Autogenous soft tissue grafting is a commonly performed procedure in periodontal and implant surgery. Reharvesting a connective tissue graft (CTG) from the same palatal donor site is often required, but little is known about the volumetric changes that occur after harvesting a free gingival graft and how long the palatal mucosa takes to regain its original form and thickness. This study evaluated the volumetric changes that occur at the palatal donor site after harvesting a soft tissue graft with a noninvasive digital technology. Nineteen patients needing a CTG for a single site were enrolled. Intraoral digital scans of the palatal donor sites were obtained at baseline and at 1, 3, 6, and 12 months. The digital scans were imported and analyzed with an imaging software to evaluate volumetric changes. Average volume losses of 5.82 ± 2.63 mm³ and 11.03 ± 5.47 mm³ were observed after 1 and 3 months, respectively. Only minor changes were observed at 6 and 12 months. Linear dimensional changes at 5 and 7 mm from the gingival margin were substantially higher than the changes at 3 mm for the 1- and 3-month interval comparisons compared to baseline. Graft dimension was associated with volume loss at 1 and 3 months (P < .01). After palatal harvesting, the donor site undergoes volumetric changes, mostly during the first 3 months, and is attenuated thereafter. Int J Periodontics Restorative Dent 2022;42:393–399. doi: 10.11607/prd.5268

Three-Dimensional Volumetric Analysis of the Palatal Donor Site Following Soft Tissue Harvesting

Lorenzo Tavelli, DDS, MS1/Shayan Barootchi, DMD, MS2 Rafael Siqueira, DDS, MS, PhD3/Frederic Kauffmann, DMD4 Jad Majzoub, BDS2/Martina Stefanini, DDS, PhD5 Giovanni Zucchelli, DDS, PhD5 Hom-Lay Wang, DDS, MS, PhD2

Soft tissue volumetric changes after periodontal and implant surgeries have progressively become an outcome of great interest.1–3 Over the years, several techniques have been used to evaluate soft tissue thickness, from transgingival probing with the use of an injection needle or periodontal probe under local anesthesia,4,5 to more recent approaches that improve accuracy and reproducibility, such as the use of an endodontic silicon stop fixated with cyanoacrylate.6,7 Nevertheless, the need for a standardized stent, the possibility of bending the needle or endodontic instrument, and patient discomfort are major limitations of transgingival probing for assessing soft tissue thickness.8 Ultrasonography and optical scanners have been proposed as noninvasive technologies for assessing soft tissue volume.9–12 In particular, optical scanners can obtain digital impressions of dental arches or specific areas of interest, with 3D digital images formatted as STL (standard tessellation language) files.13 The accuracy and reproducibility of this technology in evaluating volumetric differences were demonstrated by Windisch et al.12 Therefore, it is not surprising that these optical scanners have been widely used in the last decade for evaluating volumetric changes in a variety of clinical scenarios.11,14,15 Nonetheless, the focus of these 3D

1Department of Oral Medicine, Infection, and Immunity, Division of Periodontology, Harvard School of Dental Medicine, Boston, Massachusetts, USA.
2Department of Periodontics & Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan, USA.
3Department of Periodontics, Virginia Commonwealth University School of Dentistry, Richmond, Virginia, USA.
4Department of Oral and Craniomaxillofacial Surgery, Center for Dental Medicine, University Medical Center Freiburg, Freiburg, Germany.
5Department of Biomedical and Neuromotor Sciences, University of Bologna, Bologna, Italy.

Correspondence to: Dr Hom-Lay Wang, Department of Periodontics & Oral Medicine, University of Michigan School of Dentistry. 1011 North University Ave, Ann Arbor, MI 48109-1078, USA. Email: homlay@umich.edu

volumetric analyses has mostly been toward the grafted site, and there are no studies evaluating volumetric changes at the palatal donor site following soft tissue harvesting. This aspect is crucial, as soft tissue grafting procedures are nowadays routinely performed in periodontal and peri-implant plastic surgery, and reharvesting a connective tissue graft (CTG) from the same area is often required.

Therefore, using a noninvasive 3D digital technology, the present study aims to evaluate the volumetric changes that occur at the palatal donor site after soft tissue harvesting.

Materials and Methods

The current article abides by the stated criteria in the Preferred Reporting of Case Series in Surgery (http://www.processguideline.com/). The protocol was approved by the University of Michigan Medical School Institutional Review Board (HUM00140205) and is in accordance with the Declaration of Helsinki of 1975, revised in Tokyo in 2004. Informed consent was obtained from all subjects who participated in the study. Nineteen systemically healthy patients requiring a soft tissue graft for a single site following soft tissue harvesting.

Clinical pictures were also used to identify the region of interest (ROI) (Fig 2). The observed volumetric outcomes included: mean volumetric (Vol) changes, the mean distance between the surfaces (difference in mean thickness of the reconstructed volume; DD), and linear dimensional changes (LD) at points 3, 5, and 7 mm apical to the gingival margin of the maxillary premolars. Patient age, sex, and graft dimensions (width, height, and thickness) were also recorded. The primary outcome of the present study was to observe the postharvesting dimensional changes of the donor areas at different follow-up times by assessing Vol and DD. The secondary outcome was to evaluate LD along with patient- and surgical-related factors that could influence the volumetric outcomes (such as sex, age, and graft dimension).

An intraoral optical scanner (TRIOS, 3Shape) was used to obtain digital models as STL files at baseline (prior to harvesting) and at 1, 3, 6, and 12 months. The STL files were imported into a digital imaging software (GOM Inspect, GOM) to assess volume changes at the donor site over time. A calibrated examiner (S.B.) performed all digital volumetric analyses. The intraoperator reliability was measured on 10 random patients and revealed a satisfactory score of consistent prior measurement of cases (intrarelatability assessment score of 0.84). The STL files at baseline and follow-up visits were superimposed and matched using the best-fit algorithm (Fig 1). Stable anatomical landmarks (teeth and the contralateral palate) were used to perform the superimposition of the models to guarantee maximum accuracy of the digital analysis. Clinical pictures were also used to evaluate the postharvesting changes of the donor areas at different follow-up times by assessing Vol and DD. The secondary outcome was to evaluate LD along with patient- and surgical-related factors that could influence the volumetric outcomes (such as sex, age, and graft dimension).

Descriptive statistics were used to present the clinical data as means ± SDs. The observed Vol changes were obtained relative to baseline—which convey the changes from before graft harvesting to 1, 3, 6, and 12 months—and are presented in cubic millimeters. Similarly, DD and LD were computed as changes relative to baseline and presented in millimeters. The graft dimension was calculated by multiplying the graft length, width, and thickness to obtain the volume (in cubic millimeters) and to test its correlation with Vol changes throughout time, as well as sex and patient age. Statistical testing was
done using analysis of variance and regression models accordingly, and a P value threshold of .05 was set for significance. The analyses were conducted in Rstudio (version 1.1.383, Rstudio).

**Results**

Nineteen systemically healthy patients (14 women, 5 men; mean age: 55.5 ± 15.8 years) were included. The mean palatal thickness at baseline was 3.22 ± 0.48 mm, while the harvested soft tissue grafts were an average of 11.7 ± 1.5 mm wide, 7 ± 1.7 mm in height, and 1.6 ± 0.3 mm thick (average volume: 118.9 ± 42.5 mm³). The mean deviation of
The digital model superimposition was 0.046 ± 0.021 mm, and the mean ROI area was 41.45 ± 9.17 mm², with almost no changes when calculated for different time points. At 1 month, a mean Vol change of –5.82 ± 2.63 mm³ was observed relative to baseline, while at 3 months it was –11.03 ± 5.47 mm³. DD was approximately 0 mm at both 6 and 12 months. LD changes at points 5 mm and 7 mm apical to the gingival margin were greater than LD changes at 3 mm for the 1-month and 3-month time points compared with baseline. Volumetric outcomes at 1, 3, 6, and 12 months are reported in Table 1. Figure 4 illustrates a profilometric assessment of LD change.

Table 1 Volumetric Changes of the Palatal Mucosa at 1, 3, 6, and 12 Months

<table>
<thead>
<tr>
<th>Volumetric outcome</th>
<th>BL – 1 mo</th>
<th>BL – 3 mo</th>
<th>BL – 6 mo</th>
<th>BL – 12 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vol change, mm³</td>
<td>–5.82 ± 2.63</td>
<td>–11.03 ± 5.47</td>
<td>–0.34 ± 2.36</td>
</tr>
<tr>
<td></td>
<td>∆D change, mm</td>
<td>–0.35 ± 0.13</td>
<td>–0.62 ± 0.23</td>
<td>–0.02 ± 0.08</td>
</tr>
<tr>
<td>Max D, mm</td>
<td>0.2 ± 0.09</td>
<td>0.19 ± 0.14</td>
<td>0.26 ± 0.12</td>
<td>0.24 ± 0.06</td>
</tr>
<tr>
<td>Min D, mm</td>
<td>–0.63 ± 0.23</td>
<td>–0.89 ± 0.38</td>
<td>–0.25 ± 0.15</td>
<td>–0.17 ± 0.09</td>
</tr>
<tr>
<td>LD change, mm</td>
<td>At 3 mm</td>
<td>–0.09 ± 0.07</td>
<td>–0.14 ± 0.2</td>
<td>0 ± 0.08</td>
</tr>
<tr>
<td></td>
<td>At 5 mm</td>
<td>–0.22 ± 0.08</td>
<td>–0.49 ± 0.2</td>
<td>–0.03 ± 0.04</td>
</tr>
<tr>
<td></td>
<td>At 7 mm</td>
<td>–0.17 ± 0.2</td>
<td>–0.3 ± 0.3</td>
<td>–0.01 ± 0.07</td>
</tr>
</tbody>
</table>

BL = baseline; Vol change = volumetric change; ∆D = the mean distance between the surfaces/mean thickness of the reconstructed volume; Max D = maximum distance between the surfaces; Min D = minimum distance between the surfaces; LD change = linear dimensional change. Values are presented as mean ± SD. *Statistically significant change (P < .05) relative to baseline.

Discussion

CTG is commonly used for natural dentition and at implant sites, and the need for soft tissue graft reharvesting from the same donor area is not rare. However, little is known about the healing of the palatal donor site in terms of (1) volumetric changes that occur thereafter and (2) the suggested time before harvesting another graft from the same area. Soileau and Brannon collected specimens from the palate of patients undergoing more than one
Fig 4 Profilometric representation of linear dimensional change over time, comparing baseline measurements to those at (a to c) 1 month, (d to f) 3 months, (g to i) 6 months, and (j to l) 12 months. Each row includes a clinical view from that time point (first image); the profilometric analysis, with the blue curves indicating baseline volume and the red curves indicating the follow-up volume (middle image); and the linear dimensional changes between baseline and the respective follow-up (last image).
harvesting procedure (parallel single-incision technique) at different intervals.\textsuperscript{20} They observed that soft tissue maturation was significantly better after 63 days compared to 48- and 54-day specimens in terms of complete reepithelialization and composition of the lamina propria.\textsuperscript{20} However, it is reasonable to assume that the healing pattern is different after harvesting an epithelialized gingival graft. The present clinical study showed that there is a certain amount of volume loss during the first 3 months after harvesting, and that the palatal donor site regains its presurgical volume by the 6- and 12-month follow-ups. Therefore, harvesting an epithelialized gingival graft from the same donor area before 3 months of healing may not be recommended. Soileau and Brannon, based on histologic analyses obtained from eight patients, reported that intervals less than 9 weeks between each harvesting procedure from the same area may result in poorer graft quality.\textsuperscript{20} Results from the present volumetric analyses, however, indicate that a longer healing time might be required for the palatal donor site to regain its preharvesting volume. Indeed, these differences may be due to the methodologic differences and varying sample sizes between the present study and Soileau and Brannon’s report\textsuperscript{20} (19 patients vs 8 patients, respectively), as well as differences in the soft tissue graft harvesting technique (subepithelial connective tissue graft vs epithelialized gingival graft in the present study).

An excisional wound in the palate heals by secondary intention, with epithelial cells migrating from the periphery towards the central part of the defect.\textsuperscript{30} Therefore, it is not surprising that the observed volumetric changes were greater at the 5-mm and 7-mm reference points than at the 3-mm reference point, which was closer to the coronal horizontal incision. A recent animal study showed that palatal wound healing progressed from the most anterior and posterior wound borders, with the central part of the wound being the region that shows the slowest resolution of the inflammatory reaction.\textsuperscript{30} Additionally, that study found a significant increase in the number of myofibroblasts in the central part of the wound during the third postoperative week.\textsuperscript{30} These healing dynamics may explain the present results, in which a greater volumetric change was observed at 5 mm and 7 mm apical to the gingival margin compared to 3 mm. It can be speculated that the central region of the harvested area requires more time for inflammation resolution and myofibroblast migration, resulting in a higher volume loss at earlier time points compared with regions closer to the original incisions. The present findings suggest that the palatal donor site may need 3 to 6 months to regain its original volume, even though additional volumetric changes may occur within 1 year. Reharvesting in the same area 3 months or sooner may result in an immature graft\textsuperscript{20} and may pose additional challenges during the harvesting procedure due to the reduced palatal thickness.

Conclusions

After a free gingival graft harvesting procedure, the tissues at the donor site undergo a dynamic process of volumetric changes and healing. These volumetric changes occur mostly up to 3 months postoperative and then reduce substantially at 6 and 12 months. The volumetric dimension of the harvested area (and thus the graft) significantly correlate with the resulting volumetric changes at 1 and 3 months.

Acknowledgments

This study was self-supported. The authors declare no conflicts of interest.
References


