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ORIGINAL ARTICLE

Vertical and horizontal dimensional evaluation of free gingival grafts in the anterior mandible: a case report series

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Abstract The shrinkage of free gingival grafts (FGGs) is a well-known clinical phenomenon but there are limited studies demonstrating the dimensional changes during healing in FGGs. The aim of the study is to examine the shrinkage of FGG in both horizontal and vertical dimensions and calculate the changes in the surface area of the graft at early and delayed periods of healing. The FGG procedure was applied to 15 consecutive patients in their mandibular anterior area. The graft sizes and areas were measured and the shrinkage of the graft was calculated at baseline and days 10, 21 and 180. Hemorrhage, sense alteration and pain symptoms were also examined. Change in the horizontal direction was not statistically significant during the whole study period ($p>0.05$). However, there was a statistically significant reduction in the vertical direction in all visits, except day 10 ($p<0.05$). Calculated graft area was also significantly reduced during the study period at all time-points compared to the baseline ($p<0.001$). At day 10, 4 (26.7%) recipient sites and 5 (33%) donor sites demonstrated paresthesia. Only one (0.07%) recipient site demonstrated paresthesia at day 21 where the donor site resulted with an uneventful healing. At day 10, 5 (33%) patients demonstrated bleeding at their donor regions and resulted with a complete cessation of bleeding at day 21. Pain symptom was found in 8 (53.3%) recipient sites where 3 (20%) donor regions presented pain symptom at day 10. Graft shrinkage in the vertical dimension seems to affect the clinical outcomes of the FGG procedure. However, the influence of horizontal graft shrinkage was minimal.

Keywords Free gingival graft · Graft dimension · Mucogingival surgery · Shrinkage

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Introduction

Although several studies showed that the absence of keratinized gingiva may not disturb the healthy maintenance of the periodontium [15, 16, 48, 49], there are clinical situations in which mucogingival therapy should be considered since a thin gingiva might be less protective in the presence of inflammation and gingival recession [31]. Orthodontic treatment, inadequate plaque control, high frenulum attachment and shallow vestibular depths can be counted as the possible causes of mucogingival problems [2, 10, 20, 21, 41]. Since it was described by Björn [4] in 1963, the free gingival graft (FGG) procedure was widely utilized for the mentioned purposes in periodontal surgery. Its predictability was marked in several clinical studies, which demonstrated newly created keratinized tissue stability of up to 4 years [13, 15, 16, 18].

The healing of the graft primarily depends on the restoration of collateral circulation from the periosteal and connective tissue bed. A thin blood clot promotes tensile strength and stability of the wound. Aside from wound stability, wound contraction is also a contributing factor for healing events affecting the treatment outcome [5]. Healing of a transplanted tissue is dependent on the development of a new blood supply between donor and recipient sites [30].

The vascularization of thin grafts seems to be faster than thick ones [24, 32, 42]. Circulation in the superficial capillaries of the soft tissue grafts occur approximately 24 h after the surgical operation and presented an increase after 4 to 5 days where the circulation was completed within 8 to 10 days [29]. The functional resistance of a healed graft is considered as an important factor after a successful FGG procedure. Although the relationship of graft thickness with functional resistance is a controversy, increased resistance was attributed to thick gingival grafts [6, 31, 39, 42]. Several authors have suggested a graft thickness of 1.5 to 2 mm as a functionally optimal size [22, 43]. However, deep wounds at the donor site may be created while receiving a transplant tissue from the palatal donor site. This donor region may be a source of arterial injury [25, 47]. In addition, an unaesthetic bulky tissue profile may also occur at the recipient site [23, 40]. While a graft thickness of 0.9 mm is functionally sufficient on a periosteal bed, thickness of 1.0 to 1.5 mm was reported as optimal dimensions of the transplanted tissue [28]. On the other hand, very thin grafts (0.5 to 0.6 mm thickness) demonstrate a better color blending with that of the neighboring tissues [25]. As a matter of fact, graft thickness should be considered as an important criteria and should be controlled carefully. The thickness of the surrounding gingiva may show great intra-individual and interindividual variables, which is associated with type and shape, and is certainly also genetically determined [37]. Based on the thickness and width of facial gingiva, different periodontal phenotypes were described as either thick (flat and thick gingiva), normal or thin (scalloped and thin gingiva, especially associated with slender tooth form) [38]. In 1986, Claffey and Shanley [9] demonstrated that individuals with a thin gingival tissue phenotype are slightly more vulnerable to gingival recession than subjects with wide and thick gingival tissues. However, there is not any existing literature demonstrating a relationship between the gingival tissue thickness around the recipient site and the possible dimensional changes that may occur in FGG healing.

After utilization of a FGG, the vestibular depth of the recipient area may be diminished by the contraction of the wound and by the reinsertion of the muscle fibers in postoperative stage [14]. Therefore, dimensional changes including the contraction of the transplanted tissue may occur, especially in long-term follow-up, and as a result, expected treatment outcome including a satisfied amount of new keratinized tissue may not be achieved [14]. The vertical shrinkage of FGG is a well-known clinical phenomenon that occurs mainly during healing in the first postoperative month where 45% to 47% average shrinkages were noticed for thin grafts [17, 19, 35, 47]. Further, 25% shrinkage was reported for approximately 1.0 mm and 12% for those 0.5 to 0.6 mm graft thickness [19, 25, 35]. In other studies, considerable shrinkage was also achieved with thin grafts where 0.9 mm graft thickness demonstrated 25% to 48% shrinkage [34, 40, 42]. A recent study by Orsini et al. [33] investigated the dimensional changes of FGG during 1 year. They also evaluated the aesthetic results at the end of the therapy. Average vertical shrinkages of 10.2%, 28.4%, 37.2% and 43.25% were noticed at 1, 4, 26 and 52 weeks, respectively [33].

Aside from vertical shrinkage, the horizontal dimension is also a very important criteria after mucogingival surgery. To the authors' knowledge, the shrinkage of the FGG in two dimensions, vertical and horizontal, was not previously studied. Therefore, the present clinical trial aimed to examine the shrinkage of FGG in both horizontal and vertical dimensions and calculate the changes in the surface area of the transplanted tissue at early and delayed time-points. Moreover, postoperative patient complaints were also analyzed during follow-up visits.

Materials and methods

Study population

Included in the study were 15 patients, 11 females and 4 males, 18 to 61 years of age with keratinized gingiva ≤1 mm on the facial aspect of the mandibular anterior area (Fig. 1). All patients received the treatment protocol and detailed informed consent was given. Their general health conditions were good, had no known allergies and were non-smokers. After their examination, complete mouth scaling and polishing were performed and oral hygiene instructions were given 4 weeks before the surgery. Tension test (streching of the lower lips) was applied to determine the keratinized tissue width 4 weeks after the initial treatment. The distance between the margin of the gingiva

Fig. 1 Preoperative view of recipient area. Note the lack of keratinized tissue in the anterior mandible region

and the mucogingival junction was measured with a Michigan-O-probe (23/QOW, Hu-Friedy Manufacturing, Chicago, IL, USA) to the nearest 0.5 mm [7, 8].

Patients exhibiting gingival recession were excluded from the study to eliminate a possible affect of the avascular root surface in the dimensions of the transplanted tissue. Included in the study were 2 patients with 3, 11 patients with 4 and 2 patients with 5 teeth lengths of keratinized gingiva ≤1 mm in the horizontal dimension. Patients were asked if they had hemorrhage experience at the postsurgical period. Sense alteration and pain symptoms were also examined around the recipient and donor regions at postoperative visits of 10, 21 and 180 days.

Sensibility disorders were assessed by the same Michigan-O-probe using a 4-point discrimination scale (coronal, apical, mesial, distal) around the donor and recipient areas at the baseline, 10, 21 and 180 days after the surgical procedure [12]. A modification of the method used by Del Pizzo et al. was performed where patients were asked to identify if they had sensibility or not at the abovementioned areas [12]. Moreover, an identical assessment was made in the corresponding contralateral area to collect the most reliable data possible. Objective sense alteration was recorded using a rubbing movement and a pin-pressure nociception [12]. Hemorrhage experience was considered to be prolonged haemorrhaging from the recipient and donor sites during the postsurgical period reported by the patient. Similiar to the sensibility mesurement, pain symptoms were also evaluated as the existance of pain examined during the baseline and postoperative follow-up period due to the wounds existing in the recipient and donor regions [12].

Surgical procedure

A local anesthetic (Ultracain D-S forte, Hoechst Roussel, Frankfurt, Germany) was administered to the donor and recipient sites to achieve anesthesia. At the recipient site, a marginal horizontal linear incision was made in the mucogingival junction with a number 15 scalpel (Hu-Friedy Manufacturing, Chicago, IL, USA). Split-thickness incision was extended distally one to two teeth further than the planned graft area [30] and deepened to the adequate depth, which would not cause movement of the transplanted tissue. The horizontal dimension of the recipient site was determined according to the area demonstrating mucogingival stress. As a consequence of the present study, the horizontal dimension of the recipient site ranged between three to five teeth in the horizontal direction (Fig. 2).

A second surgical site was created on the palate where the location of greater palatine neurovascular bundle was detected [36]. A rectangular graft, 1 mm smaller than the recipient site in the mesial, distal and apical regions (to avoid the mobilization of the transplanted tissue), was intended to be harvested from the donor region at the bicuspid area by a partial thickness incision. The size of the graft was measured in vertical and horizontal directions using a Michigan-O-periodontal probe. The thickness of the FGG was assessed by the same periodontal probe by inserting the probe perpendicular to the palatal area at the mesioapical, distoapical, mesiocoronal and distocoronal corners of the planned donor region in about 1–2 mm. The number 15 scalpel was used to harvest the tissue with 1–2 mm thickness. The graft was sutured to the recipient region by silk 5-0 sling sutures (PSN1628S, Hu-Friedy Manufacturing, Chicago, IL, USA). Two or three knots of sutures were positioned between the existing intact keratinized gingiva and the transplanted tissue. Mild compress with gauze soaked in saline was also applied for 5 min. Periodontal dressing (Coe-Pak, GC America, Alsip, IL, USA) was applied over the recipient area to protect the surgical region.

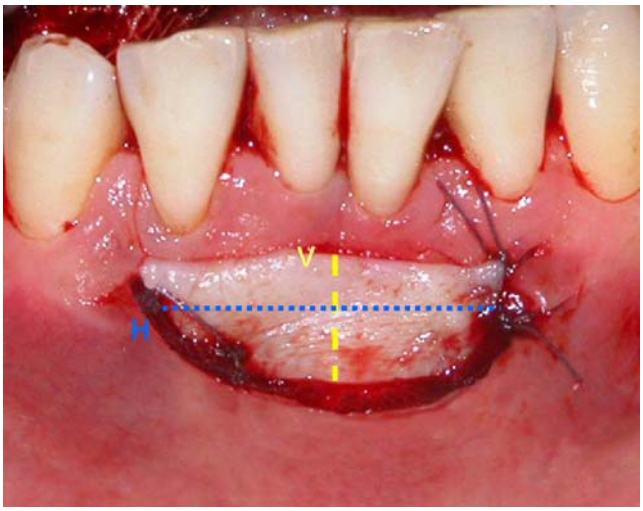

Fig. 2 Transplanted tissue was sutured and vertical and horizontal dimensions were shown (V: vertical, H: horizontal)

Postsurgical care

Patients were prescribed 0.12% chlorhexidine gluconate (G.U.M. Sunstar Butler Chicago, IL, USA) and instructed to rinse gently twice daily for 3 weeks. Toothbrushing activities in the operated sites were discontinued during this time. They were also given antibiotics (amoxicillin, 500 mg, four times daily) for 7 days to prevent a possible postoperative infection [11, 46]. The periodontal dressing and sutures were removed 10 days after the surgery [1, 44, 45]. The same investigator measured the size of the graft in the two dimensions during the follow-up visits at 10, 21 and 180 days (Figs. 3 and 4). The surface area of the transplanted tissue was calculated by multiplying the vertical and horizontal dimensions (Fig. 2). The shrinkage of the

Fig. 3 Postoperative view of the transplanted tissue at day 21

Fig. 4 Postoperative view of the transplanted tissue at day 180. Note the shrinkage of the transplanted tissue

graft and the percentage of the graft area was also calculated according to these formulas:

$$\text{Shrinkage (vertical)} = \frac{\text{Preoperative vertical dimension} - \text{Postoperative vertical dimension}}{\text{Preoperative vertical dimension}} \times 100$$

$$\text{Shrinkage (horizontal)} = \frac{\text{Preoperative horizontal dimension} - \text{Postoperative horizontal dimension}}{\text{Preoperative horizontal dimension}} \times 100$$

$$\text{Shrinkage (graftarea)} = \frac{\text{Preoperative area} - \text{Postoperative area}}{\text{Preoperative area}} \times 100$$

Statistical analysis

A computer program (GraphPad Instat 3.00 for Windows, GraphPad Software, San Diego, CA, USA) was used for all statistical analysis. The Wilcoxon matched-pairs signed-ranks test was performed for the comparison of dimensional changes during the study period.

Results

Fifteen patients (11 females and 4 males, aged 18 to 61 years) were consecutively treated with FGG. All patients healed without complication. The size of the graft in both horizontal and vertical directions was recorded at baseline, 10, 21 and 180 days. The statistical analysis for the dimensional changes between baseline and follow-up period are presented in Table 1. When the dimensional changes of the graft were analyzed, a trend of decrease in the horizontal dimension was observed. However, this trend was not statistically significant during the whole study period ($p>0.05$). Further, there was a statistically significant reduction in the vertical dimension at all time-points, except day 10 ($p<0.05$). The calculated graft area was also decreased during the follow-up period compared to the baseline and this decrease was statistically significant ($p<0.001$, Table 1).

Table 1 The mean values and SDs of the transplanted tissue in horizontal and vertical dimensions including graft areas

	Baseline	Day 10	Day 21	Day 180
Horizontal (mm)	11.74±1.83	11.26±1.58	11.00±1.69	10.40±1.35
Vertical (mm)	6.80±1.42	5.67±1.03	5.40±0.97*	5.00±1.00*
Graft area (mm^2)	80.53±27.76	63.76±13.84**	59.33±14.00**	52.13±12.65**

*$p<0.05$: compared to baseline
**$p<0.001$: compared to baseline

Table 2 Horizontal and vertical graft dimensions of each patient

Patient	Baseline (mm)		Day 10 (mm)		Day 21 (mm)		Day 180 (mm)		Tissue biotype
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	
1	11	7	11	6	11	6	11	5	Normal
2	11	7	10	6	10	6	10	6	Thick
3	12	7	11	6	11	5	9	5	Normal
4	12	6	12	4.5	11	4.5	8	4	Thin
5	11	8	11	7	11	6	11	6	Normal
6	11	6	10	5	10	5	10	5	Normal
7	11	8	11	7	11	7	11	7	Thick
8	16	5	16	5	16	5	13	4	Normal
9	11	6	11	6	11	6	11	6	Normal
10	16	11	13	7	12	7	11	5	Thin
11	12	6	12	5	12	4	12	4	Thin
12	11	6	10	4	8	4	8	4	Thin
13	10	7	10	7	10	6	10	6	Thick
14	11	6	11	4.5	11	4.5	11	4	Thin
15	10	6	10	5	10	5	10	4	Thin

Tissue biotype of each area is also given

Moreover, the horizontal and vertical dimensional changes with the tissue biotypes of each patient are given in Table 2. Almost all of the participants demonstrated graft shrinkage, especially in the vertical dimension.

None of the subjects presented clinical paresthesia, bleeding and pain complications at 180 days follow-up. However, during the healing period, 26.7% of the recipient sites and 0.33% of the donor sites demonstrated paresthesia (Table 3). Recipient paresthesia decreased to 0.07% at day 21, while the donor site resulted with an uneventful healing. Bleeding at the donor region was observed at 0.33% of the patients at day 10 and resulted with a complete cessation of bleeding at day 21. Pain symptom was found in 53.3% of the recipient sites, while the donor regions presented 20% of pain symptom at day 10 (Table 3).

Table 3 Evaluation of paresthesia, bleeding and pain features during the whole study period

Days		Recipient sites	Percent	Donor sites	Percent
Baseline	Paresthesia	0	0	0	0
	Bleeding	0	0	0	0
	Pain	0	0	0	0
10	Paresthesia	4	26.7	5	0.33
	Bleeding	0	0	5	0.33
	Pain	8	53.3	3	20
21	Paresthesia	1	0.07	0	0
	Bleeding	0	0	0	0
	Pain	0	0	0	0
180	Paresthesia	0	0	0	0
	Bleeding	0	0	0	0
	Pain	0	0	0	0

Discussion

Since the aim of the present surgical procedure was to augment the gingival tissue and transport the mucogingival line apically, the results of the present clinical investigation demonstrated significant shrinkage of the FGG despite the evident amount of gingival augmentation comparable with other studies. Mörmann et al. [30] evaluated the dimensional changes for FGGs and they reported a mean vertical graft shrinkage of 42.3% for a period of 12 months. Orsini et al. [33] evaluated the vertical dimensional changes of FGGs in prosthetically treated patients at 1, 4, 26 and 52 weeks of follow-up and the mean shrinkage of the graft size was 10.2%, 28.4%, 37.2% and 43.25% for the mentioned time-points. Similarly, 15.8%, 19.7% and 24.8% contractions were noticed in the present case series at days 10, 21 and 180, respectively. Further, horizontal graft size was also measured in our study population, and an increased amount of horizontal shrinkage [(3.6% (day 10), 5.8% (day 21) and 10.2% (day 180)] was found during the follow-up visits. On the other hand, mean graft shrinkage increased by 18.5%, 23.8% and 32.1% at 10, 21 days and 180 days, respectively where shrinkage was most evident in the vertical dimension.

The shrinkage of FGGs is a well-known clinical phenomenon that occurs during wound healing in the first postoperative month [19, 35]. Different clinical studies presented a broad range of shrinkage percentages between 12% and 48% [17, 19, 25, 35, 40, 42]. It was suggested that shrinkage occurs during first year after surgery and the width of the keratinized tissue remains stable thereafter [19, 33, 35]. In the present study, 10 out of 15 patients did

not show any dimensional changes in 10 days. However, the number of patients demonstrating measurable contraction was gradually increased during the follow-up period. No shrinkage was observed in 9 patients at 21 days follow-up and in 8 patients at 180 days period in the horizontal and vertical dimensions. The results of present trial have demonstrated different dimensional changes in the individual level. When the tissue biotype of the recipient region was considered, thin biotypes seem to have a higher tendency of graft shrinkage.

In addition, tissue thickness might be related to the dimensional changes both in the horizontal and vertical directions. Three different tissue biotypes were described (thick, normal, thin) and in their clinical investigation, Claffey and Shanley [9] noticed the increased tendency of thin gingival tissue to gingival recession than the thick tissue biotype. In this present case series, FGGs demonstrating more shrinkage seemed to involve the thin tissue biotype at the recipient region (Table 2). As a speculation, thin tissues may be attributed as one of the reasons of graft shrinkage. However, more controlled clinical studies are needed for evidence.

In the present cases, extreme care was taken to select the patients with inadequate keratinized gingiva on the facial aspect of the mandibular anterior area. Thereby, different local factors, such as the characteristics of the surgical site and different amounts of gingiva, which may affect the dimensional changes of the soft tissue grafts were minimalized as much as possible. Although creeping attachment after the FGG procedure was reported by several clinicians, creeping of the gingival tissue was apparently best observed on teeth with narrow recessions [3, 26, 27]. However, in the present clinical trial, the participants providing gingival recessions were excluded from the study. We aimed to focus on the dimensional changes related to the shrinkage of the transplanted tissue.

Histologically, it is suggested that palatal epithelium, lamina propria and a thin layer of submucosa should participate in the thickness of the graft. Hence, 1–2 mm optimal graft thickness is often recommended. Besides the influence of graft thickness during wound healing, thicker grafts may be difficult to adapt over the recipient site, the risk of hemorrhage may rise and inappropriate aesthetic results may be acquired [30]. In the present trial, care was taken not to exceed beyond 2 mm of thickness and postoperative patient complaints seemed to be minimal.

Furthermore, patients were asked if they had hemorrhage experience at the postsurgical period. Sense alterations and pain symptoms were also examined around the recipient and donor regions [12]. None of the patients demonstrated clinical paresthesia, bleeding and pain complications at 180 days follow-up. However, during the healing period, 0.33% of the donor sites and 26.7% of the recipient sites presented with paresthesia. Although recipient paresthesia decreased to 0.07% at day 21, the donor site resulted with an uneventful healing. Bleeding at the donor site occurred at 0.33% of the patients at day 10 and completely disappeared at day 21. 53.3% of the recipient sites demonstrated pain symptom, while the donor regions presented 20% at day 10. FGG is a double-sided procedure leaving a wound of considerable size in both recipient and donor regions that heal by secondary intention. Postoperative discomfort seems as an inevitable situation because of bleeding and pain symptoms in the recipient and donor regions. Expression of sense alterations in five patients at early periods of healing was a surprising determination because paresthesia is not a frequent finding in the FGG procedure. However, all the complaints were reversible and recovered in recent following appointments.

The presence of a wide band of keratinized gingiva was known to provide better plaque control, which leads to a possible significant improvement of the periodontal attachment apparatus [7]. The FGG procedure is a favorable alternative to obtain satisfying amounts of keratinized tissue. The surgical procedure is technique-sensitive and attention to the details involved in the execution of the surgery is crucial to achieve a successful and satisfying outcome.

The preliminary results of 15 consecutively treated patients were demonstrated in the present trial where the dimensional changes for a period of 180 days were evaluated. Moreover, the results of the present case series are not sufficiently conclusive; graft shrinkage occurs in the vertical and horizontal dimensions that results with a significant shrinkage for a period of 180 days. Further comparative clinical studies are needed to understand the amount of shrinkage using different surgical techniques.

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