J Clin Periodontol 2015; 42: 876–882 doi: 10.1111/jcpe.12448

Journal of Clinical Periodontology

Horizontal stability of connective tissue grafts at the buccal aspect of single implants: a 1-year prospective case series

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De Bruyckere T, Eghbali A, Younes F, De Bruyn H, Cosyn J. Horizontal stability of connective tissue grafts at the buccal aspect of single implants: a 1-year prospective case series. J Clin Periodontol 2015; 42: 876–882. doi: 10.1111/jcpe.12448

Abstract

Aim: To clinically evaluate the horizontal stability of a connective tissue graft (CTG) at the buccal aspect of single implants (1); to compare actual gingival thickness between thin and thick gingival biotype (2).

Materials and Methods: Periodontally healthy non-smoking patients with a single implant in the anterior maxilla (15–25) were selected for a prospective case series. All demonstrated a horizontal alveolar defect and were in need of contour augmentation by means of CTG for aesthetic reasons. Patients were enrolled 3 months after implant surgery and had been provided with a provisional screw-retained crown. CTG was inserted in the buccal mucosa via the envelope technique using one intrasulcular incision. An ultrasonic device was used to evaluate mucosal thickness (MT) at the buccal aspect. MT was assessed at t0 (before CTG), t1 (immediately after CTG), t2 (2 weeks after CTG = suture removal), t3 (3 months after CTG = permanent crown installation) and t4 (1 year after implant placement). The gingival biotype was categorized as thin or thick based on the transparency of a periodontal probe through the soft tissues while probing the buccal sulcus of the contra-lateral tooth. Gingival thickness (GT) was measured at the contra-lateral tooth using the same ultrasonic device.

Results: Thirty-seven patients (19 men, 18 women; mean age 38) met the selection criteria and consented to the treatment. Mean soft tissue gain immediately after CTG was on average 1.07 mm (SD 0.49). What remained of this tissue gain after 1 year was on average 0.97 mm (SD 0.48; 90.5%). Hence, mean soft tissue loss amounted to 0.10 mm (SD 0.23; 9.5%; $p = 0.015$) with no significant difference between patients with a thin or thick biotype ($p \geq 0.290$). Patients with a thin biotype had a mean GT of 1.02 mm (SD 0.21), whereas GT was on average 1.32 mm (SD 0.31) in subjects with a thick biotype ($p = 0.004$).

Conclusion: Connective tissue graft substantially thickens the peri-implant mucosa with acceptable stability over a 1-year period.

Key words: connective tissue graft; contour augmentation; dental implant; single tooth

Accepted for publication 10 August 2015

Conflict of interest and source of funding statement

Dental implants and restorative components were supplied by Nobel Biocare (Gothenburg, Sweden; support code: 2011-989). Prof. Cosyn has a collaboration agreement with Nobel Biocare.

Aesthetics are more and more becoming the key to success in oral rehabilitation. Therefore, prevention and treatment of aesthetic complications are important in contemporary implantology. The most frequent soft tissue complication following single implant treatment seems to be the lack of buccal convexity (Cosyn et al. 2011, 2012). This so-called "alveolar process deficiency" (Furhauser et al. 2005) is the result of buccal bone remodelling and/or soft tissue loss following tooth extraction (Araujo & Lindhe 2005).

Ample systematic reviews have been published supporting the effectiveness of ridge preservation in limiting horizontal and vertical ridge alterations in postextraction sites (Darby et al. 2009, Vignoletti et al. 2012, Horvath et al. 2013, Vittorini Orgeas et al. 2013). However, full preservation of the alveolar process does not seem feasible (Cosyn et al. 2014). Also in a recent study by Cosyn et al. (2014), all patients demonstrated reduction in width of the alveolar process following ridge preservation. In the vast majority of the cases contour augmentation was deemed necessary, from an aesthetic point of view.

A method to compensate for this lack of buccal convexity, could be contour augmentation by means of a connective tissue graft (CTG) (Speroni et al. 2010, Wiesner et al. 2010, Eghbali et al. 2014). However, the available literature on CTG at the buccal aspect of implants is scarce and may represent limitations. These basically include a limited sample size (Speroni et al. 2010, Wiesner et al. 2010, Eghbali et al. 2014,), inaccurate registration methods (Speroni et al. 2010, Wiesner et al. 2010), treatments in areas with low aesthetic priority (Wiesner et al. 2010) and incomplete registration (Wiesner et al. 2010). Hence, the primary study objective was to evaluate the amount of soft tissue gain at the buccal aspect of single implants by means of CTG on one hand and to assess its horizontal stability over a 1-year period on the other.

The so-called "gingival biotype" has gained a lot of interest by the scientific community (Stein et al. 2013, Stellini et al. 2013, Fischer et al. 2014, Zweers et al. 2014). In clinical practice, a proper diagnosis of gingival biotype has been considered to be related to the outcomes of periodontal, restorative and implant therapy (Kao et al. 2008, Fu et al. 2010, Cook et al. 2011, Lee et al. 2011, Zweers et al. 2014,). The study of Eghbali et al. (2009) concluded that visual assessment of the biotype may not be considered as a valid method. This was in accordance with the study of Stein et al. (2013), showing that a clear distinction between a "thin" and a "thick" gingival biotype may be difficult to make. A simple and frequently used method to identify the gingival biotype is based on the transparency of a periodontal probe through the soft tissues while probing the buccal sulcus. Interestingly, conflicting results have been published on the accuracy of this method (De Rouck et al. 2009, Kan et al. 2010, Stein et al. 2013). Therefore, the second study objective was to compare actual gingival thickness between thin and thick gingival biotype.

Materials and Methods

Patient selection

Patients with a single implant in the anterior maxilla and a horizontal alveolar defect at the buccal aspect were enrolled in a private practice in Belgium between November 2011 and September 2013. All patients needed contour augmentation by means of CTG for aesthetic reasons.

Inclusion criteria were as follows:

- At least 18 years old
- Good oral hygiene defined a full-mouth plaque score $\leq$ 25% (O'Leary et al. 1972)
- Presence of a single implant in the anterior maxilla (15–25) installed 3 months earlier and both neighbouring teeth present
- Class I alveolar defect at the implant site (buccolingual loss of tissue with normal apicocoronal ridge height) (Seibert 1983)
- Signed informed consent

Exclusion criteria were as follows:

- Systemic diseases
- Smoking
- (History of) periodontal disease

The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000 and the study protocol was approved by the ethical committee of the University Hospital in Brussels.

Contour augmentation by means of CTG

Patients were enrolled for this study 3 months after implant surgery. If patients met the selection criteria, they were scheduled for contour augmentation. Therefore, a provisional screw-retained crown was connected onto the implant. The provisional crown had a concave buccal emergence profile and was manufactured following the method of De Rouck et al. (2008). To compensate for tissue loss at the buccal aspect a CTG, harvested through a single-incision approach from the palate, was used. After removal of the provisional crown a buccal sulcular incision was made with a micro blade (Swann-Morton® fine surgical blade, Sheffield, UK) connected onto an appropriate holder (Stoma® D1007982, Liptingen, Germany). Thereupon, a partial thickness envelope or pouch with a depth of about 12 mm was prepared using this blade and a Glickman raspartorium (Hu-Friedy® P24GSP, Rotterdam, the Netherlands). An appropriately sized CTG, was pulled into the envelope and sutured (Seralon® 5/0, Serag Weissner, Naila, Germany) (Fig. 1). Subsequently, the buccal contour of the provisional crown was further concaved to provide space for the CTG and then re-installed onto the implant. Sutures were removed after 2 weeks. In the following months, provisional crowns were adapted at the buccal aspect in case of coronal migration of the mucosal margin. Following roughening with a diamond bur, flowable composite (Venus® flow, Heraeus Kulzer GmbH, Hanau, Germany) was added at the buccal aspect hereby inducing soft tissue retraction in a controlled manner. After 3 months of function, the emergence profile was replicated for the permanent restoration as described by Cosyn et al. (2013). Screw-retained full-ceramic crowns were a priori chosen.

Ultrasonic evaluation of mucosal thickness stability

An ultrasonic device (EPOCH, Olympus, Aartselaar, Belgium) was

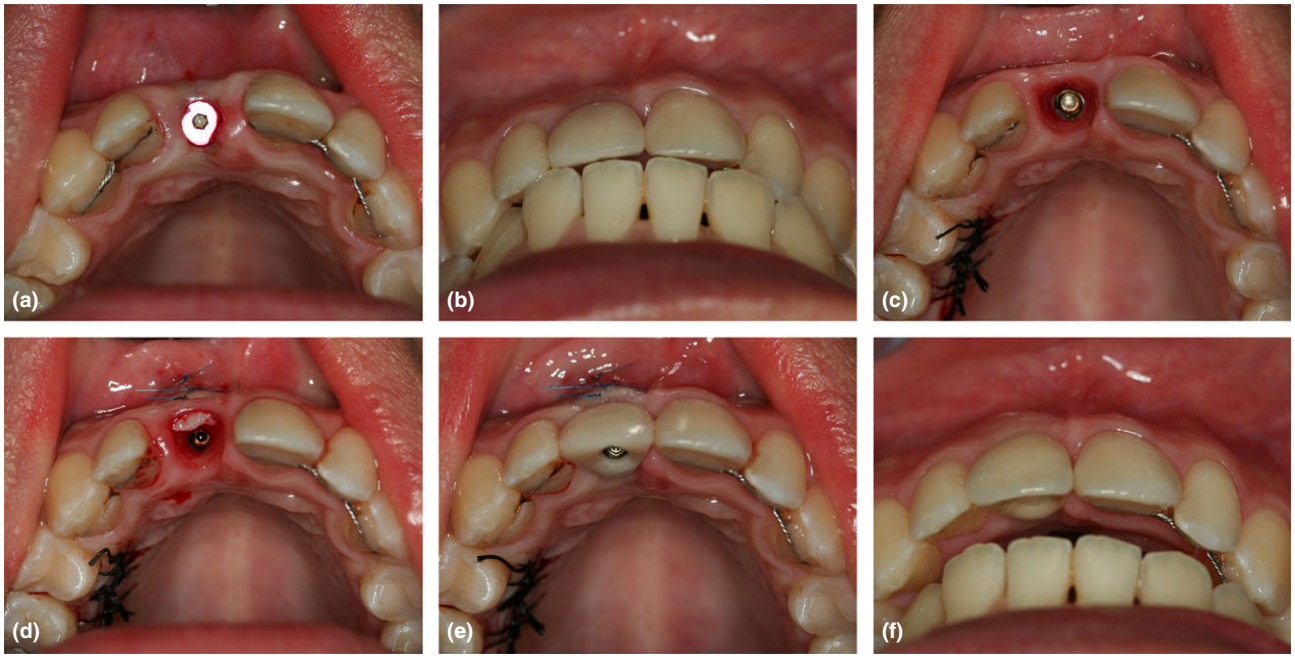

Fig. 1. Occlusal view of a NobelActive® implant (Nobel Biocare, Gothenburg, Sweden) after an osseointegration period of 3 months (a); Temporary crown installation before connective tissue graft (CTG) (b); CTG was harvested from the palate and a buccal singular incision was made with a microblade (c); CTG was pulled into the envelope and sutured (Seralon® 5/0, Serag Weissner, Naila, Germany) (d); Temporary crown installation after CTG (e); Occlusal view of the permanent crown 1 year after implant placement (f).

used to evaluate mucosal thickness (MT) at the buccal aspect of single implants over time. The device has a transducer probe with a diameter of 4 mm that was moistened with ultrasound gel (Amstel Medical, Megro, Amstelveen, the Netherlands). The probe was positioned with its lower border at the level of the free mucosal margin and applied with a minimum pressure to obtain acoustic coupling. Ultrasonic pulses were generated and transmitted through the sound permeable mucosa at 1516 m/s, which is almost similar to the sound velocity of ex vivo muscle (Muller et al. 1999, Hedrick et al. 2004). Then, the signals were reflected at the surface of the alveolar bone or tooth because of different acoustic impedance. From timing of the received echo with respect to the transmission of the pulse, thickness of the masticatory mucosa was determined and digitally displayed with details up to 0.01 mm. A pilot study using this technology at the buccal aspect of single implants was described by Eghbali et al. (2014). All pre- and postoperative registrations were performed by the same clinician (JC). MT was assessed at the following time points: t0 (before CTG), t1 (immediately after CTG), t2 (2 weeks after CTG = suture removal), t3 (3 months after CTG = permanent crown installation) and t4 (1 year after implant placement).

Gingival thickness and biotype

At intake, the gingival biotype was categorized as thin or thick based on the transparency of a periodontal probe (CP15 UNC; Hu-Friedy®, Chicago, IL, USA) through the soft tissues while probing the buccal sulcus of the contra-lateral tooth (Kan et al. 2003, 2010, De Rouck et al. 2009). Gingival thickness (GT) was measured at the contra-lateral tooth using the ultrasonic device as described above. This was done before biotype assessment to avoid bias.

Mucosal thickness and biotype

Mucosal thickness gain and stability was compared between thin and thick biotype. The following parameters were calculated:

- Immediate tissue gain defined as MT difference between t1 and t0
- Absolute tissue loss at t4 defined as MT difference between t1 and t4
- Absolute tissue gain at t4 defined as MT difference between t4 and t0
- Relative tissue gain at t4 defined as the proportion of absolute tissue gain at t4 over immediate tissue gain

Statistical analysis

The patient was the statistical unit in all analyses. Data analysis was performed using the statistical software package SPSS 22 (SPSS Inc., Chicago, IL, USA). Descriptive statistics included mean values and standard deviations for continuous variables (age, GT, MT, immediate tissue gain, absolute tissue loss at t4, absolute tissue gain at t4, relative tissue gain at t4) and frequency distributions for categorical variables (gender, tooth location, gingival biotype). GT at the contra-lateral tooth was compared to MT at t0 at the implant site using the paired *t*-test. Changes over time in MT were evaluated using one-way ANOVA. Post hoc tests included paired *t*-tests without correction for

multiple testing. GT was compared between thin and thick gingival biotype using the independent samples *t*-test. The independent samples *t*-test was used to compare immediate tissue gain, absolute tissue loss at t4, absolute tissue gain at t4, relative tissue gain at t4 between patients with a thin and thick biotype. The level of significance was set at 0.05.

Results

Patient selection

The study population consisted of 37 subjects (19 men, 18 women) with a mean age of 38 years (range, 19–81 years). Two patients dropped out before the end of the study. Twenty-four patients had a CTG at the central incisor position, nine at the lateral incisor position, two at the cuspid position and two at the premolar position.

Thirteen patients had a thin biotype and 24 patients had a thick biotype. GT as ultrasonically measured at the contra-lateral tooth, was on average 1.21 mm (SD 0.31). MT at the implant site before contour augmentation, was on average 1.51 mm (SD 0.46). The mean difference in gingival and mucosal thickness of 0.30 mm (SD 0.35) was significant ($p < 0.001$).

Ultrasonic evaluation of the mucosal thickness stability

The data corresponding to the different time points can be found in Table 1 and Fig. 2. MT significantly increased by 1.07 mm (SD 0.49) between t0 and t1 ($p < 0.001$) (immediate tissue gain). A slight yet significant swelling of 0.38 mm (SD 0.48) was observed between surgery and suture removal. Between t2 and t3, there was a significant decrease of 0.38 mm (SD 0.40; $p < 0.001$). Thereafter, MT remained stable ($p = 0.148$). After 1 year, 0.97 mm (SD 0.48; 90.5%) of the immediate tissue gain of 1.07 mm (SD 0.49) could be maintained. Hence, the absolute tissue loss at t4 was on average 0.10 mm (SD 0.23; 9.5%; $p = 0.015$).

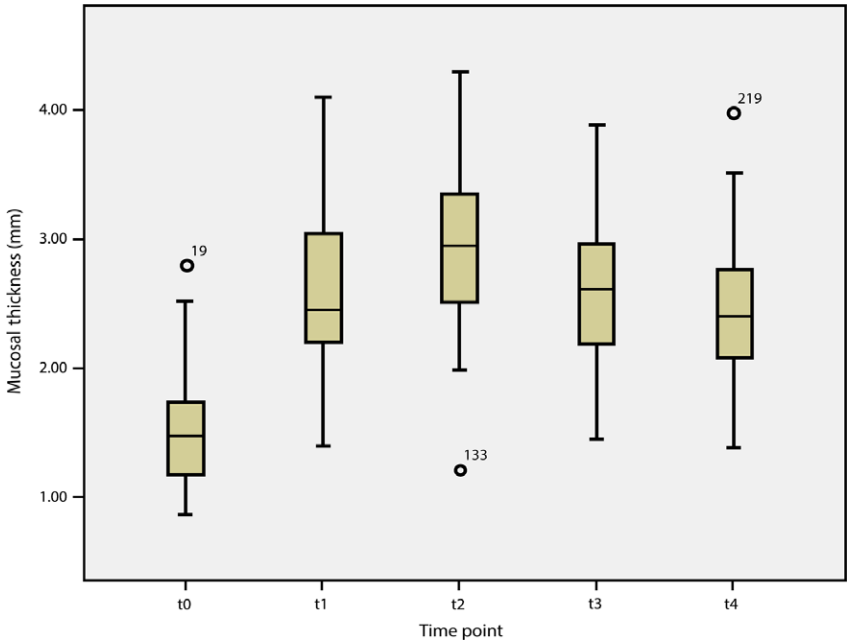

Fig. 2. Box plot of mucosal thickness at different time points (t0 = before CTG; t1 = immediately after CTG; t2 = 2 weeks after CTG = suture removal; t3 = 3 months after CTG = permanent crown; t4 = 1 year after implant placement) displaying outliers at t0, t2 and t4 (°, outlier).

Gingival thickness and biotype

Patients with a thin biotype had a mean GT of 1.02 mm (SD 0.21), whereas GT was on average 1.32 mm (SD 0.31) in subjects with a thick biotype. The mean difference in GT of 0.30 mm (SD 0.10) was significant ($p = 0.004$) (Fig. 3).

Mucosal thickness and biotype

Table 2 shows MT alterations sorted per biotype. Immediate tissue gain was comparable between patients with a thin and thick biotype ($p = 0.212$). However, patients with a thick biotype lost significantly more soft tissue 9 months after CTG insertion, pointing to 0.14 mm on average ($p = 0.039$). The mean difference in absolute and relative tissue gain at t4 between patients with a thin or thick biotype did not reach statistical significance ($p \geq 0.290$).

Table 1. Mucosal thickness at different time points

	Mucosal thickness (mm)		
	Mean (SD)	Minimum	Maximum
t0 (before CTG)	1.51 (0.46)	0.86	2.80
t1 (immediately after CTG)	2.59 (0.59)*	1.40	4.10
t2 (2 weeks after CTG = suture removal)	2.94 (0.71)*	1.21	4.30
t3 (3 months after CTG = permanent crown)	2.60 (0.54)*	1.45	3.89
t4 (1 year after implant placement)	2.50 (0.56)	1.38	3.98

CTG, connective tissue graft; SD, standard deviation.
*Significantly different in comparison to preceding time point.

Discussion

Contour augmentation by means of CTG has been described around natural teeth, pontics (Studer et al. 2000) and implants to increase the soft tissue volume. This procedure can be performed at different time points in case of implant therapy: immediately after implant placement (Wiesner et al. 2010), at second stage surgery (Speroni et al. 2010) or following the installation of a provisional crown (Eghbali et al. 2014,

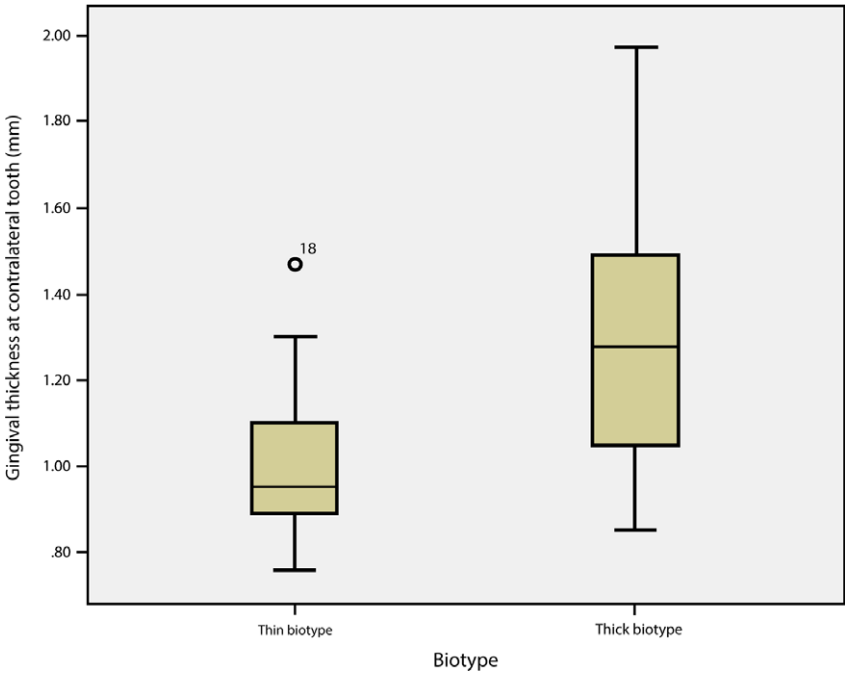

Fig. 3. Box plot of the comparison between thin biotype and thick biotype.

Table 2. Mean alterations in mucosal thickness sorted per biotype

	Immediate tissue gain (mm)	Absolute tissue loss at t4 (mm)*	Absolute tissue gain at t4 (mm)*	Relative tissue gain at t4 (%)*
Thin biotype (n = 13)	0.93 (0.50)	0.01 (0.11)	0.96 (0.50)	98.9 (11.2)
Thick biotype (n = 24)	1.14 (0.48)	0.15 (0.26)†	0.98 (0.48)	86.1 (40.1)
Overall (n = 37)	1.07 (0.49)	0.10 (0.23)	0.97 (0.48)	90.5 (33.5)

*One drop-out in the thin biotype group and one in the thick biotype group at t4.
†Significantly different between biotypes.

Cosyn et al. 2015). Despite the potential benefits from an aesthetic point of view, data regarding the horizontal stability of this treatment are scarce. To the best of our knowledge, there are only three human studies on contour augmentation at the buccal aspect of single implants (Speroni et al. 2010, Wiesner et al. 2010, Eghbali et al. 2014).

An ultrasonic device was used to evaluate MT over time in this study. Eghbali et al. (2014) assessed the precision and accuracy for MT registration of this device using four human cadaver edentulous maxillae with 100 different sites. Soft tissue thickness as recorded with the ultrasonic device was compared to MT as registered with Micro-CT, taking the latter as gold standard. They showed a strong correlation between ultrasonic and Micro-CT measurements ($r = 0.89$, $p < 0.001$), indicating substantial accuracy. In addition, a strong correlation between duplicate ultrasonic recordings could be demonstrated ($r = 0.99$, $p < 0.001$), indicating excellent precision.

In this study, mean MT gain due to CTG was 1.07 mm immediately after the grafting procedure. A slight, yet significant postoperative swelling was observed, resulting in a mean MT of 2.94 mm at suture removal. This is in accordance with findings of Eghbali et al. (2014) but, clearly lower than 5.25 mm, which was observed by Speroni et al. (2010). One possible explanation could be a difference in surgical technique. Speroni et al. (2010) used a more traumatic approach with vertical releasing incisions, which could have caused more postoperative swelling.

One year following CTG, an absolute MT gain of 0.97 mm was observed, with no significant difference between patients with a thin or thick biotype ($p \geq 0.290$). It is interesting to note that this mean gain was slightly higher when compared with the results of Eghbali et al. (2014) (0.83 mm), however, lower when compared with the results of the other available studies (1.75 mm; 1.20 mm) (Speroni et al. 2010, Wiesner et al. 2010). A number of reasons could account for these disparities. First, the time points for registration were incomplete in the study by Speroni et al. (2010) and Wiesner et al. (2010). In fact, Speroni et al. (2010) did not register MT immediately after contour augmentation. The study of Wiesner et al. (2010) included only two registration time points: one prior to implant placement and the other 1 year after implant loading. Clearly, both studies lacked proper baseline registration. Second, the registration methods performed by Speroni et al. (2010) and Wiesner et al. (2010) may have lacked accuracy. The first used transgingival probing through an acrylic stent and measurements were rounded to the nearest millimetre. The latter used an endodontic micro-opener to assess MT and measurements were rounded to the nearest half of a millimetre. Third, a different surgical approach was used. Wiesner et al. (2010) performed a split-thickness flap at implant placement. The implant was then covered with a CTG by means of the "saddle technique". After 3 months, the implant was uncovered. Speroni et al. (2010) elevated a split-thickness flap with two releasing incisions at second stage surgery. The bilaminar technique and the free epithelial-connective tissue graft were performed to optimize the buccal contour, yet summary statistics on both methods were not described. In contrast, the buccal contour was augmented by means of a CTG using the "envelope" technique at provisional crown installation in this study and in the study of Eghbali et al. (2014). Finally, the available studies in the literature all showed limited sample size and therefore effect sizes should be interpreted with caution. Eghbali et al. (2014) treated 10 patients with a single implant in the anterior maxilla. In the study of Wiesner et al. (2010)

10 subjects were included and 10 implants were placed in the posterior mandible. Speroni et al. (2010) treated 14 patients, yet the number of implants and their exact location were unclear.

One of the most frequently used methods for identifying the gingival biotype is the transparency of a periodontal probe (De Rouck et al. 2009, Fu et al. 2010, Kan et al. 2010). However, conflicting results have been published on the validity of this method. Kan et al. (2010) and Fischer et al. (2014) proposed the transparency of a probe as an appropriate method for the assessment of the gingival biotype, yet Fu et al. (2010) reported it as a nonvalid method. In the study of Stein et al. (2013) a weak correlation was found between probe transparency and actual GT. In this study a small, yet significant difference in GT of 0.30 mm was observed between a thin and thick gingival biotype, the latter being based on the transparency of a probe ($p = 0.004$). This is in accordance with the results of Fischer et al. (2014) describing a mean difference of 0.34 mm between both biotypes. These findings support the hypothesis that GT can be assessed on the basis of gingival transparency. However, the difference in GT between a thin and thick gingival biotype seems limited, which suggests that also other properties should be taken into account when categorizing patients. It might also be helpful to use a classification system that includes a "moderately thick" biotype besides the two well-described extremes since a large proportion of patients does not perfectly match with their corresponding traits (De Rouck et al. 2009, Eghbali et al. 2009, Fischer et al. 2014, Zweers et al. 2014).

When interpreting the results of this study several limitations should be acknowledged. First, MT was registered by one clinician who had not been calibrated prior to the start of the study. However, this examiner was clinically involved in previous studies on this topic and could therefore be considered as having a certain expertise in using the ultrasonic device. Second, postoperative complications and patient centred/reported outcomes had not been assessed. Third, the follow-up period was limited. Fourth, this is not a randomized controlled trial (RCT) and therefore, one should be careful in comparing the outcome of contour augmentation by means of CTG to alternative techniques. Autogenous bone grafts can be considered such an alternative. A particular advantage of such grafts is that large volumes can be restored. However, bone grafts have been shown to be prone to resorption, especially when harvested from intra-oral sites or from the iliac crest (Smith & Abramson 1974, Widmark et al. 1997, Jemt & Lekholm 2005). Guided bone regeneration (GBR) seems to provide more stable results in terms of hard and soft tissues at the midfacial aspect of implants (Chappuis et al. 2013). However, the technique requires a more invasive flap design when compared with contour augmentation by means of CTG. Clearly, RCTs are required to compare these options for minor class I defects, especially in terms of volume gain and stability, aesthetic outcomes and patient centred/reported outcomes.

Conclusion

In conclusion, this study demonstrated that contour augmentation by means of CTG at the buccal aspect of single implants substantially thickens the peri-implant mucosa with acceptable stability over a 1-year period.

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Clinical Relevance

Scientific rationale for the study: Traditional concepts for contour augmentation at the buccal aspect of single implants may fall short when looking for optimal aesthetics. The goal of this prospective study was to evaluate the amount of soft tissue gain at the buccal aspect of single implants by means of connective tissue graft (CTG) on one hand and to assess its horizontal stability over a 1-year period on the other.

Principal findings: Mean soft tissue gain immediately after CTG was on average 1.07 mm. Mean soft tissue loss amounted to 0.10 mm (9.5%) after 1 year.

Practical implications: A CTG at the buccal aspect of single implants may be considered a viable treatment option for contour augmentation.