The Versatile Modiolus Perforator Flap

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Perforator pedicle flaps are largely replacing the concept of random flaps in our practice, and for the past 8 years, freestyle perforator flaps have been our first choice local flap for facial reconstruction.\(^1\) During this time, we have noticed that the location of some large perforators appears to be consistent and predictable.\(^1,2\) Lateral to the angle of the mouth, corresponding to the modiolus area, is a reliable perforator that we have previously referred to as “the modiolus perforator.”\(^1\) The modiolus is a landmark representing a dermal insertion and decussation of muscles derived from the second branchial arch.\(^3\) Studies have shown that the facial artery is located lateral to the modiolus embedded in a fibrofatty tissue that allows for its mobility.\(^4,5\)

**Background:** Perforator flaps are well established, and their usefulness as freestyle island flaps is recognized. The whereabouts of vascular perforators and classification of perforator flaps in the face are a debated subject, despite several anatomical studies showing similar consistency. In our experience using freestyle facial perforator flaps, we have located areas where perforators are consistently found. This study is focused on a particular perforator lateral to the angle of the mouth; the modiolus and the versatile modiolus perforator flap.

**Methods:** A cohort case series of 14 modiolus perforator flap reconstructions in 14 patients and a color Doppler ultrasonography localization of the modiolus perforator in 10 volunteers.

**Results:** All 14 flaps were successfully used to reconstruct the defects involved, and the location of the perforator was at the level of the modiolus as predicted. The color Doppler ultrasonography study detected a sizeable perforator at the level of the modiolus lateral to the angle of the mouth within a radius of 1 cm. This confirms the anatomical findings of previous authors and indicates that the modiolus perforator is a consistent anatomical finding, and flaps based on it can be recommended for several indications from the reconstruction of defects in the perioral area, cheek and nose.

**Conclusions:** The modiolus is a well-described anatomical area containing a sizeable perforator that is consistently present and readily visualized using color Doppler ultrasonography. We have used the modiolus perforator flap successfully for several indications, and it is our first choice for perioral reconstruction. (Plast Reconstr Surg Glob Open 2016;4:e661; doi: 10.1097/GOX.0000000000000611; Published online 22 March 2016.)

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Doppler ultrasonography (CDU), and review of our findings in the context of the current literature.

MATERIALS AND METHODS
We performed a volunteer study to confirm the location of the modiolus perforator using a CDU on 20 hemifaces and a prospective clinical series using the modiolus perforator as a pedicle for a freestyle perforator flap design.

CDU Volunteer Study
We examined 10 volunteers bilaterally by CDU, 3 men and 7 women aged 26 to 57 (43), using a BK Medical color Doppler ultrasonographer with a 10- to 12-mHz linear transducer. The technique was performed as described above, and the location of the perforator was marked with a permanent marker (red dot). The corresponding CDU screen images are shown next to the clinical image (Fig. 1).

Clinical Study
We reviewed 14 cases, 3 male and 11 female patients aged 6 to 85, reconstructed by an island flap based only on the modiolus perforator lateral to the angle of the mouth. Four patients were smokers. The surgical indications were defects following removal of basal cell carcinoma in 6 cases, malignant melanoma in 4 cases, 2 squamous cell carcinoma, 1 atypical fibroxanthoma, and 1 trichoid epithelioma. The reconstructions were performed on the cheek in 6 cases, upper lip in 5, nose in 2 and lower lip in 1. The operative technique was either freestyle exploration or guided by preoperative CDU localization.

Freestyle Technique
The perforator location was explored through a nasolabial incision in a caudal direction until the perforator was localized. The flap was dissected circumferentially around the perforator enabling a free rotation (Fig. 2 and Video 1) (See Supplemental Digital Content 1, which displays the versatility of the modiolus perforator flap and range of motion. This video is available in the “Related Videos” section of the Full-Text article on PRSGlobalOpen.com or available at http://links.lww.com/PRSGO/A178.) The perforator was not skeletalized in any of the cases. A simple detachment of the surrounding adhesions to the zygomaticus major, risorius, and depressor anguli oris muscles was done to enable flap rotation (Fig. 3).

CDU-guided Technique
The facial artery was identified below the angle of the mouth. The artery was then followed by a very slow movement upward until the modiolus perforator was identified. The location was then marked by a permanent marker. The flap was designed based on the CDU findings and the size of the defect and surgery commenced as described above (Fig. 4).

RESULTS
CDU Volunteer Study
We identified a usable perforator close to the modiolus by CDU bilaterally in 10 subjects, 3 males and 7 females, median age 42 (26–57) years. In the majority of cases, we found that the perforator branched off from the main artery as a single branch; however, in a few cases, it divided into 2 or 3 branches. In most cases, the perforator was curved or even S-shaped as it passed between the muscles. The perforator branching point from the facial artery was marked with a red dot in the figures. Despite the observed perforator branching point variations, it appeared to pass through to the subcutis lateral to the angle of the mouth at the level of the modiolus in all cases.

Clinical Study
We performed 14 perforator flaps based on the modiolus perforator in 14 patients (Table 1). The location of the perforator was at the level of the
modiolus as predicted by the anatomical landmark and CDU. Nine flaps were propeller flaps rotated 90 to 180 degrees and 5 were V-Y flaps. The size of the flaps varied from 8 to 64 cm². The reconstructive goal was achieved in all 14 cases; however, in 3 patients, who were heavy smokers, a revision and further corrective procedures were needed due to distal tip necrosis. The perforator was identified by surgical exploration in 6 cases and guided by CDU in the latter 8 cases.

**DISCUSSION**

The modiolus has been described to be a fibrous chiasma, a condensation of the deep and superficial facial fascia, where the facial muscles join to form insertion at the angle of the mouth. The facial artery runs lateral to it, superficial to the buccal fat pad, in a window marked by the zygomaticus major muscle superiorly and risorius muscle inferiorly. The results of this article show that this window contains a sizeable perforator that is consistently present and can readily be visualized and identified by CDU. We refer to it as the modiolus perforator. The facial artery is kinked in a lazy-S shape in this area, which adds to its mobility during facial expression and mouth opening. This added mobility has been beneficial for the advancement of some of our flaps up to 4 cm especially when used in a V-Y fashion (Fig. 3).

Three anatomical studies describe the facial artery perforators and share findings similar to ours, indicating the consistency of a perforator lateral to the angle of the mouth. Hofer et al described the facial artery perforator flap for the first time in a case...
series of 5 patients in combination with an anatomical study that showed a high density of perforators lateral to the mouth. Ng et al\textsuperscript{8} named it reference point A, inferolateral to the angle of the mouth, and Qasemeyer et al\textsuperscript{9} referred to the perforator lateral to the angle of the mouth. CDU is known to be a good tool for identification of the facial artery; however, localization of the small perforators has until now been deemed unclear or unavailable.\textsuperscript{7–9}

We tested the accuracy of CDU as a tool for identification of the modiolus perforator on a random sample of 10 individuals (20 hemifaces). We were readily able to identify a sizable perforator at the modiolus level bilaterally in all cases (Fig. 1).

The modiolus perforator is a consistent finding and can easily be located by pre- or perioperative CDU or simply by careful exploration just lateral to the fibrous skin attachments of the orbicularis muscle. The modiolus perforator flap is in fact a variation of the well-known nasolabial flap and has a great potential to become a work horse flap for the reconstruction of lip, cheek, and selected nasal defects. The flap can be designed either as a V-Y advancement flap or a propeller flap depending on the location and the size of the defect. It allows for a successful reconstruction of a whole anatomical subunit, replaces like with like, and has a forgiving donor site, which can be closed directly. The localization of the perforator with CDU will most certainly make it more accessible in the near future.

We have successfully used both propeller and advancement modiolus perforator flaps for different indications, and it has become our first choice for perioral reconstruction. This article appears to be the first to recognize the benefits of CDU in the localization of facial artery perforators for a freestyle

**Fig. 3.** A lentigo malignant melanoma defect reconstructed using a large modiolus perforator flap in a V-Y fashion and a smaller perforator flap of the lower eyelid. Intraoperative view showing the perforator and adjacent muscles: immediate postoperative and patient shown 6 weeks postoperative.
flap design, and we postulate that this will positively affect its application in the future.

**CONCLUSIONS**

We have shown that perforators can readily be visualized by the operative plastic surgeon using a modern CDU device and verified the consistency of a significant facial artery perforator lateral to the angle of the mouth, the modiolus perforator. The average diameter of 1 mm provides a reliable vascular basis for an advancement or propeller flap design for various reconstructive purposes in the area.

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**Table 1. Patient Data: The Versatile Modiolus Perforator Flap**

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>Indication</th>
<th>Location</th>
<th>Comorbidity</th>
<th>Flap</th>
<th>Size (cm)</th>
<th>Complication</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67</td>
<td>M</td>
<td>BCC</td>
<td>UL</td>
<td>Smoker</td>
<td>P-180</td>
<td>7 × 5 = 35</td>
<td>1-cm tip necrosis</td>
<td>CS</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>M</td>
<td>BCC</td>
<td>CH</td>
<td>None</td>
<td>P-140</td>
<td>5 × 3 = 15</td>
<td>None</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>71</td>
<td>F</td>
<td>BCC</td>
<td>N</td>
<td>Smoker</td>
<td>P-180</td>
<td>12 × 3 = 36</td>
<td>2-cm tip necrosis</td>
<td>CR</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>F</td>
<td>AFX</td>
<td>CH</td>
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<td>V-Y</td>
<td>7 × 2 = 14</td>
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<td>75</td>
<td>M</td>
<td>SCC</td>
<td>LL</td>
<td>Smoker</td>
<td>P-140</td>
<td>4 × 2 = 8</td>
<td>None</td>
<td>C</td>
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<tr>
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<td>F</td>
<td>BCC</td>
<td>CH</td>
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<td>BCC</td>
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<td>SCC</td>
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<td>V-Y</td>
<td>7 × 4 = 28</td>
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<tr>
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<td>BCC</td>
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<td>UL</td>
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<td>C</td>
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<tr>
<td>11*</td>
<td>57</td>
<td>F</td>
<td>TE</td>
<td>N</td>
<td>Smoker</td>
<td>P-180</td>
<td>11 × 2 = 22</td>
<td>1.5-cm tip partial necrosis</td>
<td>CS</td>
</tr>
<tr>
<td>12*</td>
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<td>MM</td>
<td>CH/N</td>
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<tr>
<td>14</td>
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<td>MM</td>
<td>CH</td>
<td>None</td>
<td>V-Y</td>
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<td>None</td>
<td>C</td>
</tr>
</tbody>
</table>

Fourteen patients reconstructed with the modiolus perforator flap, patient demographics, and results.

* Freestyle without CDU.

AFX, atypical fibroxanthoma; BCC, basocellular carcinoma; C, complete reconstruction; CH, cheek; CR, complete after revision; CS, complete after secondary healing; LL, lower lip; MM, malign melanoma; N, nose; P, propeller; SCC, spino cellular carcinoma; TE, trichoid epithelioma; UL, upper lip.
Patients provided written consent for the use of their images.

REFERENCES