The Modified Apically Repositioned Flap Technique and Its Potential to Create Attached Gingiva in Areas with No Keratinized Tissue: A Long-Term (1 to 11 Years) Retrospective Case Series Study

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The modified apically repositioned flap (MARF) technique has been previously published as a successful method to increase the zone of attached gingiva with numerous advantages, such as simplicity, predictability, and long-term stability. However, this technique has only been used in areas with at least 0.5 mm of attached gingiva, presurgically. In the current study, the MARF technique was utilized in 21 sites (teeth) with no attached gingiva and only mucosa comprising the marginal tissue. The long-term follow-up results over the course of 1 to 11 years (average follow-up: 3.2 years) show a statistically significant increase of 3.6 ± 0.8 mm for keratinized tissue and of 2.21 ± 0.83 mm for attached gingiva, and no increases in probing depths or marginal tissue recession. These results indicate that the MARF procedure has generated keratinized tissue and attached gingiva in areas with a presurgical absence of these tissues. Int J Periodontics Restorative Dent 2020;40:103–109. doi: 10.11607/prd.4241

Attached gingiva is a desirable anatomical feature for the maintenance of gingival health. It aids in increasing resistance to external injury, contributes to the stabilization of the marginal gingiva, and protects teeth against physiologic and frictional forces due to its thick network of collagen fibers that attach to the tooth and/or underlying bone. In addition, it has been proposed that the presence of at least 2 mm of keratinized tissue, with a minimum of 1 mm of attached gingiva, is necessary to maintain adequate gingival health.

The most commonly accepted surgical techniques to treat sites with an absence of attached keratinized tissue are the epithelialized free gingival graft (FGG), and the connective tissue graft. The FGG is a predictable technique to develop attached/keratinized gingiva in sites with an absence of it at baseline; however, it requires a palatal donor site, has poor matching color, and is associated with comorbidities. Despite the connective tissue graft having the ability to increase the amount of attached gingiva with more esthetic results, it has similar downsides, including the requirement of a palatal donor site and potential patient comorbidities.

In 2015, the AAP Regeneration Workshop recognized the modified apically repositioned flap (MARF) as a promising, non-root coverage...
procedure. The MARF technique is a surgical procedure designed to increase the apico-coronal dimension of attached gingiva with minimal trauma: It does not require a palatal donor site, it generates minimal postoperative discomfort, and it produces better color-match predictability.

Although one of the prerequisites to qualify for MARF is the presence of at least 0.5 mm of preexisting attached gingiva at baseline, a recent publication on the technique clinically and histologically demonstrated the ability of this method to generate keratinized tissue and attached gingiva in sites with no presurgical keratinized tissue.

The objective of this case series is to report on the effectiveness of the MARF procedure when used to increase the amount of attached gingiva in sites with an absence of marginal keratinized tissue and to analyze its long-term results as well as effects on marginal tissue recession and probing depth.

### Materials and Methods

Sixteen systemically healthy patients (13 females and 3 males; mean age: 47.37 years; range: 30 to 64 years) were included in this retrospective study, with follow-up periods ranging from 4 months to 11 years. All patients were nonsmokers who presented with an absence of keratinized and attached tissue in at least one tooth. A total of 16 surgical sites and 21 teeth (mean: 1.166 teeth/surgical site) were treated with the MARF technique. The treatment areas included one to two adjacent teeth. The demographic information of the patients and the characteristics of the treated sites are presented in Table 1.

Recession was recorded as the distance from the cementoenamel junction to the tissue margin. Clinical detection of the bone crest’s position was conducted by bone sounding immediately before the surgery under local anesthesia. If the marginal bone crest was determined to be > 2.0 mm apical to the bottom of the pocket, the patient was excluded from receiving the MARF procedure to minimize the risk of increased marginal tissue recession.

### Table 1 Demographics of Patients and Sites Treated with the MARF Procedure

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Entire study</th>
<th>&lt; 3 y</th>
<th>≥ 3 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, N</td>
<td>16</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Average age, y</td>
<td>47.37</td>
<td>46.85</td>
<td>47.77</td>
</tr>
<tr>
<td>Average follow-up, y</td>
<td>3.22</td>
<td>0.9</td>
<td>5</td>
</tr>
<tr>
<td>Total treated teeth, n</td>
<td>21</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Average teeth per site, n</td>
<td>1.166</td>
<td>1.1</td>
<td>1.25</td>
</tr>
</tbody>
</table>

MARF = modified apically repositioned flap.
Surgical Technique

Local anesthesia was administered. A horizontal internal beveled incision was made approximately 2.0 mm apical to the tissue margin with the blade making contact with the periosteum at a point slightly apical to the alveolar crest. The mesiodistal extension of the initial horizontal incision was determined by the number of teeth involved in the procedure and should be extended by at least one-half tooth in the mesial and the distal directions. The marginal tissue coronal to the initial incision should remain intact around the teeth (Figs 1 and 2). A split-thickness flap was elevated, and the dissection was extended 5 mm in the apical direction. At the end of the surgical procedure, an inspection of the exposed periosteal area revealed a thin, homogeneous layer of periosteum with no elastic or muscular fibers. The flap was then moved apically, and a moist gauze was used to apply gentle pressure for 2 to 5 minutes to keep the flap in close contact with the underlying periosteum.16 Cyanoacrylate glue was applied to secure the flap in position, using sutures when necessary (Figs 1 and 2). A noneugenol periodontal dressing was used on top to protect the wound.

Postoperative medications prescribed to all patients included 0.12% chlorhexidine rinses, twice a day for 4 weeks, and ibuprofen, 600 mg four times a day or as needed. The sutures and periodontal dressing were removed 1 week after surgery. The patient was instructed to refrain from mechanical oral hygiene care at the

Fig 1 Case illustration of the MARF technique in the right mandible. (a) Baseline. The first and second premolars were referred to increase the apico-coronal dimension of the attached gingiva. (b) Baseline. A roll technique with a periodontal probe was used to identify the movable mucosa in the marginal tissue's composition. (c) A horizontal baseline incision was made in the nonkeratinized area 2 mm apical to the marginal tissue. Note that the collar of mucosa was left in its original position. (d) Healing at 1 year. Iodine was used to dye the mucogingival line.

Fig 2 Case illustration of the MARF technique in the right mandible. (a) Baseline. Patient presented with lack of keratinized tissue and attached gingiva on the second premolar. The tooth will serve as a support for the full crown. Note that the frenum was exerting traction in the tissue margin. (b) A horizontal baseline incision was made from the first premolar to the first molar, leaving a marginal collar of mucosa at the buccal site of the second premolar. A sharp dissection was then made, leaving a thin and homogeneous layer of periosteum. (c) Two years later, a new band of keratinized tissue was present in the area, and (d) the marginal tissue in the buccal area of the second premolar was comprised of 4 mm of keratinized tissue and 3 mm of attached gingiva.
surgical site during the first 4 postoperative weeks. However, professional debridement was performed once a week during this period. Mechanical oral hygiene, performed by the patient, was resumed at 5 weeks after surgery.

All surgical sites healed uneventfully. There were no infections or adverse reactions reported by any patient.

Data Analyses

Baseline and final measurements of each parameter were averaged (mean ± standard error of the mean). Statistical analysis was performed utilizing paired Student t test for comparisons between initial and final measurements. A second analysis was performed by separating the patients into two different groups based on the duration of the follow-up: < 3 years or ≥ 3 years. Student t test was also used for comparisons between the treatment results achieved in the two different groups. P ≤ .05 was considered statistically significant.

Results

Sixteen patients, treated consecutively with MARF surgical procedures, were followed for 4 months to 11 years (average: 3.2 years). The long-term results of the MARF procedure demonstrate a statistically significant increase of the apico-coronal dimension of the keratinized tissue (mean gain: 3.06 mm) and attached gingiva (mean gain: 2.25 mm) when comparing pre- and postoperative measurements. Tissue margins and pocket depths were stable between the two time points (Table 2). There was no statistically significant difference in pocket depth and marginal tissue recession.

Since the length of follow-up for these patients varied substantially (from 4 months to 11 years), the study population was subdivided into patients who had a follow-up of 3 or more years and those with less than 3 years (Table 2).

Three years after the procedure, a biopsy sample was taken from one patient, stained with h&e, and examined under light microscopy. The specimen was composed of stratified squamous epithelium overlying fibrous connective tissue. The epithelium differentiated normally. The connective tissue was dense and regular. The spacing and density amongst the fibroblast were within normal limits (Fig 3).

Discussion

The absence of the marginal keratinized tissue or inadequate presence of attached gingiva increases the susceptibility for marginal tissue recession. The FGG is the most traditional surgical technique used to increase the amount of keratinized and attached gingiva. The main disadvantages of the FGG, when compared with the MARF technique, include the use of the palatal donor area (one additional surgical site); the possibility of more

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>Final</th>
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<tbody>
<tr>
<td>KT, mm</td>
<td></td>
<td></td>
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<tr>
<td>All sites</td>
<td>0 ± 0</td>
<td>3.6 ± 0.8*</td>
</tr>
<tr>
<td>&lt; 3 y</td>
<td>0 ± 0</td>
<td>3.5 ± 0.53*</td>
</tr>
<tr>
<td>≥ 3 y</td>
<td>0 ± 0</td>
<td>3.04 ± 0.93*</td>
</tr>
<tr>
<td>AG, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sites</td>
<td>0 ± 0</td>
<td>2.21 ± 0.83*</td>
</tr>
<tr>
<td>&lt; 3 y</td>
<td>0 ± 0</td>
<td>2.5 ± 0.53*</td>
</tr>
<tr>
<td>≥ 3 y</td>
<td>0 ± 0</td>
<td>1.95 ± 0.96*</td>
</tr>
<tr>
<td>PD, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sites</td>
<td>1.26 ± 0.43</td>
<td>1.04 ± 0.15</td>
</tr>
<tr>
<td>&lt; 3 y</td>
<td>1.45 ± 0.49</td>
<td>1 ± 0</td>
</tr>
<tr>
<td>≥ 3 y</td>
<td>1.09 ± 0.30</td>
<td>1.09 ± 0.20</td>
</tr>
<tr>
<td>MTR, mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sites</td>
<td>1.57 ± 1.43</td>
<td>1.59 ± 1.33</td>
</tr>
<tr>
<td>&lt; 3 y</td>
<td>0.85 ± 1.11</td>
<td>1.05 ± 1.09</td>
</tr>
<tr>
<td>≥ 3 y</td>
<td>2.22 ± 1.36</td>
<td>2.09 ± 1.39</td>
</tr>
</tbody>
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SE = standard error of the mean; KT = keratinized tissue; AG = attached gingiva; PD = pocket depth; MTR = marginal tissue recession.
The < 3-year follow-up group included 10 sites, and the ≥ 3-year follow-up group included 11 sites.
*Statistically significant (P ≤ .0001).
postoperative bleeding; a discrepancy in tissue color between the grafted area compared to the adjacent tissues; and an increase in morbidity. The major advantages of this technique are its predictability and potential to be used in areas of marginal tissue mucosa. However, this study comparison was performed when the MARF technique was used in sites with at least 0.5 mm of attached gingiva, presurgically.

In a previous study, the MARF technique was used in an area with absence of keratinized and attached gingiva. The clinical and histologic results demonstrated a significant increase in the apico-coronal dimension of attached gingiva, presenting histologic characteristics identical to a normal gingiva. Therefore, the objective of this retrospective case series is to report the long-term changes with respect to keratinized tissue, attached gingiva, pocket depth, and gingival recession when the MARF technique is applied to sites with a presurgical absence of marginal keratinized tissue on the midbuccal aspect of the involved tooth. The results demonstrated that the apico-coronal dimension of the keratinized and attached tissue increased significantly compared to baseline. Keratinized tissue increased from 0 mm to 3.6 mm and attached gingiva increased from 0 mm to 2.21 mm. The study also reports no statistically significant differences in pocket depth and marginal tissue recession (Table 2). The follow-up data were divided into patients with 3 or more years of follow-up observation (average: 5 years) and those with less than 3 years (average: 1 year). There were no significant differences in the postoperative results observed between the two groups. These results suggest the long-term stability of the MARF technique, as they did not change over time.

More importantly, this study demonstrates clinically and histologically that the MARF technique is successful in areas with an absence of marginal keratinized tissue, as it has the ability to transform the marginal mucosa into a normal keratinized tissue with long-term stability in the area. A histologic specimen sample taken 3 years after the surgical procedure presented a dense and regular connective tissue with the spacing and density amongst the fibroblasts within normal limits, with the epithelium differentiating normally (Fig 3).

The reason(s) why keratinized/attached tissue developed in a site with no presurgical keratinized or attached tissue remains unclear. Three possible explanations for this phenomenon are suggested:

- A rapidly dividing group of cells grows around a more slowly dividing group. If there
is presence of keratinized tissue in the mesial and/or distal aspects of the wound, these cells could migrate faster than the mucosal cells present in the coronal and apical areas of the wound, therefore developing keratinized tissue over the exposed periosteum. In these cases, the interproximal papilla adjacent to the defect would exert fundamental importance in the keratinization of the area, since it is the closest source of keratinized cells (Fig 2).

- The initial incision made into the mucosa below the soft tissue margin dissipates the tension that was exercised by the muscular fibers of the alveolar mucosa onto the marginal soft tissue margin. This reduction in tension over the granulation tissue covering the exposed periosteum may induce genotypic changes to the epithelial cells that favor immobility and therefore keratinization.

- As a response to the surgical insult, the periodontal ligament may proliferate coronally, which may induce the keratinization of the epithelial cells over it.

It is important to note that in the event that additional gingiva is needed for a specific site, a second procedure could be performed following the first intervention without much inconvenience for the patient (Fig 4).

Conclusions

The MARF technique has demonstrated its efficacy in augmenting the apico-coronal dimension of the keratinized and attached gingiva in areas where the marginal tissue is composed exclusively of mucosa. The results presented herein increase the indications of this technique to areas with no keratinized and attached gingiva, providing a new treatment option to cases that require gingival augmentation.

Acknowledgments

The authors report no conflicts of interest related to this study.
References