Coverage of Soft Tissue Dehiscences Around Osseointegrated Implants in Aesthetic Areas - Surgical-Prosthetic Approach and Patient Satisfaction

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Abstract

AIM: The aim of the study is to assess the success rate of the available methods for the treatment of soft tissue dehiscences in osseointegrated implants in the anterior area. The success rate will be determined based on the degree of coverage both short and long-term as well as clinical and aesthetic parameters.

METHODS: Clinical trials and case reports on the treatment of soft tissue dehiscences between 0.7 mm ± 0.3 mm and 3.0 mm ± 0.8 mm in anterior osseointegrated implants were analyzed. The data collection was carried out in PubMed and 17 articles were included.

RESULTS: A total of 144 osseointegrated implants in the anterior area with soft tissue dehiscences were evaluated in this bibliographic review. The possibilities of coverage in millimeters range from 0.17 mm to 3 mm. Coronally advanced flap was associated with soft tissue coverage. The use of subepithelial connective tissue graft (SCTG) results in soft tissue dehiscence reduction. Crown removal one month before surgery and chamfers or shoulders in the abutment reduction provides better healing of the soft tissue after surgery. Some authors also achieved soft tissue coverage with the use of acellular dermal matrix (ADM), but the results are still controversial.

CONCLUSION: The use of SCTG to cover soft tissue dehiscences in osseointegrated implants is a reliable method, although complete coverage is not achieved in all cases. The use of ADM seems to be a shorter and less painful alternative treatment, but the results are not yet predictable.

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Accepted: Monday 16th December, 2024. **Data availability statement:** All relevant data are within the article or supplement files unless otherwise declared by the author(s).

1 Introduction

Dental implants have a high percentage of success. However, they are not exempt from complications such as failed osseointegration, peri-implantitis, peri-implant mucositis, or peri-implant mucosal dehiscences. A peri-implant mucosal dehiscence or recession means that the shift of the gingival margin is in an apical direction, causing the exposure of the margin of the crown, the abutment, or the implant suprastructure. In implants, it is measured as the distance in mm from the implant crown or abutment tip to the gingival margin (Bengazi et al., 1996). In the earlier stages of implantology, special attention was given to osseointegration and the bone-implant relationship, but in recent years, the importance of soft tissue and the relationship between soft tissue and peri-implant health has been understood.

The aetiology of peri-implant mucosal dehiscences can be diverse: gingival biotype, amount and quality of keratinized gum, mucosal attachment, bone height and width, interproximal bone level, presence of frenulum or muscle insertion, buccolingual implant malposition, implant angulation, type and material of implant, implant platform, micro- and macro-morphology of implant neck and shoulder, implant prostheses, and surgical technique.

The peri-implant mucosa anatomy differs from the mucosa surrounding teeth. In teeth, the Sharpey fibres are inserted perpendicularly into the cementum, but in implants, the connective fibres are arranged parallel and do not attach to the implant. Also, the junctional epithelium in implants is longer than in natural teeth, and the lack of periodontal ligament reduces the blood supply (Berglundh et al., 1991). These differences contribute to a difficult interpretation of clinical results and show that peri-implant mucosal plastic surgery must be discussed in comparison with the treatment of gingival recessions around teeth. Several factors have to be taken into account when choosing the surgical procedure (recession size, presence or absence of keratinized mucosa, interproximal papillae, vestibule length, and presence of muscle insertions or frenuli) (Zucchelli et al., 2003).

In the aesthetic area, not only the function and the possibility of good hygiene are important, but the degree of patient satisfaction also plays a crucial role in establishing the management of these situations. For this reason, it requires special attention. In this case, aesthetic outcomes are mostly achieved not only by surgical modifications, but the combination with an accurate implant coronal restoration is essential.

The coverage of peri-implant mucosal defects is still evolving, and the amount of literature evaluating these treatment possibilities is scarce and unclear. The aim of the study is to evaluate and compare the success rates of various surgical and prosthetic methods for treating soft tissue dehiscence in osseointegrated implants in the anterior area, focusing on short-term and long-term tissue coverage, clinical parameters, aesthetic outcomes, and patient evaluations.

2 Methods

A bibliographic review was conducted using the PubMed database. The following search strategy was employed: ((((((((((("mucosal dehiscences") OR "mucosal dehiscence") OR (("soft tissue dehiscences") OR "soft tissue dehiscence")) OR (("soft tissue recessions") OR "soft tissue recession")) OR (("marginal peri-implant recessions") OR "marginal peri-implant recession")) OR "mucosa recession") OR "mucosa recessions")) AND (((((treatment) OR treatments) OR therapy) OR therapies) OR management))) AND coverage)) AND (implant OR implants).

A secondary search was executed using the following terms: ((”soft tissue dehiscences”) OR ”soft tissue dehiscence”) OR ((”soft tissue recessions”) OR ”soft tissue recession”) OR ((”marginal peri-implant recessions”) OR ”marginal peri-implant recession”) OR ”mucosa recession”) OR ”mucosa recessions”)) AND (((((treatment) OR treatments) OR therapy) OR therapies) OR management).

To be considered for inclusion, studies needed to be carried out in vivo and could encompass various formats such as case reports, case series, retrospective clinical case series, prospective pilot studies, multi-center pilot studies, prospective cohort studies, controlled clinical trials, or randomized clinical trials. The accepted languages for these studies were English, Italian, Spanish, Portuguese, French, and German. The subjects involved in the studies were required to be no older than 16 years, and both animal and human studies were permissible. On the other hand, studies conducted in vitro were excluded from consideration. Additionally, both systematic reviews and bibliographic reviews were not included in the selection.

During the initial search on PubMed, 385 articles were found. After removing duplicates and screening titles and abstracts, 32 articles were initially included. However, 15 of these were later excluded for not meeting the inclusion criteria, resulting in a total of 17 publications being used in the bibliographic review (**Figure 1**). These studies varied in sample size from 1 to 30 implants, with a total of 144 implants analyzed.

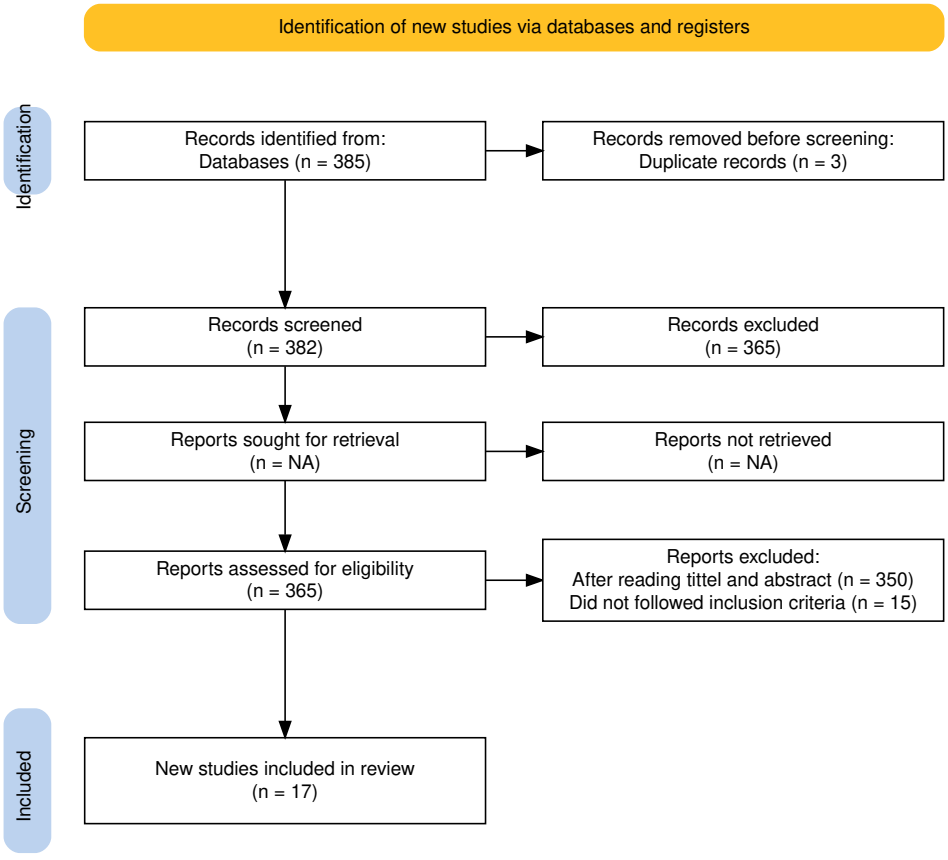

Figure 1. PRISMA flow diagram.

2.1 Statistics

Descriptive statistics, frequency analysis, and content analysis were employed as part of the qualitative methodology to systematically analyze the textual content of the included studies. It is important to note that, given the narrative nature of this study, regression analysis and meta-analysis techniques were not deemed suitable for the analytical framework.

3 Results

A total of 142 implants in aesthetic areas are included in this review. The soft tissue dehiscence (STD) was located in one implant per patient in the aesthetic area after osseointegration, except in one study, where the problem was related to three implants (Lee et al., 2016) and another study where the clinical situation was represented in six beagle dogs (Schwarz, 2012).

3.1 Methods for the treatment of osseointegrated implant soft tissue dehiscence

The best manner to treat STD is to prevent it. Atraumatic extraction, socket preservation, and the relationship between implant placement and soft tissue conditions determine the final soft tissue situation. There are some basic rules to follow in implant placement procedures in the anterior area, which include: implant placement 3 mm below the amelocementary line of the adjacent tooth, $1-2$ mm palatally in the buccolingual dimension, a minimum 1.5 mm from the adjacent tooth, and a 3 mm distance between implants (Deeb & Deeb, 1999).

However, once the STD appears, there are some techniques developed to try to restore it. The aim of STD coverage around osseointegrated dental implants is to achieve an acceptable aesthetic result and facilitate correct hygiene. The methods used by the authors to correct this problem can be divided into surgical procedures and prosthetic interventions.

Different flap and incision designs are carried out to avoid the loss of keratinized gingiva and interdental papillae, and to favour the soft tissue augmentation bed.

Surgical techniques include, depending on the author, covering the mucosal dehiscence with a subepithelial connective tissue graft (from the palate or retromolar area) or with a collagen allograft matrix to increase soft tissue volume and the width of the keratinized gingiva. The use of bone substitute materials can also be considered to restore hard tissue and reduce the colour discrepancy due to the transparency of the implant suprastructure, although this is far less common. Hard tissue intervention was described only once, using solvent-dehydrated mineralized bone allograft and particulate mineralized bone allograft material (Lee et al., 2016). Finally, after the soft tissue coverage, the prosthetic interventions (provisional crowns, new abutments, and definitive crowns) play an important role in modelling the shape of the gingiva.

Flap and incisions design. The flap designs analysed in this review can be categorized into three groups: Coronally Advanced Flap (CAF), Envelope/Tunnel or pouch flap, and open book flap. An overview of methods used is given in supplemental **Table S1**.

Five articles used the CAF, described by Allen and Miller (1989) and the most commonly described and used in the literature. It consists of an intrasulcular incision connected with two vertical divergent releasing incisions lateral to the exposed implant so that the trapezoidal split-thickness flap can be raised passively in a coronal direction. Apical muscular

insertion has to be removed to allow the displacement of the flap. Then, deepithelialization of the adjacent papillae on the buccal side is carried out to have a connective tissue bed where the surgical papilla of the flap can be sutured. The suture method starts at the apical site of the vertical incisions, followed by sutures in the coronal direction to allow the correct repositioning of the flap and avoid tension.

Eight of the studies analysed in this review described the use of the envelope flap, tunnel, pouch, or circumferential techniques, where the subepithelial connective tissue graft (SCTG) or acellular dermal matrix (ADM) is placed and sutured without reflecting a traditional flap. In this case, a sulcular incision is designed in the recessed area and then a supra-periosteal dissection is performed to create a deep pouch where the soft tissue graft is placed. No papilla or vertical releasing incisions are made to accelerate the blood supply and healing, and to avoid postoperative pain and scar tissue formation (Zuhr et al., 2018).

Four authors used an open book flap, where a crestal lingual incision is made to preserve as much keratinized gingiva as possible, followed by a distal vertical incision and papilla reflection on the mesial side to achieve better visualisation in the recessed area.

Grafts: harvesting techniques and substitution materials. After the flap design, autogenous connective tissue and allografting materials are essential to increase the soft tissue volume and width of the keratinized gingiva. In this case, fourteen authors considered obtaining the subepithelial connective tissue from the masticatory mucosa at the palate, one from the tuberosity area, and seven used an acellular dermal matrix (ADM).

The standard technique to harvest connective tissue from the palate is located between the canine and first molar, always respecting the presence of the greater palatine artery. There are two treatment strategies depending on harvesting only the subepithelial connective tissue or the connective tissue with the epithelial strip (in this case, the mucosal epithelium has to be subsequently removed). The retromolar area is an alternative donor site where the soft tissue thickness is greater than 4 mm. This procedure is easier to perform with fewer molars present. In both cases, after connective tissue harvesting, the donor area must be sutured horizontally to compress the wound (Vignoletti et al., 2014).

The ADM is a connective tissue substitute material used when there is a large recipient site or to avoid excessive postoperative discomfort (Deeb & Deeb, 2015).

Hard tissue grafts are more uncommon in this context. No one used autologous bone. Bone substitutes were only used by the same author in two different articles (Lee et al., 2016). Lee et al. used mineralized bone allograft mixed with the patient's blood, and then the material was covered with an ADM.

3.2 Prosthetic Interventions

It is necessary to take into account the prosthetic elements (healing abutment, provisional crown, definitive crown abutment, and definitive crown) in order to achieve an acceptable aesthetic result after performing surgery. The primary reason for removing the crown before surgery is to obtain a clear overview of the clinical situation. After the surgery, a healing abutment (mostly made from zirconia in the anterior area) is adapted relative to the homologous adjacent tooth (fixed temporary restorations function better than removable ones). Screw-retained provisional crowns are a better option to avoid the inflammation caused by cement; they also allow remodelling of the contours to guide the papilla formation (Deeb & Deeb, 1999). A provisional crown is fabricated to restore aesthetics, model the gum according to its emergence profile, and preserve papillae. In this process, the contact points

in the adjacent teeth and bone height are essential for an aesthetic result. Complete adjacent papilla fill has been found when the distance from the contact point and the crestal bone is 5 mm or less (Tarnow et al., 1992). Some techniques, such as flap designs (coronally advanced flap), fill materials (hyaluronic acid, platelet-rich fibrin), or contact point contour modulation in the temporary restoration, are used to achieve this interproximal papilla complete fill.

After the healing period, a definitive crown can be placed. Some authors (Hidaka et al., 2012; Shibli et al., 2004) decided, after the surgery healing period, to use a new abutment, placed more apically than the previous one and symmetrical taking into account the amelocementary line from the analogous teeth, and subsequently place a new crown. Another possibility was to use a provisional crown to moderate the soft tissue and then an ultimately definitive one (Lai et al., 2010; Lee et al., 2015; Mathews, 2012). However, using only a new definitive crown was also possible (Le et al., 2016; Shibli et al., 2006). Zucchelli et al. (2012, 2013) had another protocol. They decided to polish the previous abutment to eliminate the shoulders and create an adequate finishing line, then place a provisional crown, and eight to nine months after surgery, the final crown was placed. The rest of the authors did not provide information about the prosthetic procedure or simply cleaned the previous crown (Burkhardt et al., 2008).

Soft tissue dehiscence or recession. The different clinical parameters measured by the authors are described below to evaluate the recession in the first instance and to analyse the outcome achieved after the treatment process.

A recession can be explained as the shift of the gingival margin in the apical direction causing the exposure of the margin of the crown, the abutment, or the implant suprastructure. A recession is measured in natural teeth from the cement-enamel junction to the gingival margin. In implants, it is measured as the distance in mm of the implant crown or abutment tip to the gingival margin (Bengazi et al., 1996).

As shown in **Table 2**, in all the articles studied except one (Schallhorn et al., 2015), there is, regardless of the method, an improvement in coverage of the STD. The increase in coverage of the recession in millimetres ranges from 0.17 mm to 3 mm. Fourteen authors used an SCTG, thirteen from the palate and one from the maxillary tuberosity. Apparently, the results achieved with the connective tissue harvested from both the palate and the tuberosity do not show a significant difference; both result in recession reduction. Four case report studies reached total soft tissue coverage. The highest total soft tissue coverage results were achieved by Zucchelli et al. (2013), where 20 patients were studied; the soft tissue recession improvement was in 96% of the cases and in 75% of cases there was total soft tissue coverage.

ADM was used by six authors. Five of them also achieved recession reduction. Only one author found no significant change in mean recession (-0.1 ± 0.7 mm) (Schallhorn et al., 2015). Some authors compared per group the efficacy of the two methods. Anderson et al. (2014) and Lorenzo et al. (2011) compared the outcomes between the use of subgingival connective tissue and the use of a xenogeneic collagen matrix in two different patient groups. Anderson et al. showed better recession correction with the SCTG group. Lorenzo et al. demonstrated that in both groups, there was a mean increase of about 0.5 mm in the soft tissue coverage and no difference between the outcomes per group. One author (Kassab, 2010) combined the use of both SCTG and ADM in the same patient, SCTG to increase gingiva width and soft tissue volume and ADM to mask the implant colour through the gingiva. The use of two palate SCTG to cover one mucosal dehiscence has also been done

Table 2. Different methods used to treat soft tissue dehiscences around implants and results in mm between baselines and follow up or effect size. [Ins.] = Insufficient; [incr.] = increase; [dim.] = dimensions; [SCTG] = Subepithelial Connective Tissue Graft; [ADM] = Acellular Dermal Matrix; [P] = p-value; [F-up] = Follow-up; [Cor.] = Coronal; [Apic.] = Apical; [Tuberosity] = maxillary tuberosity; [Gingival] = gingival.

AUTHORS	CONTROL/TEST	TREATMENT	RECESSION OUTCOMES			
			BASELINE	LAST F-UP (MM)	CHANGE	P-VALUE
Anderson (2014)	SCTG	SCTG palate		40 %	P <0.001	
	ADM	ADM		28 %		
Burkhardt (2008)	SCTG	SCTG palate	3.0	--	66 %	P <0.05
Hidaka (2012)	SCTG	SCTG palate	3.0	0.0	3.0	
Kassab (2010)	SCTG/ADM	SCTG palate	1.0	Gingival dim. incr.		
		ADM to mask implant color				
Lai (2010)	SCTG	SCTG palate	1.0	0.0	1.0	
Le (2016)	ADM	ADM	1.0	Sign. incr.		
Le (2016)	ADM	ADM		1.2	P <0.001	
Lee (2015)	SCTG	SCTG palate	1.0	0.0	1.0	
Lorenzo (2011)	SCTG	SCTG palate	0.7	0.5	0.2	P=0.25
	ADM	ADM	1.1	0.4	0.7	P=0.63
Mathews (2012)	SCTG	SCTG palate	Ins.		Acceptable	
Rocuzzo (2018)	SCTG	SCTG max. tuberosity	1.9	0.2	86 %	P <0.001
Schallhorn (2015)	ADM	ADM	1.5	1.5	-0.1	P=0.3
Schwarz (2012)	ADM	CAF+ADM	1.2	--	1.0	P=0.4
	SCTG	CAF+SCTG	0.9	--	0.9	
	No SCTG/ADM	CAF alone	0.7	--	0.2	
Shibli (2004)	SCTG	SCTG palate	3.0	0.0	3.0	
Shibli (2006)	SCTG	SCTG palate	1.5	0.0	1.5	
Zucchelli (2012)	SCTG	SCTG palate	2.7	0.1	96 %	P <0.001
Zucchelli (2013)	SCTG	2 SCTG (Cor. & Apic.)	1.5	0.0	1.5	

(Zucchelli et al., 2013).

Also, Schwarz (2012) carried out a study in six beagle dogs to compare the outcomes between three methods. In the first group, only a CAF was carried out without a soft tissue replacement graft, in the second group, an SCTG was done, and in the third, an ADM was used. He concluded that all of the procedures were effective in soft tissue recession coverage and that the coverage was almost complete, with better results shown when using SCTG and ADM, with no difference between them.

Soft tissue thickness and keratinized tissue width. It has been postulated that the lack of keratinised gingiva and the mobility of the soft tissue around the implant can be a factor related to the presence of STD (Bengazi et al., 2016). The presence of keratinised gingiva and therefore of a mucosa tissue band provides a seal around the implant suprastructure (Chiu et al.). Thicker soft tissue around the implant creates better aesthetic outcomes and allows better hygiene and therefore less plaque accumulation. However, the need for keratinised gingiva around implants is a topic still under discussion.

Soft tissue grafting or the use of substitute materials reduces recession and also improves the contour of the implant's soft tissue. This parameter has been studied by seven authors. In all cases, after the surgical intervention with SCTG or ADM, an augmentation in the soft tissue volume is achieved, with no difference between the techniques used. Only Anderson et al. (2014) reported a 105% increase in the ADM group compared with the 63% of the SCTG group (**Table 3**).

Table 3. Overview in change of keratinized/soft tissue thickness. [SCTG] = Subepithelial Connective Tissue Graft; [ADM] = Acellular Dermal Matrix; [P] = p-value; [F-up] = Follow-up.

AUTHORS	GROUP	TREATMENT	BASELINE	LAST FOLLOW-UP (MM)	CHANGE	P-VALUE
Anderson (2014)	SCTG	SCTG Palate		N/A	63 %	< 0.001
	ADM	ADM		N/A	105 %	N/A
Burkhardt (2008)	SCTG	SCTG Palate	1.3	1.3	N/A	NS
Le (2016)	ADM	ADM		N/A	1.3	1
Lorenzo (2011)	SCTG	SCTG Palate	0.4	2.8	N/A	0.59
	ADM	ADM	0.5	2.8	N/A	0.13
Schallhorn (2015)	ADM	ADM	1.7±1.8	2.1±1.0	0.7	< 0.0016
Zucchelli (2012)	SCTG	SCTG Palate	0.9	2.5	N/A	< 0.001
Zucchelli (2013)	SCTG	2 SCTG: Coronal & Apical	0.7	2.8	N/A	N/A

Probing depth, bone thickness and crestal bone height. The peri-implant probing depth (PPD) is measured by five authors with a periodontal probe at 0.25 N. **Table 4** shows that no significant differences in this value were found after the surgery.

As mentioned before, bone remodelling is only discussed by one author, Le B., in 2016 in two different studies. He considers it important to camouflage the bony defect to create support for the soft tissue because marginal bone loss has been related to a higher crestal bone stress and STD (Spray, 2000).

In the first article, the individual case report, it was shown that there was an increase of bone tissue ($1.8 - 2$ mm) and soft tissue with keratinised gingiva. Following that, a clinical case series with 14 patients also showed significant results. Crestal bone thickness augmented 1.84 mm measured 2 mm from the crest and 2.07 mm in the mid-implant buccal bone after one year of treatment.

Table 4. Overview change in peri-implant probing depth. PPD, peri-implant probing depth. [SCTG] = Subepithelial Connective Tissue Graft; [ADM] = Acellular Dermal Matrix; [P] = p-value; [F-up] = Follow-up; [ppd] = Peri-implant probing depth; [mm] = Millimetre; [NS] = Not Significant.

AUTHORS	CONTROL/TEST	TREATMENT	BASELINE PPD	LAST F-UP PPD	CHANGE	P-VALUE
Burkhardt (2008)	SCTG	SCTG palate	2.8	3.0		NS
Hidaka (2012)	SCTG	SCTG palate ×2	2-3	2-3		
Lorenzo (2011)	SCTG	SCTG palate			0.0	P=1.0
	ADM	ADM			0.0	P=0.34
Rocuzzo (2018)	SCTG	SCTG max tuberosity	2.7	2.9		P=0.88
Zucchelli (2012)	SCTG	SCTG palate	2.0	2.0		P<0.05

3.3 Patient satisfaction

Alterations in symmetry and gingival harmony are most notable in the anterior area. Therefore, one of the most important aspects when dealing with the anterior sector, apart from function, is the degree of patient satisfaction with the aesthetic result. This satisfaction has been assessed by asking the patient directly, using a Complex Aesthetic Index (Anderson et al., 2014) or with the VAS scale (Roccuzzo et al., 2018; Scharllhorn et al., 2015; Zucchelli et al., 2012).

Table 5 shows a high degree of satisfaction after treatment with SCTG or ADM. Anderson et al. (2014) and Roccuzzo et al. (2018) compared opinions between the two groups. Anderson et al. noted that patients treated with SCTG reported favourable results in terms of soft tissue contour, colour, and texture but experienced more eventful wound healing compared to the ADM group. Roccuzzo et al. found that patients treated with ADM required a shorter surgery time and less use of painkillers.

Table 5. Patient satisfaction is measured by some authors with the VAS scale, aesthetic index or asking to the patient. [SCTG] = Subepithelial Connective Tissue Graft; [ADM] = Acellular Dermal Matrix; [VAS] = Visual Analog Scale.

AUTHOR	CONTROL & TEST	INTERVENTION	SATISFACTION		METHOD
Anderson (2014)			**Baseline**	**Follow-up**	Aesthetic Index
	SCTG	SCTG palate	4.0	3.9	
	ADM	ADM	2.6	3.4	
Hidaka (2012)	SCTG	SCTG palate x2	Satisfied		
Kassab (2010)	SCTG, ADM	SCTG palate x2, ADM mask color	Satisfied		
Le (2016)	ADM	ADM	Satisfied		
Lee (2015)	SCTG	SCTG palate	Satisfied		
Lorenzo (2011)	SCTG	SCTG palate	Satisfied, less pain, shorter time		
Rocuzzo (2018)			**Baseline**	**Follow-up**	VAS scale
	SCTG	SCTG maxillary tuberosity	3.6	8.1	
Schallhorn (2015)	ADM	ADM	90 ±20/100	VAS scale	
Zucchelli (2012)			**Baseline**	**Follow-up**	VAS scale
	SCTG	SCTG palate	3.8	8.0	
Zucchelli (2013)	SCTG	2 SCTG: Coronal, Apical	Satisfied		

4 Discussion

The aim of this study was to evaluate the efficacy of the available methods for the treatment of STD in osseointegrated single implants in the anterior area. Therefore, different surgical and prosthetic procedures have been compared according to various clinical parameters and also taking into account patient satisfaction.

SCTG to cover soft tissue dehiscences was the standard method, but today, the use of ADM to treat the same defect is also carried out. The follow-up shows a soft tissue coverage with these techniques ranging from 0.17 mm to 3 mm. In addition, the surgical methods are combined with prosthetic strategies to achieve harmonic results. The degree of patient satisfaction is high in the long term.

The surgical and prosthetic methods for the treatment of implant soft tissue dehiscence currently in use are as follows. The surgical procedure begins with the flap design. The objective is always to preserve the interproximal papillae and the presence of keratinized soft tissue around the implant. Ensuring good vascularization of the flap and a well-prepared graft bed is therefore essential. The flap designs used by the authors range from CAF, envelope flap, tunnel flap or pouch flap to open book flap. These techniques have shown good results in achieving soft tissue coverage around implants and are also confirmed by other authors (Zucchelli et al., 2003; Zuhr et al., 2018; Deeb & Deeb, 1999). However, other techniques such as partial-thickness double pedicle graft, semilunar and lateral sliding flaps,

pinhole surgical technique, and submerged techniques are also described (Mazzotti et al., 2018; Deeb & Deeb, 1999). De Santis and Clementini (2014) also suggest the potential of using pedicled flaps to treat soft tissue dehiscences around implants could be interesting and yet unexplored. The use of a free gingival graft to cover recessions is also a possibility; however, due to the poor aesthetic outcome, it has not been commonly performed in these cases.

The STD has to be filled with soft tissue grafts or substitution materials. Soft tissue grafts from the lateral or anterior palate were always the gold standard (fourteen authors in this review have followed this concept). Today, other methods are also in use, depending on the amount of connective tissue in the donor site or the surgeon's personal preference. Soft tissue grafts from the retromolar area or maxillary tuberosity are also alternatives for obtaining connective tissue and are supported by other authors in the literature (Zuhr et al., 2014; Mazzotti et al., 2018). Due to the discomfort caused by healing in soft tissue harvesting procedures and the challenge of obtaining enough soft tissue to cover the defect, soft tissue substitution materials (like ADM) are also currently in use and also show efficacy in covering soft tissue dehiscence.

The use of mineralized bone allograft seems promising (Lee et al., 2016), as it could be beneficial for increasing the soft tissue profile and masking the transparency of the implant colour in the soft tissue. Although there is limited information about the quality of integration of this bone graft, Lee et al. (2016) performed the same procedure first with one patient and then with fourteen in the same year, concluding after an eight-year follow-up that the alveolar and soft tissue dimensions were increased. More studies are needed in this area to compare this technique with traditional methods such as connective tissue grafts.

Some authors follow a concept based on smoothening the implant suprastructure or implantoplasty (Schwarz et al., 2012), but this has not been carried out by the authors of the reviewed articles. Implantoplasty is mostly performed in cases of soft tissue dehiscence combined with peri-implantitis to achieve decontamination of the implant surface.

Correct prosthetic procedures often enhance the results of the surgical methods. Most authors recommend using a new abutment and provisional crown post-surgery to shape the soft tissue. Zucchelli et al. (2012, 2013) suggest the crown be removed one month before surgery to allow interproximal tissue growth, and the crown's abutment be milled to reduce chamfers or shoulders, facilitating better healing of the soft tissue post-surgery. This method achieved a 96.3% soft tissue coverage rate, with complete coverage in 75% of cases.

Most authors use Zirconia abutments to avoid metal transparency and because Zirconia is believed to be less aggressive to soft tissue. However, according to the 4th EAO Consensus Conference (Sicilia et al., 2015), there was no difference between Zirconia and metal regarding soft tissue health. In cases where the soft tissue around the implants is delicate, screw-retained restorations are proposed as a better option to avoid peri-implant mucositis due to excess cement (Levin et al., 2015).

A comparison of the different methods regarding soft tissue dehiscence coverage is necessary. The soft tissue treatment in teeth has been transferred to implants, but the predictability of soft tissue coverage in implants is lower. Sixteen studies reported a decrease in dehiscence, and only one article showed no significant difference in the results. Coronally advanced flaps (CAF) seem to be an effective method to preserve soft tissue amount; a CAF procedure combined with subepithelial connective tissue graft (SCTG) shows 66% of soft tissue coverage (Burkhardt et al., 2008). The same technique, 10 years later, showed 86% of dehiscence coverage (Rocuzzo et al., 2018). In those articles, only a surgical method is described; no prosthesis modifications were taken into account. On the other hand, the

combined surgical-prosthetic procedure with SCTG carried out by Zucchelli et al. (2012, 2013) has the best predictable results in soft tissue coverage. A 96.3% of soft tissue coverage was achieved, and in 75% of the cases, the coverage was complete. The review by Mazzoti et al. (2018) also supports the combined surgical-prosthetic method of Zucchelli as the best method to achieve complete soft tissue coverage and, in general, SCTG as the best option to cover dehiscences.

Acellular dermal matrixpresents a potential alternative method for soft tissue management, though results remain variable. While Anderson et al. (2014) found subepithelial connective tissue graft superior, Lorenzo et al. (2012) reported predictable ADM outcomes. Schallhorn's clinical study showed low predictability, and Schwarz's canine research demonstrated no significant difference between techniques. Fickl (2015) and Sculean et al. (2017) noted that soft tissue dehiscence coverage around dental implants is challenging, with predictable results limited to recessions 2 mm. Basseti et al. (2016) concluded that coronally advanced flap combined with SCTG achieved similar soft tissue recession coverage, whereas split-thickness flap with ADM or CAF with allogenic grafts showed no significant improvement.

Comparative methods for clinical parameters such as soft tissue thickness and keratinized tissue width remain contentious. While some authors assert that a minimum 2 mm of keratinized tissue is crucial to prevent crestal bone resorption and soft tissue dehiscence, others demonstrate high implant success rates irrespective of keratinized tissue presence. This review indicates that soft tissue dehiscence coverage can enhance keratinized tissue around implants. Literature presents mixed findings: Anderson et al. (2014) reported higher keratinized soft tissue with acellular dermal matrix (ADM), whereas other studies found no significant differences between ADM and subepithelial connective tissue graft (SCTG). Although SCTG shows superior results in tooth recession treatment, implant-specific evidence remains limited. The systematic review by Basseti et al. (2016) suggests comparable keratinized tissue increase across ADM, SCTG, and free gingival graft techniques.

Peri-implant probing depth shows no relevant differences. Regarding bone thickness and crestal bone height, Le (2016) confirmed an increase in crestal and buccal bone using mineralized bone allograft. However, no further studies have been conducted since then, making current comparisons unfeasible.

The different methods can also be compared with regard to aesthetic parameters and patient evaluation. This parameter was difficult to compare between articles because it is a subjective aspect. Some authors considered the patient's opinion, while others considered the opinion of the dental professional. In the highest quality articles, a form was filled according to the different aspects studied, but in others, the result was simply termed satisfactory or not. In any case, we can confirm that the level of patient satisfaction after STD coverage in the anterior area is high. Patients reported better results with SCTG coverage, but the postoperative pain and recovery period is greater with SCTG treatment compared to ADM. This topic is not yet extensively developed; most of the evaluated studies were case reports, case series, or clinical trials with a small sample size. Additionally, comparing the articles is complicated in some points due to their non-homogeneity. Further studies with longer follow-ups are needed to establish the effectiveness of the procedures reported in this review.

Conclusions

The use of SCTG to cover STD in osseointegrated implants is a reliable method, although complete coverage is not achieved in all cases. The use of ADM seems to be a shorter and less painful alternative treatment, but the results achieved are still not predictable.

Acknowledgements

Not applicable.

Ethical approval

No ethical approval was required for this study as it did not involve human participants, animal subjects, or sensitive data. This study falls under the category of data collection without participant identification.

Authors' contributions

The author(s) declare that all the criteria for authorship designated by the International Committee of Medical Journal Editors have been met. More specifically, these are: (a) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) Drafting the work or revising it critically for important intellectual content; AND (c) Final approval of the version to be published; AND (d) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The author(s) declare that there are no competing interests related to this work.

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