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The aim of this case series report is to compare the results of the increase in keratinized mucosa using three different techniques of stage-two surgery. Thirty-two patients with one to eight dental implants who received prosthetic rehabilitation of the maxilla were included. Patients were divided into three groups based on preoperative anatomical considerations. Stage-two surgery was performed using either the apically repositioned flap (ARF; n = 14), the roll flap (RF; n = 10), or an apically repositioned flap combined with a connective tissue graft (ARFCT; n = 8). The height of the keratinized mucosa and relative tissue thickness were measured preoperatively and postoperatively at 2 weeks and 3, 6, and 12 months after surgery. The mean gains of keratinized mucosa and tissue thickness were calculated from these measurements. After 1 year, the mean gains in tissue thickness and keratinized tissue were 1.37 and 4.63 mm in the ARF group, 2.41 and 1.35 mm in the RF group, and 3.10 and 4.10 mm in the ARFCT group, respectively. There was no significant statistical difference between the 12-month and postoperative measurements (P > .05). In patients with deficient tissue thickness, a roll flap or an apically repositioned flap should be performed, while a lack of keratinized mucosa indicates the use of an apically repositioned flap with or without a connective tissue graft. When an increase in both keratinized mucosa and tissue thickness is necessary, an apically repositioned flap combined with a free connective tissue graft can be recommended. After a 12-month healing period, the obtained results showed excellent stability. (Int J Periodontics Restorative Dent 2013;33;411–418. doi: 10.11607/prd.0616)

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considered crucial for maintaining peri-implant health. However, tissue vulnerability and resistance have been shown to depend on the epithelial barrier cells regardless of the presence or absence of keratinization. Because of the absence of perpendicular fibers between implants and the surrounding mucosa, the absence of attached and keratinized mucosa might jeopardize adequate plaque control and therefore enhance inflammatory peri-implant diseases. Though some animal studies have shown that the absence of keratinized mucosa around dental implants increases tissue susceptibility to plaque-induced tissue destruction, cross-sectional and longitudinal clinical trials have failed to support the hypothesis that lacking keratinized tissue is related to peri-implant health. As long as controversy regarding the necessity for fixed mucosa around dental implants continues, and it should be kept in mind that at least one to four surgical interventions are necessary during implant treatment, the surgical procedures should include techniques that allow keratinized tissue growth to overcome any problem that might arise from its absence, ie, overt signs of inflammation, difficulty in cleaning the crestal implant area, and tendency for peri-implant disease.

Tooth loss often leads to alveolar bone loss and a consecutive reduction of the alveolar process width. Since a lack of tissue thickness might persist if the implant is placed without or after augmentative procedures, it must be corrected during stage-two surgery to avoid esthetic as well as functional problems, ie, food beneath the suprastructure with consecutive inflammatory reactions. Several methods have been described to correct anatomical deficiencies during stage-two surgery, including apically repositioned flaps, pedicle flaps, connective tissue grafts, and free gingival grafts. Most of these techniques have been published either as case reports or small case series. The authors’ knowledge, no clinical studies have been performed to evaluate the outcome of these procedures regarding the gain of tissue thickness and height of keratinized mucosa, while the absence/presence of the interdental papilla has been studied previously. Hence, the aim of this case series report is to evaluate the outcome of three basic procedures of stage-two surgery: the apically repositioned flap (ARF), the roll flap (RF), and the apically repositioned flap combined with a connective tissue graft (ARFC). Focus was placed on the 12-month stability of tissue thickness gain of the alveolar contour and the height of the keratinized mucosa.

**Method and materials**

Thirty-two systemically healthy patients that were referred to a private clinic for implant rehabilitation with one to eight implants (Xive, Dentsply Friadent) were chosen for this study. They were divided into three groups for stage-two surgery based on preoperative anatomical considerations (Table 1). The criteria used to assign the patients to the different treatment groups were the height of the keratinized mucosa, which should exceed 3 mm after surgery, and tissue thickness deficiency of the neighboring width of the alveolar crest. Stage-two surgery was performed using either an RF (n = 10), ARF (n = 14), or ARFC (n = 8). Surgical procedures were performed as follows.

Patients rinsed with 10 mL chlorhexidine varnish for 1 minute preoperatively. The surgical field was anesthetized with articaine containing epinephrine 1:100,000 (Ultracain DS forte, Novartis). All three surgical techniques have been described to correct anatomical deficiencies during stage-two surgery, including apically repositioned flaps, pedicle flaps, connective tissue grafts, and free gingival grafts. Most of these techniques have been published either as case reports or small case series. To the authors’ knowledge, no clinical studies have been performed to evaluate the outcome of these procedures regarding the gain of tissue thickness and height of keratinized mucosa, while the absence/presence of the interdental papilla has been studied previously. Hence, the aim of this case series report is to evaluate the outcome of three basic procedures of stage-two surgery: the apically repositioned flap (ARF), the roll flap (RF), and the apically repositioned flap combined with a connective tissue graft (ARFC). Focus was placed on the 12-month stability of tissue thickness gain of the alveolar contour and the height of the keratinized mucosa.

**Table 1** Demographic variables for each treatment group

<table>
<thead>
<tr>
<th></th>
<th>ARF (n = 14)</th>
<th>RF (n = 10)</th>
<th>ARFC (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>9</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Men</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td><strong>No. of implants</strong></td>
<td>36</td>
<td>23</td>
<td>19</td>
</tr>
</tbody>
</table>

**Table 1** Demographic variables for each treatment group

ARF = apically repositioned flap; RF = roll flap; ARFC = apically repositioned flap combined with a connective tissue graft.
Patients were prescribed ibuprofen (400 mg) to use if necessary for postoperative pain control and 0.2% chlorhexidine three times daily for infection control until suture removal.

The ARF was performed according to the method of Vence (Figs 1a to 1c). The initial incision ran 5 to 10 mm palatally from the ridge of the crest. Two vertical releasing incisions were necessary and performed in a parallel manner. A partial-thickness flap was prepared toward the vestibule and had to pass the mucogingival junction, which enabled the flap to be apically repositioned. The flap was sutured to the abutment screws, the lateral mucosa, and the buccal periosteum.

The RF was performed according to Israelson and Plemons’ modification of Abrams (Figs 2a to 2c). The palatal horizontal incision was performed at the oral border of the implant without dissecting the periosteum. Releasing incisions ran either sulcularly or paramarginally at the interproximal border of the implant. An internal bevel was prepared from the horizontal incision to mobilize the connective tissue. The periosteum was dissected apically and laterally, and a full-thickness flap was raised to the buccal end of the alveolar crest, at which the periosteum was dissected and a partial-thickness flap was prepared buccally. The connective tissue pouch was sutured to the buccal flap, and the buccal and lingual flaps were sutured close to the implant.

The ARFCT was carried out as described by Khoury and Tunkel (Figs 3a to 3d). The graft was harvested on the same side of the palate using the horizontal incision of the flap as access or it was grafted from the other side of the palate or the tuberosity. The recipient bed was prepared as described. The graft was sutured to the mesial and distal aspect and then covered by the repositioned flap. Special healing abutments with holes (Loop healing abutments, Dentsply Friadent) were used to facilitate suturing of the flap in the correct coronal position.

Preoperatively, an impression was taken and an acrylic resin splint was fabricated to allow vertical and horizontal measurement of the mucosa of the alveolar crest prior to stage-two surgery. The splint was fabricated using a spacer in the area of interest to allow it to be placed.
in the arch even after prosthetic rehabilitation of the measured implants (Fig 4). The splint was fixed on the remaining untreated teeth or on the hard palate. Measurements were performed using a standard periodontal probe (PCP-UNC 15, Hu-Friedy) and were rounded to the nearest millimeter. All surgeries were performed by the authors. Measurements were performed by either the first or second author (whomever had not performed the surgical intervention). Repeated measurements at different time points were taken by the same examiner to guarantee reproducibility. For this reason, interexaminer variability was not controlled. If more than one implant was discovered with the same flap design in a patient during stage-two surgery, all implants were measured and a mean difference was calculated per patient so that the patient was the statistical unit.

**Statistical analysis**

The distributions of the mean gain in keratinized mucosa ($\Delta KM$) and tissue thickness ($\Delta V$) measured postoperatively were examined and found to be fairly symmetric. Means and standard deviations were calculated separately by time point and treatment arm. Changes from baseline (surgery) to the 12-month follow-up in the observed values ($\Delta KM$ and $\Delta V$) were formally compared using linear regression models, with standard errors estimated using robust methods to account for clustering of implants by patient. F test statistics were calculated to assess whether these temporal changes varied with treatment. The F test is used to assess the equality of the means of several normally distributed populations, all having the same variance. The Student t test is used to assess the equality of the means of two normal populations with unknown but equal variances. Both were used because of reported comparisons between the three populations (the three treatment groups) as well as two other populations (tissue at baseline and at 12 months). Of note is that these tests, when used with two populations, are equivalent: When the F test is used to compare two groups, its square root is the t test.

**Figs 3a to 3c** Apically repositioned flap combined with connective tissue graft in the anterior maxilla.

**Fig 3d** Clinical situation 14 days and 12 months after surgery and prosthetic rehabilitation.

**Fig 4** Prefabricated splint with space for different prosthetic restorations used as a reference point for repeated measurements.
Results

The mean age of subjects was 43.2 years (range, 23 to 65 years), with no significant differences between the three groups. Twenty women and 12 men participated in the study. Altogether, 78 implants were placed in the maxilla. All implants placed were Xive, and their lengths varied between 11 and 15 mm and diameters between 3.4 and 4.5 mm. No implants failed during or after stage-two surgery over the 12-month follow-up period. All 32 patients completed the study and were examined at the scheduled measurement time points.

Height of keratinized mucosa

In the ARF group, ∆KM immediately after stage-two surgery and at suture removal was 5.15 and 4.65 mm, respectively. The values after 3, 6, and 12 months were 4.51, 4.70, and 4.63 mm, respectively. In the ARFCT group, ∆KM was 5.00, 5.12, 4.48, 4.33, and 4.10 mm at the same time points, respectively. The RF group showed smaller mean gain values: 2.18, 1.90, 1.36, 1.43, and 1.35 mm, respectively (Fig 5). Mean changes from postoperative status to 12 months were significantly different for all three groups, although they did not vary throughout treatment (P = .37; Tables 2 and 3).

Gain in tissue thickness

In the ARF group, ∆V immediately after finishing the surgical procedure was 1.46 mm. At suture removal, the mean value was 1.43 mm, and at the different follow-up examinations at 3, 6, and 12 months, it was 1.37, 1.34, and 1.37 mm, respectively. The two other treatment groups showed greater ∆V, with the RF group reaching mean values of 2.86, 2.97, 2.41, 2.41, and 2.41 mm at the different examination time points, respectively. The ARFCT group showed an even

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Table 2 Comparison of ∆KM postoperatively and at 12 months

<table>
<thead>
<tr>
<th>Difference</th>
<th>95% confidence interval</th>
<th>P*</th>
</tr>
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<tbody>
<tr>
<td>ARF</td>
<td>0.52</td>
<td>–0.51 to 1.55</td>
</tr>
<tr>
<td>RF</td>
<td>0.83</td>
<td>–0.18 to 1.83</td>
</tr>
<tr>
<td>ARFCT</td>
<td>0.90</td>
<td>–0.40 to 2.19</td>
</tr>
</tbody>
</table>

∆KM = mean gain in keratinized mucosa.  
* t test based on treatment-specific differences.

Table 3 Intergroup comparison of ∆KM at 12 months

<table>
<thead>
<tr>
<th>Difference</th>
<th>95% confidence interval</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF vs ARF</td>
<td>–3.27</td>
<td>–4.38 to –2.17</td>
</tr>
<tr>
<td>ARFCT vs ARF</td>
<td>–0.52</td>
<td>–1.83 to 0.78</td>
</tr>
<tr>
<td>ARFCT vs RF</td>
<td>2.75</td>
<td>1.33 to 4.17</td>
</tr>
</tbody>
</table>

∆KM = mean gain in keratinized mucosa.  
* F test, P < .001; analysis of variance; t test based on the linear regression model.
greater ∆V of 3.31, 3.69, 3.15, 3.10, and 3.10 mm, respectively. The changes between the measurements taken at the time of surgery and at the 12-month postoperative visit were statistically significant for ARF and ARFTC but not for RF (Table 4). The differences between treatments were statistically significant \( (P < .001; \text{Table 5}) \). The graphic comparison of the three groups over the 12-month range in terms of changes from baseline confirms these differences (Fig 6).

### Discussion

This clinical study was designed to explore the clinical outcomes and the 12-month stability of three different methods of stage-two surgery: the ARF, RF, and ARFTC. All of these techniques were described years ago, but to the authors’ knowledge, no clinical trials have been performed comparing their outcomes and stability.

All implants placed during this clinical trial were inserted according to the accepted anatomical requirements. Bone augmentations in the form of autologous block grafts and sinus floor elevations were performed before or during implant placement where necessary. Hence, correct three-dimensional positioning of the implant was possible and controlled by splints fabricated according to the prosthetic demands of the patient’s situation. Nevertheless, before stage-two surgery, the patients enrolled in this study required surgical correction of the soft tissue volume, showed a lack of keratinized mucosa, or a combination of both. For this reason, the surgical procedures performed were not randomized but based on preoperative anatomical considerations.

The results of this study emphasize that the surgical procedures performed did in fact confirm the expected outcome: a gain of keratinized mucosa with the ARF procedure, a gain of tissue thickness with the RF, and a combination of both with the ARFTC. Hence, the procedures can be chosen by preoperative anatomical considerations. Of

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**Table 4** Comparison of ∆V postoperatively and at 12 months

<table>
<thead>
<tr>
<th></th>
<th>Difference</th>
<th>95% confidence interval</th>
<th>( P^* )</th>
</tr>
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<tbody>
<tr>
<td>ARF</td>
<td>0.08</td>
<td>−0.54 to 0.71</td>
<td>.79</td>
</tr>
<tr>
<td>RF</td>
<td>0.45</td>
<td>−0.56 to 1.46</td>
<td>.37</td>
</tr>
<tr>
<td>ARFTC</td>
<td>0.21</td>
<td>−0.71 to 1.12</td>
<td>.63</td>
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</tbody>
</table>

\( ∆V = \) mean gain in tissue thickness. *t test based on treatment-specific differences.

**Table 5** Intergroup comparison of ∆V at 12 months

<table>
<thead>
<tr>
<th></th>
<th>Difference</th>
<th>95% confidence interval</th>
<th>( P^* )</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF vs ARF</td>
<td>1.04</td>
<td>0.23 to 1.85</td>
<td>.010</td>
</tr>
<tr>
<td>ARFTC vs ARF</td>
<td>1.73</td>
<td>0.78 to 2.69</td>
<td>.001</td>
</tr>
<tr>
<td>ARFTC vs RF</td>
<td>0.69</td>
<td>−0.35 to 1.74</td>
<td>.190</td>
</tr>
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</table>

\( ∆V = \) mean gain in tissue thickness. *F test, \( P < .001; \) analysis of variance; \( t \) test based on the linear regression model.

**Fig 6** Intergroup comparison of ∆V postoperatively, at 14 days, and at 3, 6, and 12 months after surgery by treatment group.
great interest was the question of whether the obtained soft tissue results would remain stable over 1 year of follow-up. A 12-month follow-up had initially been chosen as the first cutoff point since data from other periodontal surgical soft tissue procedures, eg, crown lengthening or root coverage, have shown stable results at least 1 year after surgery.33-35 It must be kept in mind, however, that soft tissue shrinkage may increase during the second year of follow-up.36 A study concerning the outcome of surgical soft tissue management procedures would not be useful if lasting longer than 5 years, since biologic complications (eg, peri-implantitis) impairing the soft tissue profile of an implant restoration would mask true relapse. These complications increase between the sixth and the ninth year after implant insertion.37-39

All three surgical procedures performed in this study showed perfect stability after a 12-month healing period. Between suture removal and the 3-month visit, a loss was recorded, especially with the ARFCT procedure. Tissue thickness was more susceptible to shrinkage most likely because of postoperative edema. After that time point, the soft tissue remained perfectly stable for the 1-year follow-up. Therefore, prosthetic procedures in an esthetically demanding situation should be delayed for 3 months after stage-two surgery.

Conclusions

This study showed that it is possible to gain tissue thickness or keratinized mucosa during stage-two surgery by use of the AFR, RF, and ARFCT. The results demonstrate that in cases of missing tissue thickness, an RF or ARF should be performed, while a lack of keratinized mucosa requires the ARF with or without a connective tissue graft. When an increase in keratinized mucosa as well as tissue thickness is necessary, an ARFCT can be recommended. After a healing period of approximately 3 months, the obtained results remained stable over the observation period of 1 year.

Acknowledgment

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