastic collagen fibers in the connective tissue seems to be determinant for the existence of keratinized tissues (KT). Because most fibers in the periodontal ligament space are non-elastic, around teeth, even following its complete surgical excision, a narrow band of gingiva will, in most cases, reform [17]. Dental implants can be surrounded by keratinized mucosa (KM) as well as mobile alveolar mucosa [18].

Since the specificity of the epithelium (keratinized or non-keratinized) seems to be influenced by the type of underlying connective tissue, the connective tissue, harvested from the subepithelial palatal area and transplanted into a region covered by non-keratinized epithelium, has the potential to induce keratinization [19, 20]. However, KM does not inevitably have to be attached, i.e., the peri-implant mucosa is not always attached to the underlying bone, even though keratinization is present. In this case, the peri-implant soft tissue is usually located more coronal and further away from the bone crest, consequently also the junction between KM and lining mucosa is situated more coronally in relation to the peri-implant bone margin [18].

The potential effects of circumferential KM around dental implants on the long-term stability of peri-implant tissues remain controversial [21–33]: in particular, older animal and human studies stated that an adequate width of KM was not essential for implant success or to maintain clinically healthy peri-implant soft tissue conditions [21, 22, 26, 29, 31]. In contrast, the results of three earlier studies indicated that implant sites without an adequate band of KM exhibit increased susceptibility to inflammation and adverse peri-implant soft and hard tissue reactions [23, 30, 33]. However, earlier reviews identified insufficient reliable evidence regarding any possible influence of the width of KM and peri-implant disease [24, 25, 28]. Moreover, more recent publications suggest that an inadequate width and thickness of peri-implant KM may lead to higher plaque deposition [34–38], higher rates of mucosal inflammation [34, 36, 37, 39, 40], a higher risk of peri-implant alveolar bone loss [39], soft tissue dehiscence [34, 37, 38, 41], and clinical attachment loss [41]. Additionally, there is evidence that the width of peri-implant KM has an influence on immunological parameters [40, 42]. Only the results of one recent retrospective study reported a low incidence of peri-implant disease over long periods in patients enrolled in a maintenance program, independent of the absence or presence of KM [43]. Accordingly, recent systematic reviews have concluded that an inadequate width of peri-implant KM was associated with more plaque accumulation, signs of inflammation, soft tissue recession, and attachment loss [32, 44–46]. Additionally, in contrast to the attached gingiva, the peri-implant mucosa seems to have less capacity to mount an inflammatory response against external irritants (plaque accumulation) [47].

Basically, two methods can be used to augment the soft tissues around dental implants:

1. Enlargement of the KM width by means of an apically positioned flap/vestibuloplasty (in combination with a free gingival graft (FGG) or an allogeneic or xenogeneic graft material)
2. Gain of soft tissue volume using a subepithelial connective tissue graft (SCTG) or soft tissue replacement grafts

The concepts and efficacy of using SCTG and FGG to increase the thickness or to enlarge the width of KT are well documented [20, 48–50]. To optimize the width of KM or to enhance the mucosal thickness around dental implants, regarding the time point of implant placement, four different protocols are distinguishable [51]:

1. As a preliminary pre-implantation intervention before implant placement
2. As part of the implant placement surgery
3. As part of the second-stage surgery (re-entry)
4. When the implant is already uncovered and eventually loaded

Currently, there is a lack of systematic reviews analyzing outcome data of different soft tissue augmentation/correction methods to improve anatomical soft tissue deficiencies during second-stage surgery (re-entry).

The focused question of this systematic review was: What is the efficacy of different soft tissue augmentation/correction methods in terms of increasing the peri-implant width of KM and/or gain of soft tissue volume during second-stage surgery.

Material and methods

Focused question

Using the PICO criteria, the focused question for the specific literature search was framed [52]: P: patients with insufficient soft tissue conditions (inadequate width of peri-implant keratinized mucosa (KM), movements caused by the buccal frenula, thin buccal mucosa) around submucosally osseointegrated dental implants immediately before second-stage surgery (re-entry), I: soft tissue surgery to improve the peri-implant soft tissue conditions during second-stage surgery, C: different soft tissue augmentation/correction methods, peri-implant soft tissue conditions before and after different surgical soft tissue augmentation/correction procedures, and O: efficacy of different soft tissue augmentation/correction methods in terms of increasing the peri-implant width of KM and/or gain of soft tissue volume.

Definitions

Two peri-implant soft tissue conditions are considered insufficient:

1. Absence or inadequate amount of peri-implant KM (peri-implant KM width of <2 mm)
2. Presence of a thin peri-implant mucosal tissue (peri-implant mucosal thickness of ≤2 mm)

Search strategy

An electronic search was performed of two databases—MEDLINE (via PubMed) and EMBASE (via OVID)—to identify systematically the relevant literature. Articles published up to July 31, 2015 were considered. The search string comprised the combination of key words (medical subjects headings, MeSH) and free-text terms. The linkage was conducted using Boolean operators (OR, AND). The following search strategy was applied:

(((acellular dermal matrix[Title/Abstract]) OR (dermal matrix allograft[Title/Abstract]) OR (alloderm[Title/Abstract]) OR (keratinized gingiva[Title/Abstract]) OR (keratinized mucosa[Title/Abstract]) OR (soft tissue graft[Title/Abstract]) OR (subepithelial connective tissue graft[Title/Abstract]) OR (connective tissue[Title/Abstract]) OR (FGG[Title/Abstract]) OR (human fibroblast-derived dermal substitute[Title/Abstract]) OR (dermagraft[Title/Abstract]) OR apligraf[Title/Abstract]) OR (collagen matrix[Title/Abstract]) OR (extracellular membrane[Title/Abstract]) OR (gingival autograft[Title/Abstract]) OR (attached gingiva[Title/Abstract]) OR (keratinized gingiva[Title/Abstract]) OR (buccal soft tissue thickness[Title/Abstract]) OR (soft tissue margin[Title/Abstract]) OR (attached mucosa[Title/Abstract]) OR (soft tissue augmentation[Title/Abstract]) OR (soft tissue transplantation[Title/Abstract]) OR (soft tissue defect*[Title/Abstract]) OR (ridge augmentation[Title/Abstract]) OR (soft tissue correction[Title/Abstract]) OR (apically positioned flap[Title/Abstract]) OR (coronally advanced flap[Title/Abstract]) OR (bilaminar technique[Title/Abstract]) OR (tunneling technique[Title/Abstact]) OR (vestibuloplasty*[MeSH Terms])) AND ((dental implant*[MeSH Terms]) OR (reentry[Title/Abstract]) OR (re-entry[Title/Abstract]) OR (second stage[Title/Abstract]) OR (second-stage[Title/Abstract]) OR (stage-two surgery[Title/Abstract])).

Additionally, a manual search of relevant articles published between January 1, 1900 and July 31, 2015 was performed in the following journals: *Journal of Oral Rehabilitation*, *Clinical Oral Implants Research*, *International Journal of Oral & Maxillofacial Implants*, *Implant Dentistry*, *Clinical Implant Dentistry and Related Research*, *International Journal of Periodontics and Restorative Dentistry*, *International Journal of Prosthodontics*, *Journal of Oral and Maxillofacial Surgery*, *Quintessence International*, *Journal of Periodontology*, *International Journal of Oral and Maxillofacial Surgery*, and *Journal of Oral Implantology*. Finally, the references of all selected full-text articles were searched for relevant articles.

Inclusion criteria

For study selection, the following inclusion criteria were applied:

1. Publication in the peer-reviewed literature
2. Any case series, prospective cohort study (PCS), controlled clinical trial (CCT), randomized clinical trial (RCT) (five or more patients included)
3. Full text in English or German
4. Studies in which an insufficient soft tissue condition around submucosally osseointegrated dental implants (inadequate width of peri-implant KM, movements caused by the buccal frenula, thin buccal mucosa) existed at the time of second-stage surgery
5. All dental implants were placed submucosally
6. Surgical soft tissue augmentation/correction methods were used to improve the peri-implant soft tissue condition
7. An observation period after second-stage surgery of at least 3 months

Exclusion criteria

The following exclusion criteria were applied:

1. Studies not meeting all inclusion criteria
2. In vitro studies
3. Animal studies
4. Studies in which the effect of soft tissue surgery could not be determined from the data (e.g., combination of guided bone regeneration and soft tissue surgery)
5. Studies in which the surgical techniques used were not clearly evaluable

Validity assessment

The publication records and abstracts identified by the electronic and the hand search were screened by two reviewers (R.G.B. and A.S.). Only reports with available full text were evaluated and determined for inclusion by the two review authors. Discrepancies and disagreements were resolved by discussion and consensus. Both reviewers used a data extraction form to extract the data independently.

Quality assessment

Quality and risk of bias assessments were performed independently by two authors (R.G.B. and A.S.) as part of the data extraction process. Discrepancies and disagreements were resolved by discussion and consensus.

The quality assessment of included randomized controlled trials (RCTs) and controlled clinical trials (CCT) was conducted using the Cochrane collaboration's tool for assessing risk of bias [53]. For included studies, not conducted as RCTs or CCTs, the quality assessment addressed the study design (prospective or retrospective), inclusion of a control group, predefined indication criteria for treatment, record of peri-implant clinical parameters (width of peri-implant KM and/or volume of peri-implant soft tissue and/or papilla index score and record of peri-implant clinical periodontal parameters (plaque index (PI), gingival index (GI), probing pocket depth (PPD), and/or clinical attachment level (CAL)) at both baseline and at least at one postoperative follow-up time point, completeness of outcome data for each main outcome, including exclusion from the analysis according to the quality criteria "incomplete outcome data" of the Cochrane collaboration's tool for assessing risk of bias [53], and radiographic follow-up. The studies were then rated to have a low risk of bias (all criteria met), an unclear risk of bias (one criteria not met), or a high risk of bias (two or more criteria not met).

Data synthesis

With the objective of determining all possible data and checking for variations in terms of study characteristics and outcomes, data were pooled into evidence tables, and a descriptive summary was performed. This allowed the detection of similarities and differences between studies and facilitated the suitability of further synthesis or comparison methods.

Results

Study selection

The electronic search of the MEDLINE and EMBASE databases and the manual search resulted in the identification of 1627 (1413 (MEDLINE) + 210 (EMBASE) + 4 (manual search)) potential titles and abstracts. After removal of duplicates and abstract screening, in total, 30 studies were selected (inter-reviewer agreement $k = 0.98$). For the second phase, the 30 full-text articles were screened and thoroughly evaluated. In total, 20 publications were excluded at this stage, because they did not fulfill the inclusion criteria (inter-reviewer agreement $k = 1.0$). Reasons for exclusion are presented in Table 1. Finally, 10 publications fulfilled the inclusion criteria applied in this systematic review (Fig. 1).

Quality and risk of bias assessment of selected publications

The quality and risk of bias assessments of selected studies are summarized in Table 2. None of the included publications was conducted as a randomized controlled trial (RCT). Thus, the quality assessment according to the Cochrane collaboration's tool for assessing risk of bias [53] could not be used. Eight studies were conducted using a prospective study design [54–61], whereas in two publications, the study design was unclear [62, 63]. In four publications, a control group included [54, 55, 61, 62]. Six studies reported on predefined criteria for treatment, whereas in three studies the definition was unclear. In one study, no criteria for treatment were available. Four studies did not completely or did not at all record peri-implant clinical parameters. None of the included studies recorded peri-implant clinical periodontal parameters. Only three publications were complete in terms of completeness of outcome data, and radiographs were obtained at baseline and follow-up in only one study. According to the given definition, in all 10 publications evaluated, the estimated risk of bias was considered high (Table 2).

Table 1 Studies excluded at the second stage of selection and the reason for exclusion

Publication	Reason for exclusion
Elkhaweldi et al. [84]	Case series with fewer than five subjects included
Sieira et al. [85]	Case series with fewer than five subjects included
Fischer et al. [86]	Case series with fewer than five subjects included
Malo et al. [41]	Mucogingival surgery and dental implant placement at the same time point
Park and Wang [87]	Case series with fewer than five subjects included
Giordano et al. [88]	Case report
Schneider et al. [89]	Soft tissue augmentation before second-stage surgery
Lee et al. [90]	Follow-up <3 months
Speroni et al. [91]	Surgical techniques applied are not clearly evaluable
Cillo and Finn [92]	Case report
Kwasnicki and Butterworth [93]	Case report
Hakim et al. [94]	Follow-up partially <3 months
Mathews [95]	Case series with fewer than five subjects included
Nemcovsky and Artzi [96]	Follow-up time not specified
Bousquet et al. [97]	Mucogingival surgery was performed before dental implant placement
Silverstein et al. [98]	Case report
Silverstein and Lefkove [99]	Case report
Silverstein et al. [100]	Case report
ten Bruggenkate et al. [101]	Mucogingival surgery was performed before dental implant placement
Buser [102]	Mucogingival surgery was performed before dental implant placement

Subdivision of included publications

Seven of the 10 selected publications examined several second-stage methods to enlarge the width of KM during second-stage surgery [54–59, 61] (Table 3). Two studies examined a surgical approach to augment the buccal soft tissue volume and/or improve the interproximal papilla fill [60, 63] (Table 4) and one other study reported on both: the augmentation of soft tissue volume and the enlargement of KM [62] (Tables 3 and 4).

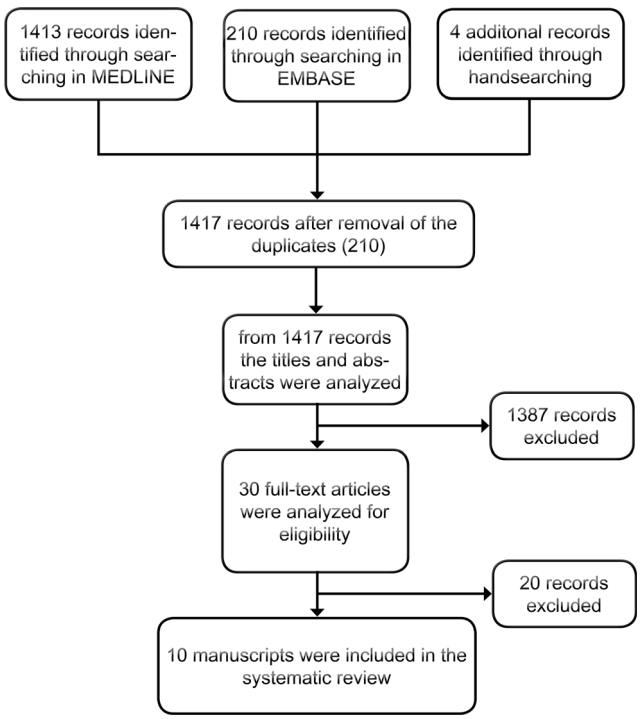

Fig. 1 Flow chart of search strategy

Enlargement of KM width during second-stage surgery

Eight studies dealing with treatment outcomes of KM enlargement at second-stage surgery around osseointegrated dental implants are presented in Table 3. In total, 172 patients and 450 implant sites were treated for peri-implant KM gain, while in one study, the number of implant sites was not reported. The methods and techniques to enlarge KT included apically positioned partial-thickness flap/vestibuloplasty (APPTF/VP) in combination with autogenous tissues FGG or in combination with xenogeneic collagen matrices (XCM) (Mucograft®, Geistlich, Wolhusen, Switzerland), a split-thickness skin graft (STSG), or with cultured mucosal epithelium (CME), APPTF in combination with a SCTG without a graft material as well as an apically positioned full-thickness flap (APFTF) in combination with a pediculated coronally positioned connective tissue graft (PCPCTG). The observation time periods ranged from 3 to 60 months. In four studies, the main indication for treatment was an inadequate width of KM in the region of dental implants before second-stage surgery (≤1 to ≤3.5 mm) [54, 55, 57, 61]. In one study,

Table 2 Risk of bias assessment for included studies not conducted as randomized controlled trials, as judged by the authors

	Prospective (+)/retrospective (−) design	Inclusion of a control group	Predefined indication criteria for treatment	Record of peri-implant clinical parameters (width of peri-implant keratinized mucosa (KM) and/or volume of peri-implant soft tissue/papilla index score)	Record of peri-implant clinical periodontal parameters (plaque index (PI), gingival index (GI), probing pocket depth (PPD), and/or clinical attachment level (CAL))	Completeness of outcome data for each main outcome, including attrition and exclusion from the analysis	Radiographic follow-up	Summary assessment
Schmitt et al. [61]	+	+	+	+	−	+	−	High
Man et al. [60]	+	−	?	+	−	−	+	High
Schmitt et al. [54]	+	+	+	+	−	+	−	High
Tunkel et al. [62]	?	+	+	?	−	−	−	High
Stimmelmayr et al. [55]	+	+	+	+	−	+	−	High
Heberer and Nelson [56]	+	−	?	?	−	−	−	High
Nemcovsky and Arzti [57]	+	−	+	?	−	−	−	High
Nemcovsky et al. [63]	?	−	?	+	−	−	−	High
Barone et al. [58]	+	−	+	+	−	?	−	High
Ueda et al. [59]	+	−	−	−	−	−	−	High

+ low risk of bias, ? unclear risk of bias, − high risk of bias

the distance between the buccal bone margin of the emerging implant and the mucogingival junction at implant placement had to be ≤3 mm [58]. In another study, there was a prospective indication for treatment: the width of KM should exceed 3 mm after second-stage surgery [62]. In two studies, no clear indication for treatment was provided [56, 59]. Due to the heterogeneity of study designs, observation times, surgical procedures, and the use of different augmentation materials, no meta-analysis was performed.

Treatment outcomes

Width of keratinized tissue Overall, eight studies reported on the width of augmented KT. Depending on the surgical technique applied and graft material used, the enlargement of KT ranged between −0.20 and 9.35 mm. Two studies compared the application of XCM (gain after 3 months 9.35 mm [54], gain after 6 months 7.13 mm, gain after 60 months 5.53 mm [61]) to that of FGG (gain after 3 months 8.93 mm [54], gain after 6 months 8.13 mm, gain after 60 months 7.70 mm [61]), both combined with an APPTF/VP design, whereby in one study, an implant-retained vestibular splint was incorporated during the healing phase (30 days) [54]. In both groups, a statistically significant increase in KT was achieved [54, 61]. Another study compared the application of APPTF alone (group 1, gain 4.63 mm) with the application of a roll envelope flap (REF) (group 2, gain 1.35 mm) as well as with the application of APPTF in combination with a SCTG (group 3, gain 4.10 mm): The differences between groups 1 and 2 and between groups 2 and 3 were statistically significant ($p > 0.001$) [62]. A further study compared APPTF/VP + FGG at second-stage surgery (gain 3.35 mm) with APPTF + FGG at the time of implant placement (gain 3.25 mm). No statistically significant difference was found regarding the buccal final KT gain [55]. In a prospective clinical study, a combination of APFTF and PCPCTG was applied at second-stage surgery. At the follow-up examination after 3–5 months, a mean final gain of KT of 3.07 mm was reported. Compared with baseline, a statistically significant increase was achieved [57]. Compared with baseline, in only one study applying an APPTF technique, a final loss of KT (−0.20 mm) was reported [58]. In two publications, no data were provided in terms of KT gain [56, 59].

Postoperative shrinkage or relapse of KM Six of the eight included publications reported on postoperative shrinkage or relapse of augmented KT. In three studies, the shrinkage rate of KM was presented in percentage terms and partially in millimeters. In the first study, a shrinkage rate after a follow-up of 6 months of 32.92 % for the control group (APPTF + FGG) and 41.12 % for the test group (APPTF + XCM) and

Table 3 Included studies: augmentation of keratinized mucosa (KM) around dental implants at second-stage surgery

Publication	Study design	Number of implants (I) and patients (P)	Indication for treatment	Surgical soft tissue intervention	Use of synthetic material:	Observation time (months)	Outcome measurements	Baseline (before surgical intervention)	Last follow-up	Final gain of KM//soft tissue thickness	Postoperative relapse of KM/ soft tissue thickness	Comments
Schmitt et al. [61]	PCS	Follow-up 6 months Group 1: I, 74 P, 21 Group 2: I, 102 P, 27 Follow-up 60 months Group 1: I, 20 P, 5 Group 2: I, 20 P, 5	Inadequate width of peri-implant KM (≤2 mm) Submerged implant placement performed Before second-stage surgery	Group 1: APPTF/ VP + FGG Group 2: APPTF/ VP + XCM	Group 2: XCM	6/60	Peri-implant width of KM (mm) Total surgery time Clinical appearance (texture and color)	Group 1, 0.70 ± 0.69 mm Group 2, 0.62 ± 0.65 mm (NSSD)	Follow-up 6 months Group 1, 8.83 ± 2.68 mm[a] Group 2, 7.75 ± 2.75 mm[a] Follow-up 60 months Group 1, 8.40 ± 2.41 mm[a] Group 2, 6.15 ± 1.23 mm[a]	Follow-up 6 months Group 1, 8.13 mm Group 2, 7.13 mm (NSSD) Follow-up 60 months Group 1, 7.70 mm Group 2, 5.53 mm (SSD)	Follow-up 6 months Group 1, 4.23 mm (32.92 %)[b] Group 2, 5.21 mm (41.12 %)[b] (NSSD) Follow-up 60 months Group 1, −4.66 mm (40.65 %)[b] Group 2, −6.81 mm (52.89 %)[b] mm (NSSD) % (SSD)	The FGG and XCM are both suitable for regeneration of peri-implant KM. However, concerning the stability of regenerated KM over time, the FGG still remains the gold standard. Total surgery time: Group 1, 84.33 min Group 2, 65.11 min (SSD) In group 1, the augmented mucosa appeared dissimilar to the adjacent areas in texture and color. In group 2, no difference was detected.
Schmitt et al. [54]	PCS	Group 1: I, 24 P, 7 Group 2: I, 25 P, 7	Inadequate width of peri-implant KM (≤2 mm) Submerged implant placement performed Before second-stage surgery	Group 1: APPTF/ VP + FGG + splint Group 2: APPTF/ VP + XCM + splint	Group 2: XCM	3	Peri-implant width of KM (mm) Total surgery time Clinical appearance (texture and color)	Group 1, 0.88 ± 0.65 mm Group 2, 0.97 ± 0.64 mm (NSSD)	Follow-up 3 months Group 1, 9.81 ± 2.45 mm[a] Group 2, 10.32 ± 3.15 mm[a]	Follow-up 3 months Group 1, 8.93 mm Group 2, 9.35 mm	Follow-up 3 months Group 1, −3.86 mm (28.35 %)[b] Group 2, −5.08 mm (32.98 %)[b] (NSSD)	Both groups showed comparable clinical and histological outcomes Total surgery time: Group 1, 74.43 min Group 2, 49.86 min (SSD) In group 1, the augmented mucosa appeared dissimilar to the adjacent areas in texture and color after 3 months. In group 2, no difference was detected.
Tunkel et al. [62]	CS	Group 1: I, 36 P, 14 Group 2: I, 23 P, 10 Group 3: I, 19 P, 8	Width of KM should exceed 3 mm after surgery	Group 1: APPTF Group 2: REF Group 3: APPTF + SCTG	Nihil	12	Peri-implant width of KM Soft tissue thickness (mm)	NA NA	NA NA	Group 1, 4.63 mm Group 2, 1.35 mm Group 3, 4.10 mm (SSD = > Group 1:2/2:3) Group 1, 1.37 mm Group 2, 2.41 mm Group 3, 3.10 mm (SSD = > Group 1:2/1:3)	Group 1, −0.52 mm[a] Group 2, −0.83 mm[a] Group 3, −0.90 mm[a] (NSSD) Group 1, −0.08 mm[b] Group 2, −0.45 mm[a] Group 3, −0.21 mm[b]	It is possible to gain soft tissue thickness or KM during second-stage surgery using APPTF, REF, and APPTF + SCTG. In cases of missing tissue thickness, a REF or APPTF should be performed,

Table 3 (continued)

Publication	Study design	Number of implants (I) and patients (P)	Indication for treatment	Surgical soft tissue intervention	Use of synthetic material:	Observation time (months)	Outcome measurements	Baseline (before surgical intervention)	Last follow-up	Final gain of KM//soft tissue thickness	Postoperative relapse of KM/ soft tissue thickness	Comments
												while a lack of KM requires the APPTF with or without a SCTG.
Stimmelmayr et al. [55]	PCS	Group 1: I, 46 P, 19 Group 2: I, 24 P, 10	Inadequate width of KM (≤3.5 mm)	Group 1: APPTF/ VP + FGG (re-entry) Group 2: APPTF/ VP + FGG (implant placement)	Nihil	12	Peri-implant width of KM (mm)	Group 1, 3.00 mm Group 2, 2.75 mm	Group 1, 6.35 mm Group 2, 6.00 mm	Group 1: buc, 3.30 mm ling, −0.35 mm Total, 3.35 mm Group 2: buc, 3.30 mm ling, −0.05 mm Total, 3.25 mm	Group 1, −1.25 mm (buc, −0.90 mm/ ling, −0.35 mm) Group 2, −1.45 mm (buc, −1.40 mm/ ling, −0.05 mm) buc: NSSD ling: SSD	Four patients dropped out. The combination of ridge augmentation with APPTF/VP + FGG resulted in the stable extension of peri-implant KM.
Heberer and Nelson [56]	PCS	I, 68 P, 17	Patients had received surgical therapy for a malignant oral tumor in the mandible	APPTF/VP + STSG (buc + ling)	Nihil	24	Peri-implant width (length) of augmented soft tissue (mm)	NA	NA	NA	12 months: Vertical length buc, 10.5 % Vertical length ling, 9.7 % (NSSD) Total vertical length, 9.5 % Horizontal length, 6.7 % (SSD) 24 months: Vertical length buc 18.5 % Vertical length ling, 19.1 % (NSSD) Total vertical length, 18.5 % Horizontal length, 10.4 % (SSD)	Use of a surgical splint in order to ensure sufficient pressure on the graft STSGs were harvested from the posterolateral upper thigh (thickness of 0.4 mm).
							Probing depth	NA	Mesial, 2.56 mm Distal, 2.64 mm	NA	NA	
Nemcovsky and Arzti [57]	PCS	I, 40 P, 13	Minimal or nonexistent buccal KM prior to second-stage surgery (≤1 mm)	APFTF (from pal towards buc) + PCPCTG (from pal towards cor)	Nihil	3–5	Peri-implant width of KM (mm)	0.23 ± 0.48 mm	3.30 ± 0.76 mm[a]	3.07 ± 1.00 mm	NA	Simple and predictable second-stage technique in the lateral upper jaw
Barone et al. [58]	PCS	I, 35 P, 35	Distance between the buccal bone margin of the	APPTF	Nihil	12	Peri-implant width of KM (mm)	3.40 ± 1.03 mm (range 1–5 mm)	3.20 ± 0.90 mm (range 2–5 mm)	−0.20 mm	−0.34 mm	This second-stage protocol is recommended for the treatment of cases where the presence of

Table 3 (continued)

Publication	Study design	Number of implants (I) and patients (P)	Indication for treatment	Surgical soft tissue intervention	Use of synthetic material:	Observation time (months)	Outcome measurements	Baseline (before surgical intervention)	Last follow-up	Final gain of KM//soft tissue thickness	Postoperative relapse of KM/ soft tissue thickness	Comments
			emerging implant and the mucogingiv-al junction was ≤3 mm (at implant placement)									an adequate amount of KM is necessary.
Ueda et al. [59]	PS	I, NA P, 12	NA	APPTF/VP + CME + plastic splint	Nihil	3	Peri-implant width of KM (mm)	NA	NA	NA	NA	In six patients, partial necrosis of the CME was observed (10–50 % of the graft).

APFTF apically positioned full-thickness flap, *APPTF/VP* apically positioned partial-thickness flap/vestibuloplasty, *buc* buccally, *CME* cultured mucosal epithelium, *cor* coronally, *CPPTF* coronally positioned partial-thickness flap, *CS* case series, *FGG* free gingival graft, *KM* keratinized mucosa, *ling* lingually, *NSSD* no statistically significant difference, *pal* palatally, *PCPCTG* pediculated coronally positioned connective tissue graft, *PCS* prospective clinical study, *REF* roll envelope flap, *PS* pilot study, *STSG* split-thickness skin graft, *SSD* statistically significant difference, *XCM* xenogeneic collagen matrix (Mucograft®, Geistlich Pharma AG, Switzerland)

[a] Statistically significant difference compared to baseline

[b] Statistically significant decrease

Table 4 Included studies: augmentation of soft tissue volume around dental implants at second-stage surgery

Publication	Study design	Number of implants (I) and patients (P)	Indication for treatment	Surgical soft tissue intervention	Use of synthetic material	Observation time (months)	Outcome measurements	Before surgical intervention	1 week after second-stage surgery	Last follow-up	Final gain of KM/soft tissue thickness/ increase in PIS	Postoperative relapse of KM/ soft tissue thickness	Comments
Man et al. [60]	PCSS	I, 12 P, 12	Absence of a buccal convex profile before second-stage surgery Single-tooth implants	REF	Nihil	6	CPF (0 = absence of a CPF, 1 = partial presence of a CPF, 2 = presence of a CPF, 3 = over-contour of CPF)	0.58 ± 0.51 (0–1)	2.58 ± 0.51 (2–3)[b]	1.83 ± 0.39 (1–2)[b]	NA	NA	Two patients presented partial necrosis of the palatal mucosa. The PERT is useful for labial soft tissue and interproximal papilla reconstruction adjacent to an anterior maxillary single-implant restoration.
							PIS (0 = no papilla, 1 = papilla fills less than half of the height of interproximal space, 2 = papilla fills more than half of height of interproximal space, 3 = papilla fills up the entire interproximal space, 4 = hyperplastic papilla)	NA	0.88 ± 0.74 (0–2)	2.79 ± 0.40 (2–3)[b]	NA	NA	
							FML in relation to the location of the contralateral tooth (positive value when FML in a more coronal position compared to the contralateral tooth)	NA	−1.22 ± 0.49 (−2.2 to −0.5)	0.10 ± 0.18 (−0.5 to 0.2)[b]	NA	NA	
							MBL (mm)	0	0	−0.88 ± 0.34 mm	NA	NA	
							PBL (mm)	0	0	−0.15 ± 0.26 mm	NA	NA	
Tunkel et al. [62]	CS	Group 1: I, 36 P, 14 Group 2: I, 23 P, 10 Group 3: I, 19 P, 8	Width of KM should exceed 3 mm after surgery	Group 1: APPTF Group 2: REF Group 3: APPTF + SCTG	Nihil	12	Peri-implant width of KM	NA	NA	NA	Group 1, 4.63 mm Group 2, 1.35 mm Group 3, 4.10 mm (SSD = > Group 1:2/2:3)	Group 1, −0.52 mm[b] Group 2, −0.83 mm[b] Group 3, −0.90 mm[b] (NSSD)	It is possible to gain soft tissue thickness or KM during second-stage surgery using APPTF, REF, and APPTF + SCTG.
							Soft tissue thickness (mm)	NA	NA	NA	Group 1, 1.37 mm Group 2, 2.41 mm Group 3, 3.10 mm (SSD = > Group 1:2/1:3)	Group 1, −0.08 mm[a] Group 2, −0.45 mm[a] Group 3, −0.21 mm[a]	In cases of missing tissue thickness, a REF or APPTF should be performed, while a lack of KM requires the APPTF with or without a SCTG.

Table 4 (continued)

Publication	Study design	Number of implants (I) and patients (P)	Indication for treatment	Surgical soft tissue intervention	Use of synthetic material	Observation time (months)	Outcome measurements	Before surgical intervention	1 week after second-stage surgery	Last follow-up	Final gain of KM/soft tissue thickness/ increase in PIS	Postoperative relapse of KM/ soft tissue thickness	Comments
Nemcovsky et al. [63]	CS	I, 36 P, 32	Implants placed in the anterior and premolar maxillary region Single-tooth implants	PSEF + papilla de-epitheliali-zation	Nihil	6	PIS (0 = no papilla and no curvature of soft tissue contour, 1 = papilla fills less than half of the height of interproximal space and a convex curvature of soft tissue contour, 2 = papilla fills more than half of height of interproximal space, but disharmonious, 3 = papilla fills up the entire interproximal space to the same level as in the proximal teeth and in harmony with the adjacent papillae)	1.10 ± 0.58 PIS 0: (11 %) PIS 1: (45 %) PIS 2: (14 %) PIS 3: (2 %)	NA	2.17 ± 0.56[b] PIS 0: (0 %) PIS 1: (11 %) PIS 2: (38 %) PIS 3: (23 %)	1.07 ± 0.43[b] (no increase in PIS unit 11 % Increase of 1 PIS unit 71 % Increase of 2 PIS units 18 %)	NA	This technique seems to be useful for partial or total interproximal papilla reconstruction in single-implant restorations.

APFTF apically positioned full-thickness flap, *CPF* convex profile on the facial aspect, *CS* case series, *FML* facial mucosal level, *KM* keratinized mucosa, *MBL* marginal bone level, *NA* not available, *PBL* proximal bone level of the adjacent teeth, *PCSS* prospective case series study, *PCS* prospective cohort study, *PIS* Jemt papilla index scores, *PSEF* palatal split envelope flap, *REF* roll envelope flap, *SCTG* subepithelial connective tissue graft

[a] Not statistically significant difference compared with baseline

[b] Statistically significant difference compared with baseline

after 60 months such one of 40.65 % for the control group and 52.89 % for the test group was documented, respectively. In both groups, the highest reduction in KT width after surgery occurred in the early healing phase (1 month) and up to 6 months. After 6 months, the shrinkage slowed down in both groups and showed only minimal changes up to 60 months. The inter-group difference was not statistically significant after 6 months ($p = 0.613$), but reached a statistically significant level after 36 ($p = 0.034$), 48 ($p = 0.01$), and 60 months ($p = 0.001$) after surgery [61]. In the second publication, a shrinkage rate of 28.35 % for the control group (APPTF + FGG) and 32.98 % for the test group (APPTF + XCM) after an observation period of 3 months was reported. The difference was not statistically significant ($p = 0.77$) [54]. In the third study, after an observation period of 24 months, relapse rates of 18.5 % in the vertical dimension and 10.4 % in the horizontal dimension were measured, applying an APPTF + STSG [56]. In the three other publications, postoperative shrinkage dimensions of −0.34 to −1.45 mm were reported. In the first study, three different surgical techniques were compared (group 1: APPTF (shrinkage of −0.52 mm), group 2: REF (shrinkage of −0.83 mm), group 3: APPTF + SCTG (shrinkage of −0.90 mm)). In all three groups, the shrinkage was at statistically significant level. No statistically significant difference was detected between the groups ($p = 0.37$) [62]. In the second publication, using APPTF/VP + FGG at second-stage surgery, over an observation period of 12 months, an overall mean shrinkage of −1.25 mm was reported. No statistically significant difference was reported, compared to the overall mean shrinkage of −1.45 mm applying a one-stage procedure (APPTF/VP + FGG at implant placement). However, considering only the lingual aspect, after the single-stage procedure (−0.05 mm), the resorption was significantly higher than that after the two-stage procedure (−0.35 mm) [55]. In the last publication, after an observation period of 12 months, a mean shrinkage of −0.34 mm was documented [58].

Soft tissue thickness Only one of the seven included studies reported on the change in soft tissue thickness between baseline and 12 months after intervention. In group 1 (APPTF), a mean soft tissue thickness gain of 1.37 mm was measured. Furthermore, measurements of 2.41 mm in group 2 (REF) and 3.10 mm in group 3 (APPTF + SCTG) were reported. The differences between group 1 and 2 ($p < 0.010$) as well as group 1 and 3 ($p < 0.001$) were statistically significant. The postoperative shrinkage of soft tissue volume over the observation period of 12 months was −0.08 mm in group 1, −0.45 mm in group 2, and −0.21 mm in group 3. In none of the three groups, the amount of shrinkage in volume did reach a statistically significant level [62].

Peri-implant probing depth Peri-implant probing depth (PPD) values were reported in only one study. At 24 months after the intervention (APPTF/VP + STSG), mean PPDs of 2.56 mm (mesial) and 2.64 mm (distal) were measured [56].

Total surgery time Two studies reported on the total surgery time spent in two different surgical procedures [54, 61]. The surgeries applying APPTF/VP + FGG lasted a mean of 74.43 and 83.33 min, respectively, while the surgeries using APPTF/VP + XCM lasted a mean of 49.86 and 65.11 min, respectively. In both studies, the inter-group difference reached statistically significant level ($p = 0.013$) [54] ($p = 0.001$) [61].

Texture and color Two publications compared the texture and color of augmented soft tissue areas with adjacent areas: In the FGG groups, the mucosa in the augmented regions appeared dissimilar to the adjacent areas in texture and color after 3–60 months. In the XCM groups, no differences were detected after follow-up periods of 3 months as well as 60 months [54, 61].

Augmentation of peri-implant soft tissue volume during second-stage surgery

Treatment outcomes for the augmentation of peri-implant soft tissue volume at second-stage surgery from three studies are presented in Table 4. The first was performed as a prospective case series with a follow-up of 6 months [60], whereas the second publication was a comparative case series including three groups, of which only in two groups a soft tissue augmentation was performed [62]. The third publication was a case series with a follow-up of 6 months [63]. Overall, 62 patients and 90 implant sites were treated using a soft tissue augmentation technique. In the first study, a roll envelope flap (REF) was applied [60]. In the second study, in group 1 an APPTF, in group 2 a REF, and in group 3 an APPTF + SCTG were used [62]. The third study applied a palatal split envelope flap (PSEF) in combination with a papilla de-epithelialization procedure [63]. The observation time periods ranged from 6 to 12 months. In the first study, the main indication for treatment was the absence of a buccal convex profile before second-stage surgery [60]. In the second study, there was a prospective indication for treatment: the width of KM should exceed 3 mm after second-stage surgery [62]. In the third study, no clear predefined clinical indication criteria for treatment were described [63]. Due to the heterogeneity of study designs, observation times, surgical procedures, and the use of different augmentation materials, no meta-analysis was performed.

Treatment outcomes

Soft tissue volume and postoperative shrinkage In the first publication, the soft tissue volume was indicated using an

index system where the soft tissue convexity at the facial implant aspect (CPF) was assessed before surgery (CPF 0.58), 1 week after surgery (CRF 2.58), and 6 months after surgery (CRF 1.83). A statistically significant increase in volume was reported at both follow-up time points (baseline—1 week after surgery: $p = 0.002$, baseline—6 months after surgery: $p = 0.001$). No data were available regarding final gain or postoperative relapse in soft tissue volume [60]. In the second study, no measurements were documented. However, the alteration of soft tissue thickness between baseline and 12 months after intervention was reported. In group 1 (APPTF), a mean soft tissue thickness gain of 1.37 mm was measured. Furthermore, gains in volume of 2.41 mm in group 2 (REF) and 3.10 mm in group 3 (APPTF + SCTG) were reported. The differences between group 1 and 2 ($p < 0.010$) as well as group 1 and 3 ($p < 0.001$) were statistically significant. The postoperative shrinkage of soft tissue volume over the observation period of 12 months was −0.08 mm in group 1, −0.45 mm in group 2, and −0.21 mm in group 3. In none of the three groups, the amount of shrinkage in volume did reach a statistically significant level [62].

Width of keratinized tissue and postoperative shrinkage Only one publication reported on changes in the KT dimension. The application of APPTF alone (group 1, gain 4.63 mm) with the application of a roll envelope flap (REF) (group 2, gain 1.35 mm) as well as with the application of APPTF in combination with a SCTG (group 3, gain 4.10 mm): The differences between groups 1 and 2 and between groups 2 and 3 were statistically significant ($p > 0.001$). In addition, the postoperative KT shrinkage was evaluated (group 1: APPTF (shrinkage of −0.52 mm), group 2: REF (shrinkage of −0.83 mm), and group 3: APPTF + SCTG (shrinkage of −0.90 mm)). In all three groups individually, the shrinkage was statistically significant. No statistically significant difference was detected between the groups ($p = 0.37$) [62].

Jemt papilla index score [64] In one study, the Jemt papilla index score (PIS) was assessed 1 week (PIS 0.88) and 6 months after surgical intervention (PIS 2.79), where a score of 0 means "no papilla" and 4 means "hyperplastic papilla." The increase in PIS was statistically significant ($p = 0.002$) [60]. In another publication, a modification of the Jemt papilla index score (mPIS) [64] was assessed prior to implant exposure (mPIS 1.10) and 6 months postoperatively (mPIS 2.17). The increase in mPIS was also statistically significant ($p < 0.001$) [63].

Facial mucosal level One publication reported on the facial mucosal level (FML) in relation to the location of the contralateral tooth assessed 1 week (FML −1.22) and 6 months after second-stage surgery (FML 0.10). A positive score was assigned when FML at the implant was in a more coronal position than at the contralateral tooth. A statistically significant difference was detected between the two time points ($p = 0.002$).

Marginal bone level The marginal bone level (MBL), reported in one study, was measured only at 6 months after surgical intervention (−0.88 mm), where the bone level at baseline (immediately before (T0) or 1 week after second-stage surgery (T1)) was used as a reference (0 mm). Therefore, the value measured at follow-up was also the bone level change (ΔMBL) between the time point before and 6 months after the second-stage surgery.

Proximal bone level Proximal bone level (PBL) was assessed by measuring the marginal bone levels of the adjacent teeth in an analogous manner to the MBL. An average PBL change (ΔPBL) of −0.15 mm was reported.

Discussion

Owing to the absence of a periodontal ligament space, dental implants can be surrounded by both keratinized mucosa (KM) and mobile alveolar mucosa. In some cases, the peri-implant mucosa, even though keratinized, lacks a firm attachment to the underlying bone [18].

Recent studies demonstrated that both an adequate peri-implant width of KM and an adequate soft tissue thickness seem to have an impact on the long-term stability of peri-implant tissues, which includes an increased long-term prognosis of an implant therapy [65–70]:

1. Compared to implant sites with a band of ≥2 mm KM, sites with <2 mm seem to be more prone to brushing discomfort, plaque accumulation, and peri-implant soft tissue inflammation [65], exhibit impaired immunological parameters [68], and are associated with the occurrence of peri-implantitis [69].
2. Thin peri-implant mucosal tissue is associated with more crestal bone loss compared to naturally thick or augmented soft tissue [66, 67]. A prospective clinical trial demonstrated that compared to sites presenting a soft tissue thickness of >2 mm, sites with ≤2 mm are associated with significant more peri-implant marginal bone loss [70]. A recent study using the same benchmark of 2 mm soft tissue thickness concluded that thin mucosal tissue results in a significant more pronounced marginal bone loss than naturally thick or thickened peri-implant mucosal soft tissue [67].

Therefore, the present systematic review was conducted to address the question of the efficacy of several soft tissue

augmentation/correction methods to increase the peri-implant KM width and/or gain of soft tissue volume during second-stage surgery in cases of a soft tissue deficiency at the time of second-stage surgery and so to improve the long-term stability of peri-implant tissues.

Overall, the literature search revealed that the studies concerning outcomes for the enlargement of KM and the augmentation of soft tissue volume around dental implants during second-stage surgery have been conducted in an inhomogeneous manner and thus no meta-analysis could be performed. Most of the included studies did not have a control group, and no study was designed as a randomized controlled trial. Thus, no quality assessment according to the Cochrane collaboration's guidelines [53] could be performed. Consequently, a high risk of bias was revealed for all included studies. This should be taken into account when considering the outcomes of this review.

Enlargement of KM width during second-stage surgery

Gain of width of keratinized tissue

Overall, eight studies reported on techniques and graft materials to enlarge keratinized tissue (KT) around dental implants during second-stage surgery. A significant increase in KT width was achieved in five of the eight included studies. Regarding the final gain of KT, second-stage surgical techniques applying an apically positioned partial-thickness flap/vestibuloplasty (APPTF/VP) in combination with a free gingival graft (FGG) with a gain of 3.35–8.93 mm [54, 55, 61] or in combination with a xenogeneic collagen matrix (XCM) with a gain of 5.53–9.35 mm [54, 61] as well as APPTF without a graft material (4.63 mm) or in combination with a subepithelial connective tissue graft (SCTG) (4.10 mm), which was covered by the repositioned flap [62], were very effective. However, the APPTF technique, where a displacement of KT from the palatal to the buccal implant aspect is performed with or without a SCTG, remains reserved for the maxilla, where the palatal reservoir of KM can be used. The APPTF/VP-technique in combination with FGG or XCM can be used in both the maxilla and the mandible and seems to be ideal for the lower jaw, because there is a lack of a KM reservoir, compared with the maxilla. In another study, a special second-stage surgical procedure was proposed, applying an apically positioned full-thickness flap (APFTF) (from the palatal aspect towards the buccal aspect of the implants) in combination with a pediculated coronally positioned connective tissue graft (PCPCTG) at the palatal implant aspect. Using this technique, proposed for the second-stage surgery in the maxillary lateral tooth area, an average gain in KT of 3.07 mm was reported [57]. In a prospective clinical study, among other re-entry procedures, the roll envelope flap (REF) was used [62]. Only a KT gain of 1.35 mm was achieved, using this technique. In two other studies, no measurement data were available [56, 59]. In one study, a loss of −0.20 mm of KT was reported [58]. This could be explained by the fact that the distance between the buccal bone margin of the emerging implant and the mucogingival junction, measured at implant placement, served as basis for the re-entry technique to be used. At this time point, it is not possible to foresee the buccal width of KT immediately before second-stage surgery. In this study, an APPTF was applied at the second-stage surgery, where a displacement of KT from the palatal to the buccal implant aspect and consequently a displacement of the mucogingival junction in a more apical direction was performed. The reported minimal and maximal buccal width of KT before second-stage surgery ranged between 1 and 5 mm and 12 months after the intervention between 2 and 5 mm, meanwhile in the same observation period, the mean width of KT decreased slightly (from 3.40 to 3.20 mm). It seems that the smaller the KT width before the second-stage surgery, the higher is the gain of KT applying this kind of APPTF. Consequently, the decision for the application of the suitable surgical technique during second-stage surgery should be made based on the clinical situation immediately before the uncovering procedure and based on the intraoral location of the implant (maxilla/mandible).

Postoperative shrinkage or relapse of KM

The extent of postoperative shrinkage of augmented KT over time can be determined to estimate the predictability of different surgical soft tissue augmentation procedures. Six of the eight included studies reported on the outcome of postoperative shrinkage of augmented KT. Regardless of the surgical procedure, a certain relapse of initially augmented KT always has to be taken into account. Evaluating the included studies in this review, shrinkage of 0.34 to 6.81 mm [54, 55, 58, 61, 62] or a shrinkage rate of 18.5 to 52.89 % [54, 56, 61] have to be expected. The variability may depend on the surgical soft tissue augmentation technique used as well as on differences in graft materials: The surgical augmentation techniques applying APPTF/VP + FGG or APPTF/VP + XCM seem to be accompanied by increased postoperative relapse [54, 55, 61] versus other techniques, like APPTF/VP + STSG [56]. None of the studies included in this review applied a VP alone. However, it is known from other studies that a VP without the use of a graft material yields significantly less favorable results in terms of postoperative relapse [71]. The choice of the timepoint to serve as baseline will also greatly influence the results. Different studies demonstrate that the highest reduction occurs within the first month after surgery and continue on a lower level up to 6 months [61, 72]. After 6 months, the shrinkage rate seems to slow down in the FGG-group as well as in the XCM-group and shows only minimal changes up

to 60 months, whereby the relapse is more pronounced in the XCM-group [61]. Other reasons for differences regarding shrinkage rates between studies may include different observation periods (3 and 60 months) and differing surgical sites. In all studies in which an APPTF to transfer KT together with a pediculated split or full-flap from the palate to the buccal aspect of the implants was applied, a relatively small amount of shrinkage (−0.34 to −0.90 mm) was reported [58, 62]. This minimal shrinkage could be explained by the atleast partially maintained vascular nutrition using the APPTF design, compared with nutrition by diffusion starting with a graft material such as FGG or XCM. However, the APPTF procedure can be applied only in the maxilla.

Peri-implant probing depth

Only one study reported on peri-implant probing depth (PPD), measured 24 months after second-stage surgery. The mean PPD values of 2.56 mm mesially and 2.64 mm distally seemed not to be increased, especially as some of the implants were situated in jaw areas that received postsurgical radiotherapy because of a malignant oral tumor in the mandible [56]. Because PPD measurements cannot be taken before the second-stage surgery, a comparison with baseline is not possible.

Total surgery time

In two included publications, the total surgery time was compared between two surgical procedures [54, 61]. It was demonstrated that the surgery time could significantly be reduced by avoiding an autogenous soft tissue harvesting procedure, whereby the donor site morbidity can be avoided. On average, a time of 19.22–24.57 min was saved when a soft tissue substitute graft material was applied. Similar outcome data regarding surgery time have been reported in other studies where the surgical intervention was performed in implants that were already loaded [72, 73]. However, besides the reduced chair time, another advantage is that in surgical procedures in which wound areas have to be covered, the donor site area on the palate for the removal of an FGG is limited. In contrast, XCM is available limitless [61]. However, such materials are not costless and increase material expenses.

Texture and color

Only two included studies reported on differences in texture and color of the augmented soft tissue areas compared with the adjacent areas applying FGG or XCM [54, 61]: No difference was identified in the XCM group, whereas in the FGG group slight dissimilarities were detected. These dissimilarities between the grafted areas and the adjacent regions were still apparent at the 60-month examination time point in the FGG group [61]. This side effect of FGG application is known from other studies [50, 74]. As a consequence, in esthetically relevant areas, XCM is to prefer to FGG.

Augmentation of peri-implant soft tissue volume during second-stage surgery

Soft tissue volume and postoperative shrinkage

Only three studies reporting on augmentation techniques to gain soft tissue volume around dental implants during second-stage surgery were included in this review. In one, the volume of peri-implant soft tissue was assessed using an index system, that evaluated the soft tissue convexity at the facial implant aspect (CPF) at different time points. After an observation period of 6 months, a statistically significant increase of soft tissue volume was achieved applying the roll envelope flap (REF) [60]. In another comparative study in the maxilla, three different soft tissue augmentation techniques were compared regarding the gain in peri-implant soft tissue volume. Using an APPTF design, a final soft tissue thickness gain of only 1.37 mm was achieved. This increase was statistically significantly smaller compared to the gain when using the roll envelope flap (REF 2.41 mm) or the APPTF combined with a SCTG, which was then covered by the repositioned flap (3.10 mm) [62]. The results of this comparative study demonstrated that using a SCTG, whether pediculated (REF) or harvested from the palate and transplanted, can be considered the gold standard technique in cases of missing soft tissue thickness. However, it should be noted that the connective tissue graft material should be covered by a full- or split-thickness flap to ensure an adequate blood supply. In only one study [62], shrinkage of soft tissue volume was reported. Applying the REF, the mean shrinkage of 0.45 mm was more pronounced compared with 0.21 mm using the APPTF + SCTG. This difference, although not statistically significant, could be explained by the fact that the REF was performed using a full-flap design whereas the APPTF + SCTG used a split-flap design. However, it was suggested that differences in the SCTG harvesting technique might have an influence on the shrinkage rate [75]. The advantage of a REF compared with the APPTF + SCTG is the minimally invasive surgical technique, thus reducing patients' morbidity. Data on

soft tissue substitutes were not reported in the included studies.

Esthetic outcomes

Successful implant-supported restorations should have the appearance of natural teeth and should be in symmetry with the contralateral reference tooth [76]. The buccal soft tissue thickness, the peri-implant soft tissue level, and its color and texture are key factors [77, 78]. There is evidence that 2 mm is the threshold of buccal soft tissue thickness for better esthetic outcomes [79, 80]. The Jemt papilla index score (PIS) is an easy applicable measuring tool to assess the esthetic outcome of implant therapy regarding the fill of the interproximal space of the implant [64]. One included study demonstrated that applying the REF at maxillary single-implants, with a mean score of 2.79 6 months after second-stage surgery, resulted in favorable clinical esthetics [60]. In the same study, the facial mucosal level (FML) in relation to the contralateral tooth was assessed and an almost ideal mean score was reported [60]. The authors of another publication, applying a special technique of palatal split envelope flap (PSEF) in combination with a papilla de-epithelialization technique, reported on a significant increase in the modified PIS [64] from 1.10 at baseline to 2.17 at 6 months after the intervention [63]. The outcomes suggest that in the presence of an adequate width of KT, the REF is useful for buccal soft tissue volume augmentation and REF and PSEF can be recommended for interproximal papilla reconstruction for anterior maxillary single-implant restorations.

Bone level measurements

The peri-implant marginal bone level changes (ΔMBL) as well as the proximal bone level changes of the adjacent teeth (ΔPBL) were assessed in only one study, based on peri-apical radiographs [60]. The baseline for radiographic bone level measurements took place either immediately before (T0) or 1 week after second-stage surgery (T1). These measurements were compared with the bone level measurements 6 months after second-stage surgery. After second-stage surgery, a certain amount of peri-implant bone resorption is expected, regardless of whether a bone level or a machined collar implant design is used [81, 82]. However, there is evidence that the thickness of the peri-implant soft tissue has a significant impact on the amount of crestal bone level changes: Implant sites presenting an inadequate soft tissue volume (thickness of ≤2 mm) are associated with significantly more crestal bone loss, compared to sites with >2 mm soft tissue volume, being it a naturally thick or augmented mucosa [66, 67]. Even, a platform switching dental implant design does not prevent crestal bone loss if the peri-implant mucosal soft tissue is thin [83].

Conclusions

The clues solidify that an adequate peri-implant width of KM and soft tissue volume seem to have a positive impact on the long-term stability of peri-implant tissues. Therefore, in case of peri-implant soft tissue deficiency, the knowledge of the appropriate surgical technique seems to be of utmost clinical relevance for planning the second-stage surgery.

To gain KT or soft tissue volume around dental implants during second-stage surgery, different surgical techniques and augmentation materials have successfully been used. However, considering the limitations of this review, it can be concluded that, depending on the localization (maxilla, mandible, front or lateral jaw area) and the clinical situation (amount of KT and/or soft tissue volume present), different second-stage techniques can be used. Because of the extensive reservoir of KM and connective tissue in the palate, the apically positioned partial-thickness flap (APPTF) to gain KT and the roll envelope flap (REF) to gain soft tissue volume at the buccal implant aspect are effective and minimally invasive techniques for the maxilla. If there is need for both KT and soft tissue volume augmentation in the upper jaw, a combination of APPTF and subepithelial connective tissue graft (SCTG) harvested from the palate can be a good option. In the lower jaw, to gain KT, the application of APPTF/VP in combination with a free gingival graft (FGG) or a xenogeneic graft material (XCM) are both highly predictable, whereby the FGG still remains the gold standard, especially regarding postoperative shrinkage rate. However, in esthetic relevant regions, due to the clinical appearance of the grafted area in color and texture, the XCM can be recommended. In addition, the use of XCM has the advantage to avoid donor site morbidity and is available in unlimited amounts. On the other hand, the use of soft tissue substitutes increases material expenses. If there is a need for a large graft size, for example after surgery for a malignant oral tumor in the mandible, a split-thickness skin graft (STSG) may be an alternative.

Indeed, in all grafting procedures, a certain postoperative shrinkage has to be expected, whereby the extent depends on the grafting material or surgical technique used, the follow-up time, and the time point serving as baseline.

Finally, it is important to point out that in the present systematic review, only 10 studies fulfilled the inclusion criteria and none was conducted as a RCT. Therefore, RCTs comparing different soft tissue augmentation techniques are of high clinical relevance.

Compliance with ethical standards This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of interest The authors declare that they have no conflict of interest.

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References

1. Lekovic V, Kenney EB, Weinlaender M, et al. (1997) A bone regenerative approach to alveolar ridge maintenance following tooth extraction. report of 10 cases. J Periodontol 68:563–570
2. Camargo PM, Lekovic V, Weinlaender M, et al. (2000) Influence of bioactive glass on changes in alveolar process dimensions after exodontia. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 90: 581–586
3. Iasella JM, Greenwell H, Miller RL, et al. (2003) Ridge preservation with freeze-dried bone allograft and a collagen membrane compared to extraction alone for implant site development: a clinical and histologic study in humans. J Periodontol 74:990–999
4. Schropp L, Wenzel A, Kostopoulos L, et al. (2003) Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 23:313–323
5. Araujo MG, Lindhe J (2009) Ridge alterations following tooth extraction with and without flap elevation: an experimental study in the dog. Clin Oral Implants Res 20:545–549
6. Landsberg CJ (1997) Socket seal surgery combined with immediate implant placement: a novel approach for single-tooth replacement. Int J Periodontics Restorative Dent 17:140–149
7. Buser D, Janner SF, Wittneben JG, et al. (2012) 10-year survival and success rates of 511 titanium implants with a sandblasted and acid-etched surface: a retrospective study in 303 partially edentulous patients. Clin Implant Dent Relat Res 14:839–851
8. Belser UC, Buser D, Hess D, et al. (1998) Aesthetic implant restorations in partially edentulous patients—a critical appraisal. Periodontol 2000(17):132–150
9. Becker W, Becker BE (1990) Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: surgical techniques and case report. Int J Periodontics Restorative Dent 10:376–391
10. Stimmelmayr M, Allen EP, Reichert TE, et al. (2010) Use of a combination epithelized-subepithelial connective tissue graft for closure and soft tissue augmentation of an extraction site following ridge preservation or implant placement: description of a technique. Int J Periodontics Restorative Dent 30:375–381
11. Bassetti M, Kaufmann R, Salvi GE, et al. (2015) Soft tissue grafting to improve the attached mucosa at dental implants: a review of the literature and proposal of a decision tree. Quintessence Int 46:499–510
12. Berglundh T, Lindhe J, Ericsson I, et al. (1991) The soft tissue barrier at implants and teeth. Clin Oral Implants Res 2:81–90
13. Listgarten MA, Lang NP, Schroeder HE et al (1991) Periodontal tissues and their counterparts around endosseous implants [corrected and republished with original paging, article orginally printed in Clin Oral Implants Res 1991 Jan-Mar; 2(1):1–19]. 2:1–19
14. Berglundh T, Lindhe J (1994) Jonsson K et al. The topography of the vascular systems in the periodontal and peri-implant tissues in the dog 21:189–193
15. Ikeda H, Shiraiwa M, Yamaza T, et al. (2002) Difference in penetration of horseradish peroxidase tracer as a foreign substance into the peri-implant or junctional epithelium of rat gingivae. Clinical oral implants research 13:243–251
16. Moon IS, Berglundh T, Abrahamsson I, et al. (1999) The barrier between the keratinized mucosa and the dental implant. An experimental study in the dog. J Clin Periodontol 26:658–663
17. Karring T, Ostergaard E, Loe H (1971) Conservation of tissue specificity after heterotopic transplantation of gingiva and alveolar mucosa. J Periodontal Res 6:282–293
18. Zuhr O, Hürzeler M (eds) (2011) Plastisch-ästhetische Parodontal- und Implantatchirurgie. Quintessenz Verlag, Berlin
19. Karring T, NP L, Loe H (1975) The role of gingival connective tissue in determining epithelial differentiation. J Periodontal Res 10:1–11
20. Sculean A, Gruber R, Bosshardt DD (2014) Soft tissue wound healing around teeth and dental implants. J Clin Periodontol 41(Suppl 15):S6–22
21. Adell R, Lekholm U, Rockler B, et al. (1986) Marginal tissue reactions at osseointegrated titanium fixtures (I). A 3-year longitudinal prospective study. Int J Oral Maxillofac Surg 15:39–52
22. Bengazi F, Wennstrom JL, Lekholm U (1996) Recession of the soft tissue margin at oral implants. A 2-year longitudinal prospective study. Clin Oral Implants Res 7:303–310
23. Block MS, Gardiner D, Kent JN, et al. (1996) Hydroxyapatite-coated cylindrical implants in the posterior mandible: 10-year observations. Int J Oral Maxillofac Implants 11:626–633
24. Esposito M, Grusovin MG, Maghaireh H et al (2007) Interventions for replacing missing teeth: management of soft tissues for dental implants. Cochrane Database Syst Rev: CD006697
25. Heitz-Mayfield LJ (2008) Peri-implant diseases: diagnosis and risk indicators. J Clin Periodontol 35:292–304
26. Lekholm U, Adell R, Lindhe J, et al. (1986) Marginal tissue reactions at osseointegrated titanium fixtures. (II) A cross-sectional retrospective study. Int J Oral Maxillofac Surg 15:53–61
27. Roos-Jansaker AM, Renvert H, Lindahl C, et al. (2006) Nine- to fourteen-year follow-up of implant treatment. Part III: factors associated with peri-implant lesions. J Clin Periodontol 33:296–301
28. Schou S, Holmstrup P, Hjorting-Hansen E, et al. (1992) Plaque-induced marginal tissue reactions of osseointegrated oral implants: a review of the literature. Clin Oral Implants Res 3:149–161
29. Strub JR, Gaberthuel TW, Grunder U (1991) The role of attached gingiva in the health of peri-implant tissue in dogs. 1. Clinical findings. Int J Periodontics Restorative Dent 11:317–333
30. Warrer K, Buser D, Lang NP, et al. (1995) Plaque-induced peri-implantitis in the presence or absence of keratinized mucosa. An experimental study in monkeys. Clin Oral Implants Res 6:131–138
31. Wennström JL, Bengazi F, Lekholm U (1994) The influence of the masticatory mucosa on the peri-implant soft tissue condition. Clin Oral Implants Res 5:1–8

32. Wennström JL, Derks J (2012) Is there a need for keratinized mucosa around implants to maintain health and tissue stability? Clin Oral Implants Res 23(Suppl 6):136–146
33. Zarb GA, Schmitt A (1990) The longitudinal clinical effectiveness of osseointegrated dental implants: the Toronto study. Part III: problems and complications encountered. J Prosthet Dent 64: 185–194
34. Adibrad M, Shahabuei M, Sahabi M (2009) Significance of the width of keratinized mucosa on the health status of the supporting tissue around implants supporting overdentures. J Oral Implantol 35:232–237
35. Artzi Z, Carmeli G, Kozlovsky A (2006) A distinguishable observation between survival and success rate outcome of hydroxyapatite-coated implants in 5-10 years in function. Clin Oral Implants Res 17:85–93
36. Chung DM, Oh TJ, Shotwell JL, et al. (2006) Significance of keratinized mucosa in maintenance of dental implants with different surfaces. J Periodontol 77:1410–1420
37. Crespi R, Cappare P, Gherlone E (2010) A 4-year evaluation of the peri-implant parameters of immediately loaded implants placed in fresh extraction sockets. J Periodontol 81:1629–1634
38. Schrott AR, Jimenez M, Hwang JW, et al. (2009) Five-year evaluation of the influence of keratinized mucosa on peri-implant soft-tissue health and stability around implants supporting full-arch mandibular fixed prostheses. Clin Oral Implants Res 20: 1170–1177
39. Bouri A Jr., Bissada N, Al-Zahrani MS, et al. (2008) Width of keratinized gingiva and the health status of the supporting tissues around dental implants. Int J Oral Maxillofac Implants 23:323–326
40. Boynuegri D, Nemli SK, Kasko YA (2013) Significance of keratinized mucosa around dental implants: a prospective comparative study. Clin Oral Implants Res 24:928–933
41. Malo P, Rigolizzo M, Nobre M, et al. (2013) Clinical outcomes in the presence and absence of keratinized mucosa in mandibular guided implant surgeries: a pilot study with a proposal for the modification of the technique. Quintessence Int 44:149–157
42. Zigdon H, Machtei EE (2008) The dimensions of keratinized mucosa around implants affect clinical and immunological parameters. Clin Oral Implants Res 19:387–392
43. Frisch E, Ziebolz D, Vach K et al (2013) The effect of keratinized mucosa width on peri-implant outcome under supportive postimplant therapy. Clin Implant Dent Relat Res
44. Brito C, Tenenbaum HC, Wong BK, et al. (2014) Is keratinized mucosa indispensable to maintain peri-implant health? A systematic review of the literature. J Biomed Mater Res B Appl Biomater 102: 643–650
45. Gobbato L, Avila-Ortiz G, Sohrabi K, et al. (2013) The effect of keratinized mucosa width on peri-implant health: a systematic review. Int J Oral Maxillofac Implants 28:1536–1545
46. Lin GH, Chan HL, Wang HL (2013) The significance of keratinized mucosa on implant health: a systematic review. J Periodontol
47. Zitzmann NU, Berglundh T, Marinello CP, et al. (2001) Experimental peri-implant mucositis in man. J Clin Periodontol 28:517–523
48. Dello Russo NM (1982) Gingival autografts as an adjunct to removable partial dentures. J Am Dent Assoc 104:179–181
49. Nabers JM (1966) Free gingival grafts. Periodontics 4:243–245
50. Thoma DS, Benic GI, Zwahlen M, et al. (2009) A systematic review assessing soft tissue augmentation techniques. Clin Oral Implants Res 20(Suppl 4):146–165
51. Hürzeler MB, Weng D (1996) Periimplant tissue management: optimal timing for an aesthetic result. Pract Periodontics Aesthet Dent 8:857–869 quiz 869
52. Needleman IG (2002) A guide to systematic reviews. J Clin Periodontol 29(Suppl 3):6–9 discussion 37-38
53. Higgins JP, Altman DG, Gotzsche PC, et al. (2011) The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 343:d5928
54. Schmitt CM, Tudor C, Kiener K, et al. (2013) Vestibuloplasty: porcine collagen matrix versus free gingival graft: a clinical and histologic study. J Periodontol 84:914–923
55. Stimmelmayr M, Stangl M, Edelhoff D, et al. (2011) Clinical prospective study of a modified technique to extend the keratinized gingiva around implants in combination with ridge augmentation: one-year results. Int J Oral Maxillofac Implants 26:1094–1101
56. Heberer S, Nelson K (2009) Clinical evaluation of a modified method of vestibuloplasty using an implant-retained splint. J Oral Maxillofac Surg 67:624–629
57. Nemcovsky CE, Moses O (2002) Rotated palatal flap. A surgical approach to increase keratinized tissue width in maxillary implant uncovering: technique and clinical evaluation. Int J Periodontics Restorative Dent 22:607–612
58. Barone R, Clauser C, Grassi R, et al. (1998) A protocol for maintaining or increasing the width of masticatory mucosa around submerged implants: a 1-year prospective study on 53 patients. Int J Periodontics Restorative Dent 18:377–387
59. Ueda M, Hata KI, Sumi Y, et al. (1998) Peri-implant soft tissue management through use of cultured mucosal epithelium. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 86:393–400
60. Man Y, Wang Y, Qu Y, et al. (2013) A palatal roll envelope technique for peri-implant mucosa reconstruction: a prospective case series study. Int J Oral Maxillofac Surg 42:660–665
61. Schmitt CM, Moest T, Lutz R et al (2015) Long-term outcomes after vestibuloplasty with a porcine collagen matrix (Mucograft) versus the free gingival graft: a comparative prospective clinical trial. Clin Oral Implants Res
62. Tunkel J, de Stavola L, Khoury F (2013) Changes in soft tissue dimensions following three different techniques of stage-two surgery: a case series report. Int J Periodontics Restorative Dent 33:411–418
63. Nemcovsky CE, Moses O, Artzi Z (2000) Interproximal papillae reconstruction in maxillary implants. J Periodontol 71:308–314
64. Jemt T (1997) Regeneration of gingival papillae after single-implant treatment. Int J Periodontics Restorative Dent 17:326–333
65. Souza AB, Tormena M, Matarazzo F et al (2015) The influence of peri-implant keratinized mucosa on brushing discomfort and peri-implant tissue health. Clinical oral implants research
66. Puisys A, Linkevicius T (2015) The influence of mucosal tissue thickening on crestal bone stability around bone-level implants. A prospective controlled clinical trial. Clin Oral Implants Res 26: 123–129
67. Linkevicius T, Puisys A, Linkeviciene L, et al. (2015) Crestal bone stability around implants with horizontally matching connection after soft tissue thickening: a prospective clinical trial. Clin Implant Dent Relat Res 17:497–508
68. Buyukozdemir Askin S, Berker E, Akincibay H, et al. (2015) Necessity of keratinized tissues for dental implants: a clinical, immunological, and radiographic study. Clin Implant Dent Relat Res 17:1–12
69. Costa FO, Takenaka-Martinez S, Cota LO, et al. (2012) Peri-implant disease in subjects with and without preventive maintenance: a 5-year follow-up. J Clin Periodontol 39:173–181
70. Linkevicius T, Apse P, Grybauskas S, et al. (2009) The influence of soft tissue thickness on crestal bone changes around implants: a 1-year prospective controlled clinical trial. Int J Oral Maxillofac Implants 24:712–719
71. Basegmez C, Ersanli S, Demirel K, et al. (2012) The comparison of two techniques to increase the amount of peri-implant attached

mucosa: free gingival grafts versus vestibuloplasty. one-year results from a randomised controlled trial. Eur J Oral Implantol 5:139–145
72. Sanz M, Lorenzo R, Aranda JJ, et al. (2009) Clinical evaluation of a new collagen matrix (Mucograft prototype) to enhance the width of keratinized tissue in patients with fixed prosthetic restorations: a randomized prospective clinical trial. J Clin Periodontol 36:868–876
73. Lorenzo R, Garcia V, Orsini M, et al. (2012) Clinical efficacy of a xenogeneic collagen matrix in augmenting keratinized mucosa around implants: a randomized controlled prospective clinical trial. Clin Oral Implants Res 23:316–324
74. McGuire MK, Scheyer ET (2014) Randomized, controlled clinical trial to evaluate a xenogeneic collagen matrix as an alternative to free gingival grafting for oral soft tissue augmentation. J Periodontol 85:1333–1341
75. Zucchelli G, Mazzotti C, Mounssif I, et al. (2013) A novel surgical-prosthetic approach for soft tissue dehiscence coverage around single implant. Clin Oral Implants Res 24:957–962
76. Fürhauser R, Florescu D, Benesch T, et al. (2005) Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. Clin Oral Implants Res 16:639–644
77. Chang M, Wennstrom JL, Odman P, et al. (1999) Implant supported single-tooth replacements compared to contralateral natural teeth. Crown and soft tissue dimensions. Clin Oral Implants Res 10: 185–194
78. Benic GI, Wolleb K, Sancho-Puchades M, et al. (2012) Systematic review of parameters and methods for the professional assessment of aesthetics in dental implant research. J Clin Periodontol 39(Suppl 12):160–192
79. Jung RE, Sailer I, Hämmerle CH, et al. (2007) In vitro color changes of soft tissues caused by restorative materials. Int J Periodontics Restorative Dent 27:251–257
80. Jung RE, Holderegger C, Sailer I, et al. (2008) The effect of all-ceramic and porcelain-fused-to-metal restorations on marginal peri-implant soft tissue color: a randomized controlled clinical trial. Int J Periodontics Restorative Dent 28:357–365
81. Hermann JS, Cochran DL, Nummikoski PV, et al. (1997) Crestal bone changes around titanium implants. A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. J Periodontol 68:1117–1130
82. Jung RE, Jones AA, Higginbottom FL, et al. (2008) The influence of non-matching implant and abutment diameters on radiographic crestal bone levels in dogs. J Periodontol 79:260–270
83. Linkevicius T, Puisys A, Steigmann M et al (2014) Influence of vertical soft tissue thickness on crestal bone changes around implants with platform switching: a comparative clinical study. Clinical implant dentistry and related research
84. Elkhaweldi A, Rincon Soler C, Cayarga R, et al. (2015) Various techniques to increase keratinized tissue for implant supported overdentures: retrospective case series. Int J Dent 2015:104903
85. Sieira Gil R, Pages CM, Diez EG, et al. (2015) Tissue-engineered oral mucosa grafts for intraoral lining reconstruction of the maxilla and mandible with a fibula flap. J Oral Maxillofac Surg 73(195): e191–e116
86. Fischer KR, Fickl S, Mardas N, et al. (2014) Stage-two surgery using collagen soft tissue grafts: clinical cases and ultrastructural analysis. Quintessence Int 45:853–860
87. Park SH, Wang HL (2012) Pouch roll technique for implant soft tissue augmentation: a variation of the modified roll technique. Int J Periodontics Restorative Dent 32:e116–e121
88. Giordano F, Langone G, Di Paola D, et al. (2011) Roll technique modification: papilla preservation. Implant Dent 20:e48–e52
89. Schneider D, Grunder U, Ender A, et al. (2011) Volume gain and stability of peri-implant tissue following bone and soft tissue augmentation: 1-year results from a prospective cohort study. Clin Oral Implants Res 22:28–37
90. Lee KH, Kim BO, Jang HS (2010) Clinical evaluation of a collagen matrix to enhance the width of keratinized gingiva around dental implants. J Periodontal Implant Sci 40:96–101
91. Speroni S, Cicciu M, Maridati P, et al. (2010) Clinical investigation of mucosal thickness stability after soft tissue grafting around implants: a 3-year retrospective study. Indian J Dent Res 21:474–479
92. Cillo JE, Finn R (2009) Reconstruction of the shallow vestibule edentulous mandible with simultaneous split thickness skin graft vestibuloplasty and mandibular endosseous implants for implant-supported overdentures. J Oral Maxillofac Surg 67:381–386
93. Kwasnicki A, Butterworth C (2009) 360 degrees peri-implant, keratinised, soft-tissue grafting with stereolithographic-aided dressing plate. Int J Oral Maxillofac Surg 38:87–90
94. Hakim SG, Driemel O, Jacobsen HC, et al. (2006) Exposure of implants using a modified multiple-flap transposition vestibuloplasty. Br J Oral Maxillofac Surg 44:507–510
95. Mathews DP (2002) The pediculated connective tissue graft: a technique for improving unaesthetic implant restorations. Pract Proced Aesthet Dent 14:719–724 quiz 726
96. Nemcovsky CE, Artzi Z (1999) Split palatal flap. II. A surgical approach for maxillary implant uncovering in cases with reduced keratinized tissue: technique and clinical results. Int J Periodontics Restorative Dent 19:385–393
97. Bousquet P, Montal S, Gibert P (1997) Mandibular vestibuloplasty and gingival grafts using impacted posts. Int J Prosthodont 10: 235–240
98. Silverstein LH, Kurtzman D, Garnick JJ, et al. (1994a) Connective tissue grafting for improved implant esthetics: clinical technique. Implant Dent 3:231–234
99. Silverstein LH, Lefkove MD (1994b) The use of the subepithelial connective tissue graft to enhance both the aesthetics and periodontal contours surrounding dental implants. J Oral Implantol 20:135–138
100. Silverstein LH, Lefkove MD, Garnick JJ (1994c) The use of free gingival soft tissue to improve the implant/soft-tissue interface. J Oral Implantol 20:36–40
101. ten Bruggenkate CM, Krekeler G, van der Kwast WA, et al. (1991) Palatal mucosa grafts for oral implant devices. Oral Surg Oral Med Oral Pathol 72:154–158
102. Buser D (1987) Vestibuloplasty with free mucosal grafts in implants in the edentulous mandible. Surgical method and preliminary results. Schweiz Monatsschr Zahnmed 97:766–772