Three-Dimensional Volumetric Analysis of Multiple Gingival Recession Defects Treated by the Vestibular Incision Subperiosteal Tunnel Access (VISTA) Procedure

Alfonso Gil, DDS, MS1
Neema Bakhshalian, DDS, MS, PhD2
Seiko Min, DDS, PhD3
José Nart, DDS, PhD4
Homayoun H. Zadeh, DDS, PhD5

This study sought to evaluate gingival volume changes following root coverage with the vestibular incision subperiosteal tunnel access (VISTA) procedure. Pre- and postoperative surface scans of 21 patients (154 teeth) treated with VISTA using various graft materials were digitally superimposed to quantify volumetric changes. A linear gingival thickness gain of approximately 1 mm and volumetric gain of 5.47 mm³ were achieved. A negative correlation was found between linear thickness gain and root prominence. The thickness achieved was not different with various graft materials. Since gingival thickness has been identified as an important predictor of periodontal root coverage, the methodology described in the present study, along with the identification of predictors of outcome, has important therapeutic implications. Int J Periodontics Restorative Dent 2019;39:687–695. doi: 10.11607/prd.4313

Treatment of gingival recession defects has commonly been assessed with periodontal probes to measure linear changes in the gingival margin or through sounding to measure changes in mucosal thickness, but these methods have considerable limitations.1 Digital technologies have been utilized for three-dimensional (3D) analysis of root coverage procedures,2,3 providing unprecedented opportunities.

3D digital analysis allows for the comparison of gingival surface contour and thickness changes. The importance of gingival thickness has been described with a plethora of studies in numerous periodontal applications.4–6 Specifically, flap thickness has been shown to be a predictor for root coverage in mucogingival therapy.7,8 This association with root coverage has been thoroughly investigated,9 but the assessment of periodontal biotype changes and volume gain after the use of graft materials is lacking.

Gingival recession represents denudation of periodontal tissues overlaying the roots.10 Since soft tissue loss occurs in three dimensions, it is necessary to study the loss three-dimensionally. This remains an under-investigated area of periodontal research. Hence, the present study sought to utilize 3D analysis to evaluate volumetric and linear changes in gingival thickness.
following treatment of multiple recession-type defects by the vestibular incision subperiosteal tunnel access (VISTA) root coverage procedure, in combination with various graft materials.

Materials and Methods
Characteristics of Study Participants and Study Outcomes

The Institutional Review Board of the University of Southern California approved the protocol for this retrospective pilot study. All patients were treated in a private practice by a single periodontist (H.H.Z.) as part of their routine periodontal care. The study population consisted of 21 patients with a total of 154 teeth with multiple recession-type defects (Table 1). The inclusion criteria for this study were patients between 18 to 75 years of age, multiple recession type I (RT I) or II (RT II)11 defects on at least two adjacent teeth, identifiable cemento enamel junction or restorative margin, and clear pre- and postoperative study casts. Exclusion criteria were heavy smoking (more than 10 cigarettes a day), recession type III (RT III) defects, and history of mucogingival surgeries in the area. The clinical outcomes including root coverage have been reported in another publication.2 The recession defects were treated by the VISTA technique (Fig 1) as previously described.12 Briefly, a vertical incision of approximately 10 mm was made in the vestibule in an area strategically located to provide access to the sites targeted for therapy. Odontoplasty was performed on roots that were outside of the gingival housing. A subperiosteal tunnel was elevated through the vestibular access to release and mobilize the mucoperiosteal complex from the vestibular fornix to the gingival margins, extending to the interdental tissues. The mobilized tissues were coronally advanced and anchored in the most coronal location with the aid of mattress monofilament sutures (6.0 polypropylene with a C3 needle) that were bonded to the coronal aspects of each tooth with flowable composite (Fig 1). The sutures and bonding were kept for 3 weeks before removal. The graft material used included

![Table 1 Clinical Characteristics of Included Subjects and Teeth](image)

<table>
<thead>
<tr>
<th>Patients</th>
<th>Gender</th>
<th>Male (n = 8)</th>
<th>Female (n = 13)</th>
<th>Total (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (y)</td>
<td>50.5 ± 13.4</td>
<td>53.6 ± 6.5</td>
<td>52.4 ± 9.5</td>
<td></td>
</tr>
<tr>
<td>Mean follow-up (mo)</td>
<td>14.0 ± 3.7</td>
<td>15.0 ± 5.1</td>
<td>14.6 ± 4.6</td>
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<tr>
<td>Mean number of recessions/patient</td>
<td>5.6 ± 2.4</td>
<td>8.4 ± 5.9</td>
<td>7.3 ± 5.0</td>
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</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Anatomic location</th>
<th>Maxilla (n = 73)</th>
<th>Mandible (n = 81)</th>
<th>Total (N = 154)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooth type</td>
<td>I: 11</td>
<td>I: 13</td>
<td>I: 24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: 19</td>
<td>C: 15</td>
<td>C: 34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P: 29</td>
<td>P: 35</td>
<td>P: 64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M: 14</td>
<td>M: 18</td>
<td>M: 32</td>
<td></td>
</tr>
<tr>
<td>Graft type</td>
<td>AP: 16</td>
<td>AP: 11</td>
<td>AP: 27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AT: 31</td>
<td>AT: 32</td>
<td>AT: 63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADM: 21</td>
<td>ADM: 21</td>
<td>ADM: 42</td>
<td></td>
</tr>
<tr>
<td></td>
<td>XCM: 3</td>
<td>XCM: 18</td>
<td>XCM: 21</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recession type</th>
<th>RT Class I (n =100)</th>
<th>II (n = 54)</th>
<th>Total (N = 154)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean initial recession depth (mm)</td>
<td>2.1 ± 0.8</td>
<td>2.5 ± 1.0</td>
<td>2.2 ± 0.9</td>
</tr>
<tr>
<td>Mean root prominence (mm)</td>
<td>0.6 ± 0.5</td>
<td>1.2 ± 0.6</td>
<td>0.8 ± 0.6</td>
</tr>
<tr>
<td>Volume gain (mm³)</td>
<td>5.15 ± 3.42</td>
<td>6.05 ± 6.53</td>
<td>5.47 ± 4.75</td>
</tr>
</tbody>
</table>

I = incisors; C = canines; P = premolars; M = molars; AP = autogenous palate; AT = autogenous tuberosity; ADM = acellular dermal matrix; XCM = xenogeneic collagen matrix.

The primary outcome variables were volumetric, as well as linear gingival thickness changes at different locations (1, 2, 3, 4, and 5 mm) from the postoperative gingival margin. The clinical and/or anatomical parameters assessed in the study were initial recession depth, initial gingival thickness, types of recession (RT I vs II), tooth type (incisor, canine, premolar, or molar), graft type (autogenous connective tissue graft from the palate or tuberosity; allograft [acellular dermal matrix]; or xenograft [xenogeneic collagen matrix]), root prominence, and anatomical location in the arch (maxilla vs mandible).
connective tissue graft from the lateral portion of the palate, connective tissue graft from the tuberosity, acellular dermal matrix, or xenogenic native collagen matrix. The rationale for the selection of graft material was based on a number of factors including: (1) presence and thickness of the preoperative zone of keratinized gingiva, (2) esthetic demands, (3) number of teeth with treated recession defects, (4) availability and suitability of donor tissue, (5) root prominences, (6) clinician preference, and (7) patient preference.

**Digital Image Analysis**

Baseline alginate impressions were taken preoperatively within 3 months prior to surgery. Postoperative impressions were taken during the final evaluation, which was more than 12 months postoperatively. Impressions were poured in dental stone. The pre- and postoperative study models were scanned with an optical surface scanner (3Shape D850, Ivoclar Vivadent) and saved in stereolithographic (STL) format. The surface scans were subjected to digital analysis performed by a single examiner (A.G.). The STL files were imported into a reverse-engineering software (Geomagic Control) for digital analysis (Fig 2). The pre- and postoperative surface scans were superimposed using automatic and manual tools to calculate changes in gingival thickness and volume following surgical intervention. Changes in gingival volume were quantified by measuring the volume of tissue overlying the previously denuded root surface, expressed in mm³. The changes in
gingival thickness (mm) were calculated in two dimensions in midsections of the tooth at 1, 2, 3, 4, and 5 mm relative to the postoperative gingival margin (Fig 3). Root prominence was quantified on the preoperative study models, as described in a previous publication. Briefly, the distance between the midfacial prominence point of the root to the line connecting both gingival margins was calculated and recorded as “root prominence.” The initial gingival margin thickness was measured at the zenith point of the gingival margin. To calculate initial recession depth (mm), the preoperative study model with existing recession was measured vertically at the deepest point of the recession.

Statistical Analysis

Descriptive statistics (ie, mean and standard deviation) were calculated for all variables measured. In recognition of the nature of the data, which included multiple sites within individual patients, a multilevel analysis was conducted, adjusting for the correlation among multiple observations. To that end,
Table 2  Mean Gains in Gingival Thickness

<table>
<thead>
<tr>
<th>Distance from postoperative gingival margin</th>
<th>Thickness gain (mm)</th>
</tr>
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<tbody>
<tr>
<td>1 mm</td>
<td>1.06 ± 0.30</td>
</tr>
<tr>
<td>2 mm</td>
<td>1.06 ± 0.36</td>
</tr>
<tr>
<td>3 mm</td>
<td>0.91 ± 0.30</td>
</tr>
<tr>
<td>4 mm</td>
<td>0.86 ± 0.30</td>
</tr>
<tr>
<td>5 mm</td>
<td>0.83 ± 0.33</td>
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</table>

Fig 3  Representative pre- and postoperative 3D digital images of a tooth treated with the VISTA root coverage procedure. Facial views of (a) preoperative and (b) postoperative 3D images, which were superimposed. (c) An orthogonal slice taken in the midfacial region. The landmarks used for making linear measurements included the postoperative gingival margin and 1, 2, 3, 4, and 5 mm apical to it, which postoperatively coincides with the cementoenamel junction due to complete root coverage.

Fig 4  Linear and volumetric gingival thickness gains. (a) Linear thickness gain at 1, 2, 3, 4, and 5 mm from the final gingival margin. (b) Linear thickness gain in the maxilla and mandible. (c) Volumetric thickness gain of all (RT I and RT II) defect types.

Results

Clinical Characteristics of Patients

The clinical characteristics of the study patients and the treated teeth are shown in Table 1. The data from 21 patients with multiple recession-type defects treated were included in the present study (8 males, 13 females). A total of 154 teeth (100 RT I defects, 54 RT II defects) in these patients were treated by VISTA surgical technique. A mean of 7.3 ± 5.0 teeth with recession defects were treated per patient with a mean follow-up of 14.6 ± 4.5 months.

Quantitative Digital Analysis

The mean linear gingival thickness gain values were 1.06 ± 0.30 mm, 1.06 ± 0.36 mm, 0.91 ± 0.30 mm, 0.86 ± 0.30 mm, and 0.83 ± 0.33 mm at 1, 2, 3, 4, and 5 mm relative to the postoperative gingival margin, respectively (Fig 4a and Table 2). The gingival thickness gain at 1 mm was a stringent nonparametric regression analysis was run, using the methods of Brunner and Langer. All analyses were carried out using SAS version 9.3.
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higher than at 3-mm \( (P < .0001) \), 4-mm \( (P < .0001) \), and 5-mm levels \( (P < .0001) \); the gain at 2 mm was higher than at 3-mm \( (P < .0001) \), 4-mm \( (P < .0001) \), and 5-mm levels \( (P < .0001) \).

Recession defects located in the mandible showed significantly less linear thickness gain at 1-mm and 2-mm positions than those in the maxilla \( (P = .01) \) (Fig 4b). On the other hand, total volume gained over the denuded roots of maxillary and mandibular teeth were not significantly different \( (P = .73) \).

The mean volume gain among all treated sites was \( 5.47 \pm 4.75 \text{ mm}^3 \), and the mean volume gain among sites with RT I and RT II defects were \( 5.15 \pm 3.42 \text{ mm}^3 \) and \( 6.05 \pm 6.53 \text{ mm}^3 \), respectively (Fig 4c). The intergroup differences were not statistically significant \( (P = .24) \). The initial root prominence exhibited a significant negative correlation \( (R^2 = -.18) \) with linear thickness gain \( (P = .02) \), when the gains achieved at 2-, 3-, 4-, and 5-mm levels were combined (Fig 5). Initial root prominence and volume gain did not show a significant correlation \( (P = .71) \) (data not shown).

The results revealed a statistically significant positive correlation between initial recession depth and volume gain \( (P < .0001) \)—essentially, the deeper the recession, the more volume gain was obtained (data not shown). A significant positive correlation was also observed between initial recession depth and thickness gain at the five different locations measured \( (P < .05) \). Deeper recessions showed more thickness gain.

Thickness gains achieved using various graft materials are shown in Fig 6. The thickness gain at 1 mm from the final gingival margin was \( 0.92 \pm 0.25 \text{ mm} \) for the palatal graft, \( 1.14 \pm 0.34 \text{ mm} \) for the tuberosity graft, \( 1.03 \pm 0.32 \text{ mm} \) for the acellular dermal matrix (ADM), and \( 1.11 \pm 0.17 \text{ mm} \) for the xenogeneic collagen matrix (XCM); at 2 mm depth was \( 0.99 \pm 0.24 \text{ mm} \) for the palatal graft, \( 1.18 \pm 0.41 \text{ mm} \) for the tuberosity graft, \( 0.95 \pm 0.39 \text{ mm} \) for the

\[\text{Scatter plot illustrating the correlations between root prominence and gingival thickness gain. The correlation between linear thickness gain and pre-operative root prominence is } R^2 = -0.18.\]

\[\text{Gingival thickness gain at 1, 2, 3, 4, and 5 mm relative to the postoperative gingival margin, achieved by using various graft materials. No statistically significant differences were found.}\]
be clinically assessed. Some studies have successfully used 3D digital analysis to examine changes in alveolar bone and mucosa following tooth extraction\(^{14-16}\) and buccal deficiencies around implants.\(^{17}\) On the other hand, studies using digital 3D analysis of soft tissue augmentation on teeth are scarce.\(^{2,3,18}\) The present data showed that the gain in gingival volume achieved by soft tissue augmentation around sites with RT I and RT II defects was not significantly different. This is an important observation, because it can potentially influence decision-making for the treatment of RT II cases. It is commonly considered that root coverage therapy is not predictable in RT II and RT III cases, and as such, some clinicians do not attempt root coverage therapy for those cases. The observation that the gingival thickness volume gain in RT I and RT II cases was not different suggests that soft tissue augmentation may be equally efficacious in both defect types. Moreover, a statistically significant positive correlation between initial recession depth and volume gain was observed, implying that greater volume gain was achieved in deeper recession sites. This is contrary to a previous observation that the efficacy of root coverage declines with increasing recession depth, particularly in sites with greater than 4 mm of recession.\(^{19}\)

Increasing gingival thickness has been shown to be an important factor, with multiple studies correlating flap thickness to root coverage.\(^{7,20}\) Gingival thickness gains measured in the present study ranged from 0.8 to 1 mm. This compares favorably to previous studies, such as the study by Woodyard et al.\(^{21}\) where coronal advancement did not lead to measurable thickness change, but coronal advancement plus acellular dermal matrix yielded a thickness gain of 0.4 mm. In addition, the greater coronal thickness gain can be explained by the fact that the grafts were always sutured at the most coronal locations of the tunnel.

Root convexity is a site-related factor that may influence the clinical outcome of root coverage procedures.\(^{22}\) However, the scientific data supporting this consideration are scarce due to the difficulty in its assessment. The part of the root outside of the gingival housing can be considered root prominence,\(^{23}\) and the negative correlation between root prominence and root coverage was recently reported.\(^{2}\) The results of the present study have demonstrated a negative correlation between root prominence and linear thickness gain. This may be an important risk assessment consideration prior to root coverage therapy. Although odontoplasty was performed on all sites treated in this study, root prominence remained negatively correlated with gingival thickness gain. It is important for future studies to quantify the degree of odontoplasty performed in order to determine whether it can reduce the negative influences of root prominence.

Four different types of graft material were used in the study. Autogenous grafts from different donor sites may have different characteristics and different clinical indications.\(^{24}\) The clinical decision of
where to harvest depends on the availability of tissue and surgeon preference and is hardly based on written evidence. Soft tissue substitutes (allogenic or xenogenic) have been employed to reduce patient morbidity and have shown promising results.25 Nevertheless, their added clinical value for soft tissue augmentation needs further investigation.26 Systematic reviews27,28 consider the subepithelial connective tissue graft to be the gold standard for root coverage procedures since it has shown the most stability in gingival thickness.29 The results of the present study showed a clinical, non–statistically significant trend towards greater thickness gain with the use of a tuberosity connective tissue graft. This tissue has been described to be dense, with more collagen and less adipose and glandular tissue, and may therefore undergo less shrinkage.24 It has been reported that maxillary multiple-recession defects treated with connective tissue grafts in combination with a coronally advanced flap yielded significantly greater improvements of recession depth than similar mandibular defects.30 When maxillary and mandibular sites were compared in the present study, maxillary recessions showed greater thickness gain at the most coronal depths. The muscle pull and the decreased thickness of the gingiva in the anterior mandible could negatively affect the outcome of mucogingival surgery.

The present investigation had a number of limitations. Due to the lack of control group as a result of the retrospective nature of the study, it is not possible to determine whether the thickness gain is unique to VISTA or can be achieved with other treatment methods. Additionally, analysis of surface-scanned images only revealed thickness changes rather than true mucosal thicknesses. The findings of the present study warrant a prospective randomized controlled clinical trial to address the aforementioned limitations and corroborate these findings.

Conclusions

3D analysis provides a useful method for evaluating the outcome of periodontal plastic surgery. This analysis showed gingival thickness and volumetric gain achieved with VISTA in combination with different graft materials for root coverage. Certain site-specific factors, particularly root prominence, exhibited a negative correlation with thickness gain at more apical levels.

Acknowledgments

The authors received no source of funding for this study. Dr Zadeh has patents related to the technique described in this study and financial interest in Regenimmune, Inc, which is a company engaged in commercialization of surgical instrumentation for performing the VISTA procedure. The remaining authors declare no conflicts of interest.

References


