CLINICAL ORAL IMPLANTS RESEARCH

Lukas Poskevicius
Antanas Sidlauskas
Pablo Galindo-Moreno
Gintaras Juodzbalys

Review

Dimensional soft tissue changes following soft tissue grafting in conjunction with implant placement or around present dental implants: a systematic review

Authors' affiliations:
Lukas Poskevicius, Gintaras Juodzbalys, Department of Maxillofacial Surgery, Lithuanian University of Health Sciences, Kaunas, Lithuania
Antanas Sidlauskas, Department of Orthodontics, Lithuanian University of Health Sciences, Kaunas, Lithuania
Pablo Galindo-Moreno, Department of Oral Surgery and Implant Dentistry, School of Dentistry, University of Granada, Granada, Spain

Corresponding author:
Lukas Poskevicius
Department of Maxillofacial Surgery
Lithuanian University of Health Sciences
Vysniu 4, LT-53257 Garliava, Lithuania
Tel.: +37063353895
Fax: +37037552835
e-mail: lukas.poskevicius@gmail.com

Key words: dental implants, gingivoplasty, transplantation autologous, treatment outcome

Abstract

Objectives: To systematically review changes in mucosal soft tissue thickness and keratinised mucosa width after soft tissue grafting around dental implants.

Materials and Methods: An electronic literature search was conducted of the MEDLINE database published between 2009 and 2014. Sequential screenings at the title, abstract, and full-text levels were performed. Clinical human studies in the English language that had reported changes in soft tissue thickness or keratinised mucosa width after soft tissue grafting at implant placement or around a present implant at 6-month follow-up or longer were included.

Results: The search resulted in fourteen articles meeting the inclusion criteria: Six of them reported connective tissue grafting around present dental implants, compared to eight at the time of implant placement. Better long-term soft tissue thickness outcomes were reported for soft tissue augmentation around dental implants (0.8–1.4 mm), compared with augmentation at implant placement (−0.25–1.43 mm). Both techniques were effective in increasing keratinised tissue width: at implant placement (2.5 mm) or around present dental implants (2.33–2.57 mm).

Conclusions: The present systematic review discovered that connective tissue grafts enhanced keratinised mucosa width and soft tissue thickness for an observation period of up to 48 months. However, some shrinkage may occur, resulting in decreases in soft tissue, mostly for the first three months. Further investigations using accurate evaluation methods need to be done to evaluate the appropriate time for grafting.

The main objectives of mucogingival procedures have evolved from the maintenance or creation of a band of attached keratinised gingiva to the contemporary concept of promoting periodontal health by preventing the further loss of hard and soft tissues or by restoring all lost tissues, as well as improving the patient's aesthetic appearance (Wennstrom 1996; Greenwell et al. 2005; Gupta et al. 2012). At the same time, patients' aesthetic demands have increased tremendously, especially if anterior maxillary teeth have to be replaced (Roccuzzo et al. 2014).

Dental implants are often placed in patients with a history of poor oral hygiene and edentulism and can have structures and surfaces that are different from those of natural teeth. Implants and teeth differ in their connective tissue attachment: The collagen fibres around dental implants exhibit a parallel orientation, and the self-regenerative ability of peri-implant mucosa is limited, due to the dearth of cells and vascularisation around dental implants (Ericsson et al. 1992). Moreover, the implant lacks a periodontal ligament, which reduces its blood supply (Berglundh et al. 1991). Thus, implants are more susceptible to developing inflammation and bone loss from plaque accumulations or microbial invasion, and the establishment of an adequate amount of gingiva that are firmly attached to the underlying periosteum and bone has been cited as a goal in implant maintenance (Nemcovsky & Moses 2002).

Studies in the literature have reported that the presence of an adequate width of keratinised mucosa is required to reduce the risk of mucosal recession (Kim et al. 2009) and alveolar bone loss (Bouri et al. 2008) around implants in the long term. Therefore, to

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successfully treat a soft tissue defect, it is important to achieve long-term, sustainable outcomes.

Soft tissue volume around dental implants was also investigated. Studies have showed that a thick mucosa was associated with lesser mucosal recession, compared to a thin mucosa (Zigdon & Machtei 2008). The use of soft tissue volume augmentation is also indicated for aesthetic reasons and to facilitate oral hygiene (Pini-Prato et al. 2004).

In recent decades, soft tissue grafting has been successfully employed to eliminate missing soft tissues around dental implants. Soft tissue augmentation with autogenic or synthetic grafts is widely used to increase tissue volume and the amount of keratinised gingiva, as well as improve aesthetic outcomes. Despite the favourable results achieved by the delivery of free gingival grafts, there are also some disadvantages, namely post-operative pain (Griffin et al. 2006) and limited supply of donor tissue (Kolliyavar et al. 2012). Soft tissue substitutes, such as acellular dermal matrix (ADM) (Park 2006) and collagen matrix (Sanz et al. 2009), are used to increase the dimensions of peri-implant soft tissue. Several studies have demonstrated that the allograft material was less effective and less predictable than autogenous soft tissue grafts, in terms of increasing attached keratinised tissue, due to the considerable shrinkage and inconsistent quality of the attached tissue gained (Wei et al. 2000). Furthermore, the resultant tissue types of ADM allografts resemble scar tissue (Rhee et al. 1998). Consequently, soft tissue grafts from the palate are currently the gold standard for augmenting soft tissue around implants.

Approaches to augment soft tissue can be also be manipulated at the time of implant insertion. The concept of tissue preservation was therefore developed (Kan et al. 2005). This concept entails immediate implant placement and provisionalisation (immediate tooth replacement), in which the osseous architecture is preserved by immediate implant placement, and the soft tissue architecture is maintained by immediate provisionalisation (Kan & Rungcharassaeng 2000; Garber et al. 2001; Juodzbalys & Wang 2010a,b). However, research shows that post-extractive remodelling cannot be avoided, even with the immediate implant protocol (De Rouck et al. 2008). Therefore, soft tissue defects are inevitable, and soft tissue grafting may be indicated. Consequently, the aim of this study was to systematically review changes in mucosal soft tissue thickness and keratinised mucosa width after connective tissue graft around dental implants.

Material and methods

Protocol and registration

The methods of the analysis and inclusion criteria were specified in advance and documented in a protocol. The review was registered in PROSPERO, an international prospective register of systematic reviews.

The protocol can be accessed at: www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42014014497#.VGEL4_msVCA.

Registration number: CRD42014014497.

The reporting of this systematic analysis adhered to the PRISMA (Preferred Reporting Item for Systematic Review and Meta-Analyses) Statement (Moher et al. 2009).

Types of publications

The review included studies on humans published in the English language. Letters, editorials, literature reviews, PhD theses, and abstracts were excluded.

Types of studies

The review included all human prospective and retrospective follow-up studies and clinical trials, cohort studies, case–control studies, and case series studies published between January 2009 and October 2014, on various soft tissue grafting techniques for around dental implants, as well as various follow-up soft tissue stability measurements. Case report studies were excluded.

Information sources

The search strategy incorporated examinations of electronic databases, supplemented by hand searches. A search was conducted on the National Library of Medicine database (Medline) through its online site (PubMed). Additionally, a hand search was carried out in dental implant related journals, including *Journal of Oral and Maxillofacial Implants, Clinical Oral Implants Research, European Journal of Oral Implantology, Journal of Oral and Maxillofacial Surgery, Journal of Clinical Periodontology, Journal of Periodontology, International Journal of Oral and Maxillofacial Surgery, The International Journal of Periodontics and Restorative Dentistry*. The references of each relevant study were screened to discover additional relevant publications and to improve the sensitivity of the search.

Search

The PubMed resource database was explored through advanced searches. The keywords and search inquiries that were used during the primary stage were as follows: "Dental implants" AND ("Soft tissue grafting" OR "Soft tissue correction" OR "Transplantation") AND ("Stability" OR "Thickness" OR "Keratinised mucosa width" OR "Volume" OR "Survival" OR "Follow up" OR "Amount").

The choice of keywords was intended to be broad, to collect as much relevant data as possible without relying on electronic means alone to refine the search results.

Selection of studies

The resulting articles were independently subjected to clear inclusion and exclusion criteria by 2 reviewers as follows. Reviewers compared decisions and resolved differences through discussion, consulting a third party when consensus could not be reached. The third party was an experienced senior reviewer. At the title and abstract stage, one reviewer accepted the citations that appeared to meet inclusion criteria and send them on to full-text review, with a second reviewer assessing only those citations and abstracts that the first reviewer deemed ineligible. For the stage of reviewing of full-text articles, a complete independent dual review was undertaken.

Inclusion and exclusion criteria

The applied inclusion criteria for studies were as follows:

- Investigated soft tissue grafting at implant placement or around present dental implants with various techniques: free gingival grafts or sub-epithelial connective tissue grafting (CTG).
- Followed up on soft tissue stability changes and reported clear data.
- All human prospective or retrospective follow-up studies and clinical trials, cohort studies, case–control studies, and case series studies with at least 5 patients.
- A follow-up time period of at least 6 months.
- Treatment outcomes had to include either direct or indirect measures of the thickness of soft tissue/width of keratinised mucosa.
- Could not be excluded before careful reading.

The following articles were excluded as follows:

- Studies that targeted soft tissue grafting around teeth.
- Mucogingival surgery within the past 6 months.
- Defects requiring bone grafting.
- Signs of peri-implantitis.

- Studies that targeted other soft tissue augmentation procedures (coronally advanced flap, pediculated CTG).
- Studies that investigated ADM or collagen matrix alone.
- Studies where the effect of soft tissue augmentation surgery could not be extracted from the data (e.g. a combination of guided bone regeneration and soft tissue augmentation)
- Studies that included unclear data, with authors who could not be contacted for any reason

Sequential search strategy

Following the initial literature search, all article titles were screened to eliminate irrelevant publications, review articles, case reports, and animal studies. Next, studies were excluded based on data obtained from screening the abstracts. The final stage of screening involved reading the full texts to confirm each study's eligibility, based on the inclusion and exclusion criteria.

Data extraction

The data were independently extracted from studies in the form of variables, according to the aims and themes of the present review, as listed onwards.

Data items

Data were collected from the included articles and arranged in the following fields:

"Type of study" – Indicates the type of study.

"Year" – Reveals the year of publication.

"Sample size" – Describes the number of patients examined.

"Follow-up" – Describes the duration of the observed outcomes.

"Outcome measured" – Characterises the soft tissue target investigated.

"Evaluation method" – Defines the soft tissue quantitative evaluation methods.

"Treatment outcomes" – Describes the changes in the follow-up soft tissue thickness or keratinised mucosa width.

Assessment of methodological quality

The quality of all included studies was assessed during the data extraction process. The quality appraisal involved evaluating the methodological elements that might influence the outcomes of each study.

The Cochrane Collaboration's two-part tool for assessing risk of bias (Higgins & Green 2011) was used to assess bias across the studies and identify papers with intrinsic methodological and design flaws.

Synthesis of results

Relevant data of interest on the previously stated variables were collected and organised into 2 tables, divided according to the time of soft tissue grafting. The tables include results according to the follow-up evaluations of soft tissue measurements.

Statistical analysis

No meta-analyses could be performed due to the heterogeneity between the studies (different study designs, control groups, and observation periods).

Results

Study selection

The initial search identified a total of 2131 articles. Following the screening of the article titles, 649 potentially relevant articles were identified. Independent screening of the abstracts resulted in the selection of 40 publications for possible inclusion. The inclusion and exclusion criteria were applied to the 40 full-text articles. Finally, 14 articles that met the predefined criteria were included in the systematic review (Fig. 1).

Exclusion of studies

The reasons for excluding studies after full-text assessment were as follows: augmentations using flaps (n = 10), soft tissue augmentation around teeth (n = 5), soft tissue recession measured (n = 2), cultured gingival graft used (n = 1), no minimum 6-month follow-up (n = 1), ADM used (n = 5), and pre-operative peri-implantitis present (n = 2).

Quality assessment

The quality assessment of the included studies revealed a high risk of bias (for one or more key domains) for the majority of the included studies (Speroni et al. 2010; Schneider et al. 2011; Chung et al. 2011; Tsuda et al. 2011; Lorenzo et al. 2012; Lee et al. 2012; Basegmez et al. 2012; Anderson et al. 2014; Yoshino et al. 2014), Four studies (Kan et al. 2009; Wiesner et al. 2010; Grunder 2011; Rungcharassaeng et al. 2012) were

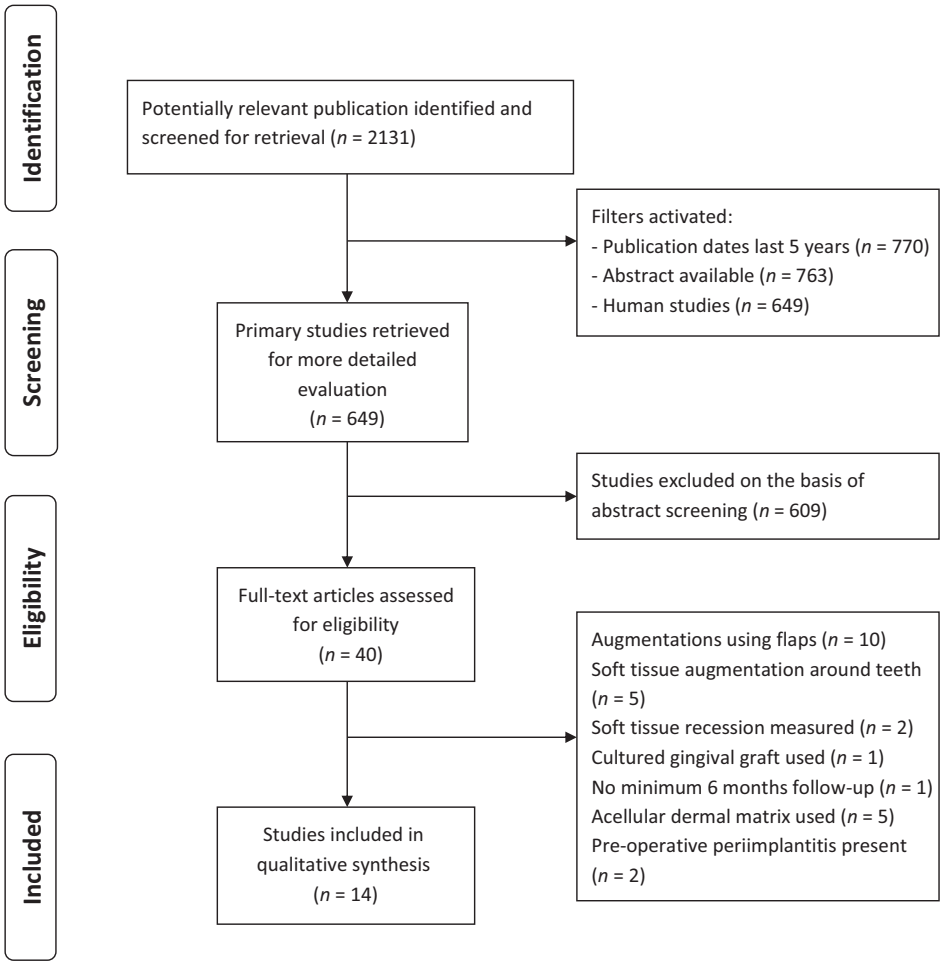

Fig. 1. Procedural flow of the literature search and selection process.

classified as unclear risk (of bias for one or more key domains), and one RCT (Basegmez et al. 2013) had low risk (of bias for all key domains) (Table 1).

Study characteristics

The included studies were further divided into two groups, characterised by the time of soft tissue grafting. The division provided a better understanding of soft tissue changes and contributed to the sensitivity of the review (Fig. 2).

Soft tissue grafting at implant placement

The eight included studies consisted of three randomised clinical trials and four case series studies, in which 113 patients were treated to increase soft tissue volume and gain keratinised gingiva (Table 2). The mean observation period was 14.25 months (ranging from 6 months to 4 years). A total of seven studies reported on changes in soft tissue volume. Four of them measured volume changes indirectly based on casts probing through a stent or used a jig (Kan et al. 2009; Chung et al. 2011; Tsuda et al. 2011; Yoshino et al. 2014). Three studies measured tissue thickness directly through probing with an endodontic micro-opener, periodontal probe, or wax calliper (Wiesner et al. 2010; Grunder 2011; Rungcharassaeng et al. 2012). The increase in facial gingival level ranged between −0.25 and 1.43 mm. Only one study measured changes in keratinised gingiva width from digital photographic images using image analysing software – The mean final gain was 2.5 mm (Lee et al. 2012).

Soft tissue grafting around present dental implants

Six studies met the inclusion criteria, as they reported on soft tissue grafting around dental implants. Four studies were designed as randomised clinical trials, with the remaining including one prospective and one retrospective cohort study. In total, 98 patients were treated to enhance their soft tissue volume and keratinised tissue width around dental implants (Table 3). The mean observation period was 13 months (ranging from 6 months to 3 years). Two studies reported horizontal changes in soft tissue volume following soft tissue grafting procedures, using stents and periodontal probes or endodontic instruments to measure the changes over time (Speroni et al. 2010; Anderson et al. 2014). Only one study reported the three-dimensional changes in the soft tissue volume following grafting (Schneider et al. 2011). All of the studies showed increases in soft tissue thickness between 0.51 and 2.57 mm. Three studies investigated gains in the widths of keratinised tissue as a distance between the mucosal margin and the mucogingival junction (Lorenzo et al. 2012; Basegmez et al. 2012, 2013). The final gain of the attached mucosa remained from 2.33 to 2.57 mm.

Table 1. **Bias summary**

	Random sequence generation	Allocation concealment	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias
Kan et al. (2009)	?	?	?	+	+	+
Speroni et al. (2010)	?	?	?	+	+	−
Wiesner et al. (2010)	+	+	?	+	+	+
Chung et al. (2011)	?	?	?	−	+	+
Grunder (2011)	?	?	?	+	+	+
Schneider et al. (2011)	+	?	?	−	+	+
Tsuda et al. (2011)	?	?	?	+	+	−
Basegmez et al. (2012)	+	+	−	+	+	+
Lee et al. (2012)	?	?	?	−	+	+
Lorenzo et al. (2012)	+	+	+	−	−	−
Rungcharassaeng et al. (2012)	?	?	?	+	+	+
Basegmez et al. (2013)	+	+	+	+	+	+
Anderson et al. (2014)	+	?	?	+	−	+
Yoshino et al. (2014)	+	?	?	+	+	−

Synthesis of results

No meta-analysis could be performed due to the heterogeneity in the study designs and treatment modalities.

Discussion

The present investigation included studies reporting on the outcomes of free full thickness CTG and sub-epithelial CTG. This systematic review was not limited to only randomised, controlled clinical trials. The included studies were of relatively short duration. Despite this, the studies revealed that maximum tissue shrinkage occurs during the first 3 months after the procedure (Horning & Mullen 1990; Agudio et al. 2008) and proceeds for 12 months at a lower rate (Sezar et al. 2004).

Although the studies varied in design, clear clinical evidence of soft tissue gains after grafting procedures was seen. Some factors are considered to affect soft tissue grafting outcomes. Thickness increases were mainly correlated with CTG thickness. Anderson et al. (2014) reported that a thicker biotype did not necessarily imply better recession or concavity correction outcomes, but rather that hard tissue morphology dictated the outcome to a greater degree over a 6-month period. Studies indicated that proper three-dimensional implant position positively affected soft tissue stability (Evans & Chen 2008). Similarly, implants with a buccal shoulder position had three times more recession than implants with a lingual/palatal shoulder position (Juodzbalys & Wang 2010a, b). Flap design (Roccuzzo et al. 2014) and the shape of the prosthesis (Vela et al. 2012) are additional important factors to consider.

The impacts of habits such as smoking are of additional consequence and can limit and jeopardise treatment results. A histomorphometry of the palatal CTG revealed a significantly smaller blood vessel density among non-smokers, compared to smokers (Souza et al. 2008). Studies demonstrate that nicotine decreases fibroblast migration (Fang & Svoboda 2005), induces apoptosis (Kang et al. 2011) and inhibits the expression of some key osteogenic and angiogenic mediators (Ma et al. 2011). Therefore, cigarette smokers respond less favourably to CTG treatment than non-smokers do to surgical therapy (Erley et al. 2006).

It is suggested that the peri-implant bone is necessary to provide a stable base for the overlying soft tissue, to ensure satisfactory long-term aesthetics (Berglundh & Lindhe 1996;

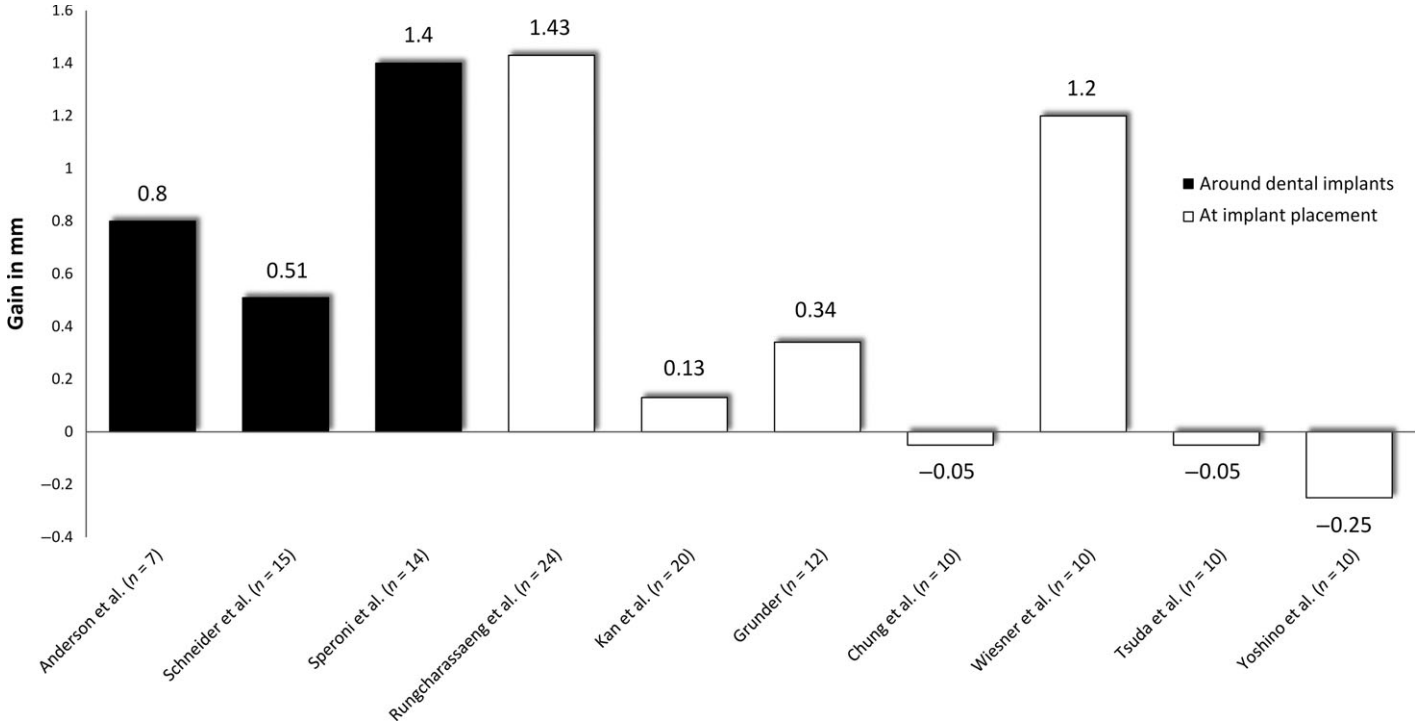

Fig. 2. Studies investigated soft tissue thickness changes.

Table 2. **Connective tissue grafting at implant placement**

Author (Year)	Sample size	Study design	Follow-up	Outcome measured	Evaluation method	Treatment outcomes
Kan et al. (2009)	20 patients with CTG	Case series	2.15 years (1 to 4)	Soft tissue volume	Volume change recorded using jig and casts	The mean overall gingival level change was 0.13 ± 0.61 mm
Wiesner et al. (2010)	10 patients split mouth technique (one side CTG, another side without augmentation)	RCT	1 year	Soft tissue volume	Transgingival probing with endodontic micro-opener and stopper.	CTG group gained 1.2 ± 0.63 mm thickness, control group changed to −0.15 ± 0.34 mm
Chung et al. (2011)	10 patients with SCTG	Case series	1 year	Soft tissue volume	Volume measurements on casts using periodontal probe through stent	A mean facial gingival level changed to −0.05 mm
Grunder (2011)	24 patients (12 with SCTG, 12 without augmentation)	Case series	6 months	Soft tissue volume	2D volume measurements with periodontal probe	An average loss in non-grafted group of 1.063 mm and 0.34 mm gain in SCTG group
Tsuda et al. (2011)	10 patients with SCTG	Case series	1 year	Soft tissue volume	Volume measurements on casts using periodontal probe through stent	A mean facial gingival level changed to −0.05 mm
Lee et al. (2012)	10 patients with CTG	Case series	2 years	Width of keratinised gingiva	Digital photographic images using image analysing software.	A mean keratinised gingiva width gain after 2 years was 2.5 ± 0.6 mm.
Rungcharassaeng et al. (2012)	55 patients (24 with SCTG, 31 without augmentation)	RCT	10.2 months (6–24)	Soft tissue volume	2D volume measurement using wax caliper	The mean thickness change was 1.43 ± 0.59 mm in SCTG group and 0.32 ± 0.36 mm in group without SCTG
Yoshino et al. (2014)	20 patients (10 with SCTG, 10 without augmentation)	RCT	1 year	Soft tissue volume	Volume measurements on casts using periodontal probe through stent	A mean facial gingival level change in control group was −0.7 ± 0.48 mm and in SCTG group −0.25 ± 0.35 mm

SCTG, sub-epithelial connective tissue graft; CTG, connective tissue graft.

Burkhardt et al. 2008). Particular attention needs to be given to the buccal bone because of its extensive remodelling ability (Araujo & Lindhe 2005) as well as its role in supporting the aesthetic buccal mucosa. The buccal bone has generally been found to be thinner than its palatal/lingual counterpart and therefore more prone to osseous dehiscence and fenestrations (Merheb et al. 2000). Implant positioning in

Table 3. **Connective tissue grafting around present dental implants**

Author (Year)	Sample size	Study design	Follow-up	Outcome measured	Evaluation method	Treatment outcomes
Speroni et al. (2010)	14 patients with FGG/SCTG	Retrospective cohort study	3 years	Soft tissue volume	2D volume measurements base on transgingival probing with North Carolina probe through stent	The mean thickness gain was 1.40 mm
Schneider et al. (2011)	15 patients with SCTG	Prospective cohort study	1 year	Soft tissue volume	3D volume measurements based on casts superimposition	The mean gain in the labial was 0.51 mm
Basegmaz et al. (2012)	64 patients (32 FGG and 32 vestibuloplasty)	RCT	1 year	Width of keratinised tissue	Probing distance between the mucosal margin and the mucogingival junction	Final gain in attached mucosa was 2.36 mm in FGG group and 1.15 mm in vestibuloplasty group
Lorenzo et al. (2012)	24 patients (12 free CTG – control group and 12 CM – test group)	RCT	6 months	Width of keratinised tissue	Probing distance between the mucosal margin and the mucogingival junction	Group CTG gained a mean width of keratinised tissue of 2.33 mm while the Group CM 2.30 mm
Basegmez et al. (2013)	36 patients (18 ADM group, 18 FGG group)	RCT	6 months	Width of keratinised tissue	Probing distance between the mucosal margin and the mucogingival junction	Final gain of attached mucosa was 1.58 mm in ADM group and 2.57 mm in FGG group
Anderson et al. (2014)	13 patients (7 SCTG – control group, 6 ADM allografts)	RCT	6 months	Soft tissue volume	2D volume measurements based on transgingival probing with #25 endodontic files and stoppers	Both groups gained tissue thickness: SCTG 0.8 mm (63%) and ADM 1.2 mm (105%)

FGG, free gingival graft; SCTG, sub-epithelial connective tissue graft; ADM, acellular dermal matrix; CTG, connective tissue graft; CM, collagen matrix.

the alveolar ridge primarily influenced the degree of bone remodelling following implant placement and was found most obviously at the buccal site (Lin et al. 2010). Such bone remodelling may, in turn, have a negative influence on the soft tissue topography and on the outcomes of the soft tissue grafting.

Several other literature reviews have recently analysed the reported success of soft tissue grafts. Most recently, Thoma et al. (2014) evaluated the efficacy of soft tissue augmentation in partially edentulous areas. They concluded that, for increasing soft tissue volume in deficient areas around dental implants, autogenous grafting had a better prognosis than soft tissue substitutes, which lack clinical data. The study confirmed that various methods based on an apically positioned flap/vestibuloplasty, in combination with autogenous tissue or soft tissue substitutes, are effective in gaining keratinised mucosa for up to 48 months.

A similar conclusion was developed by a recent literature review of Fu et al. (2012). The report argued that new xenogeneic grafts do not surpass (gold standard), yet they provide improved patient satisfaction and aesthetics, reduced postoperative discomfort and surgical time, and abundant supply. A recent review on soft tissue grafting around teeth provided a decision tree, which served as a guide for clinicians to choose the most suitable treatment modality for various clinical situations. CTG is preferred if the aim of the procedure is to increase soft tissue thickness. If increasing the keratinised width around dental implants is the goal, then a laterally positioned flap, apically positioned flap, CTG, or the use of biological agents will suffice (Leong & Wang 2011). Although this study did not apply directly to tissue augmentation around dental implants, it provides evidence that CTG is the most universal method to increase soft tissue volume.

Studies confirm that facial gingival recession is a common occurrence after immediate tooth replacement (Groisman et al. 2003; De Rouck et al. 2008). In a longer-term follow-up study (mean of 4 years) of immediate tooth replacement procedures, an average facial gingival change of −1.13 mm was reported (Kan et al. 2011). Kan et al. (2009) also reported that, in the presence of subepithelial CTG, in conjunction with immediate tooth replacement, the mean overall facial gingival change after a mean 2.15-year period was −0.13 mm. This suggests that soft tissue grafting with immediate tooth replacement might minimise facial gingival recession. However, the aesthetic result following immediate implant placement, in the case of compromised extraction sockets, might still be unpredictable, even after soft- and hard tissue corrections (Juodzbalys & Wang 2010a, b). It is therefore recommended that delayed implant placement should be performed in sites that display deficient soft and hard tissue.

Overall, due to the large heterogeneity between the studies, with some studies missing control groups and different time points applying the soft tissue grafting, it is difficult to recommend a universal technique for every clinical case.

Limitations

Most of the studies revealed a high risk of bias. According to Cochrane Collaboration's assessing risk of bias tool (Higgins & Green 2011), the proportion of information from studies at high risk of bias is sufficient to affect the interpretation of results. Five studies did not provide detailed data on randomisation methods or allocation concealment. For soft tissue grafting interventions, it is not possible to blind the surgeon or the patient to the intervention. We acknowledge that there is a risk of performance bias in the surgical trials. Assessment after the blinding of outcome evaluations is the only practical way to minimise detection bias in these trials. Therefore, only assessments with blinding of outcomes were included in the risk of bias.

Other issues that impaired the strength of the evidence for the incorporated studies include a lack of insufficient reproducibility of the measurements and inadequacies in statistical analysis. Detailed information on standardised measurements and reproducibility methods were provided in 6 studies (Wiesner et al. 2010; Schneider et al. 2011; Chung et al. 2011; Tsuda et al. 2011; Anderson et al. 2014; Yoshino et al. 2014). A sample size calculation was only performed in four publications (Wiesner et al. 2010; Lorenzo et al. 2012; Basegmez et al. 2012; Basegmez et al. 2013).

Therefore, the strength of evidence of this systematic review is moderate to low because of risks of bias and the significant

variations observed in the included investigations.

Conclusions

Soft tissue stability after a connective tissue graft around dental implants is dependent on multifactorial parameters and cannot be determined clearly by existing studies, which differ from one another. The present systematic review discovered that connective tissue grafts enhanced keratinised mucosa width and soft tissue thickness for an observation period of up to 48 months. However, some shrinkage may occur and result in the decrease of soft tissue by more than 40%, mostly in the first three months. Yet, further investigations using accurate evaluation methods need to be carried out to discover the appropriate time for soft tissue augmentation procedures. Therefore, precautions should be exercised when interpreting the results of this review.

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The authors declare that there are no financial or other conflicts of interest related to this publication.

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