Most tumors of the parotid gland are benign and can be adequately treated with facial nerve–sparing parotidectomy. Malignant tumors constitute approximately 20% of all tumors of the parotid gland, and about 20% of these will have facial nerve involvement.\(^1,2\) Total parotidectomy with resection of the involved portion of the facial nerve is recommended when the tumor infiltrates or is adherent to the facial nerve. Immediate reconstruction of the resected nerve should be performed when feasible to mitigate the devastating effects of facial paralysis.\(^3\) Facial paralysis has functional and aesthetic effects, including an asymmetric smile, oral incompetence, nasal obstruction, and lagophthalmos with a potential for corneal injury. These physical effects can have a significant psychosocial impact and result in a decline in the patient's quality of life.\(^4\)

Three options exist for nerve reconstruction, which depend on the extent of the nerve resection. Primary tension-free coaptation of the nerve segments is the best option when feasible. Cable grafting between the proximal and distal nerve stump is performed when the length of the resected nerve segment prevents primary coaptation, and a mastoid dissection may be indicated to gain access to the proximal stump of the facial nerve in some cases.\(^5\) Nerve substitution is indicated when the proximal segment of the facial nerve is not accessible.

Donor nerve graft options frequently used in facial nerve reconstruction include the great auricular nerve, sural nerve, and medial antebrachial cutaneous nerve. The medial antebrachial cutaneous nerve can be harvested with multiple branches that make it suitable for reconstruction of multiple peripheral branches.

Compared with primary nerve repair, cable grafting has a slower return of nerve function and an increased rate of synkinesis.\(^5,7\) Synkinesis results from aberrant axonal regeneration, which causes simultaneous movement of multiple muscle groups when 1 group is activated. Using a separate neural input for innervation of the upper and lower facial muscle groups can prevent or decrease synkinesis. A 2011 report by
Volk et al. demonstrated prevention of synkinesis by combining the hypoglossal nerve for innervation of the lower facial muscles with a cable graft for the upper facial muscles.

Reports on the use of multiple neural inputs for facial nerve reconstruction after radical parotidectomy remain sparse. We herein describe our experience combining masseteric nerve transfer with cable grafting for facial nerve reconstruction after radical parotidectomy.

Methods

We performed a retrospective review of the medical records of 9 patients who underwent facial nerve reconstruction using the concurrent masseteric nerve transfer and cable grafting procedure performed by one of us (J.C.K.) from January 1, 2014, to October 31, 2015. All patients were treated at the University of Michigan Medical Center in Ann Arbor. Patients underwent radical parotidectomy for resection of malignant tumors and immediate reconstruction of the facial nerve. A number of these patients received postoperative chemoradiotherapy or radiotherapy. This study was approved by the institutional review board of the University of Michigan. All patients provided written informed consent.

After resection of the parotid tumor, frozen sections were obtained from the distal and proximal stumps of the facial nerve to ensure clear margins. The peripheral facial nerve stumps were identified and tagged with the aid of a nerve stimulator. Typically, 2 to 3 distal branches, which include innervation to the perioral and periorbital regions, were chosen. The length of interposition nerve graft needed to achieve tension-free repair was measured. The donor nerve graft was harvested from the great auricular, sural, or medial antebrachial cutaneous nerve depending on the length and number of branches. The nerve to the masseter muscle was dissected and traced inferiorly to provide adequate length for tension-free coaptation. A detailed description of a technique for identification and dissection of the masseteric nerve has been reported by Collar et al. The masseteric nerve was divided and coapted to a peripheral buccal nerve branch selected by stimulating the nerve stumps. The nerve branch that provides the strongest pure oral commissure excursion on stimulation was selected for coaption to the masseteric nerve. The neurorrhaphy was performed using two to three 10-0 nylon stitches, and the site of coaptation was tubulated with a vein graft. The interposition graft was coapted to the main trunk and the remaining peripheral nerve stumps using the same technique described above. The facial nerve cable graft was coapted to 2 to 4 distal branches in this series of patients. Figure 1 illustrates the described nerve reconstruction technique.

Results

Nine patients underwent nerve reconstruction using the combined approach during the review period. The 6 women and 3 men ranged in age from 51 to 73 years (mean age, 62.6 years) at the time of surgery. A medial antebrachial cutaneous donor nerve was used in all cases. Five patients received postoperative radiotherapy. Facial function recovery was monitored with monthly physical examinations. Oral commissure movement was noted from 2 to 7 postoperative months. Synkinesis between the upper and lower face was reduced. The Table summarizes the characteristics of the patients included in this series, and 2 illustrative reports of cases follow.

Patient 3

A woman in her 60s with high-grade mucoepidermoid carcinoma of the left parotid gland underwent total parotidectomy with skin resection and loss of facial nerve. The skin and soft-tissue defect was repaired with an anterolateral thigh free flap. A medial antebrachial cutaneous donor nerve was harvested from the right arm. The facial nerve was reconstructed by grafting the harvested donor nerve between the proximal stump and 2 distal branches of the facial nerve. The masseteric nerve was coapted to a selected buccal branch. The patient received postoperative radiotherapy consisting of 6300 cGy...
in 35 fractions. Movement of the oral commissure was noted at 3 postoperative months with improved facial symmetry and minimal synkinesis (Figure 2 and Video 1).

**Patient 4**
A man in his 60s with high-grade salivary duct carcinoma of the left parotid gland underwent total parotidectomy with loss of facial nerve. Facial nerve reconstruction was performed with masseteric transfer to the buccal branch and cable grafting between the facial nerve main trunk and 4 distal nerve branches using a medial antebrachial cutaneous donor nerve. He received postoperative chemoradiotherapy consisting of cisplatin and a 6600-cGy dose of radiation. Movement of the oral commissure was noted at 4 postoperative months (Figure 3 and Video 2).

**Discussion**
Immediate reconstruction is recommended after loss of facial nerve during parotidectomy. Identification of the resected facial nerve branches is easier when performed immediately after the resection. Anticipated postoperative radiotherapy may be cited as a reason for delaying immediate nerve repair. However, postoperative radiotherapy does not appear to affect the outcome of nerve reconstruction. Positive nerve margins have also been shown to have no significant effect on nerve recovery outcomes. Our approach has been immediate nerve reconstruction after radical parotidectomy whenever feasible.

Cable grafting of facial to facial nerve is the most popular option for reconstructing facial nerve defects that result from radical parotidectomy. The multibranch configuration of the medial antebrachial cutaneous nerve makes it a suitable donor for bridging the main trunk to multiple peripheral facial nerve branches. Similarly, the sural nerve can be harvested with cutaneous branches or split into multiple fascicular bundles for reconstructing the facial nerve defects. The distal facial nerve stumps may be pooled together to provide a better-caliber match for coaptation with the cable graft.

Cable grafting comes with slow recovery of volitional movement and unavoidable synkinesis. In general, we tell patients that 6 to 12 months are required to see recovery of facial tone followed by onset of facial movement. Patients who undergo radical parotidectomy typically have advanced disease and may not survive long enough after treatment to realize

Table. Patients Who Underwent Combined Facial Nerve Repair After Radical Parotidectomy

<table>
<thead>
<tr>
<th>Patient No./Age, y/sex</th>
<th>No. of Repaired Branches</th>
<th>Diagnosis</th>
<th>Preoperative Facial Weakness/Duration, mo</th>
<th>Radiotherapy</th>
<th>Return of Commissure Movement, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/72/F</td>
<td>3</td>
<td>Carcinoma ex pleomorphic adenoma</td>
<td>No</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>2/73/F</td>
<td>3</td>
<td>Acinic cell carcinoma</td>
<td>Yes/10</td>
<td>No</td>
<td>5</td>
</tr>
<tr>
<td>3/62/F</td>
<td>3</td>
<td>High-grade mucoepidermoid carcinoma</td>
<td>Yes/4</td>
<td>No</td>
<td>3</td>
</tr>
<tr>
<td>4/65/M</td>
<td>5</td>
<td>Salivary duct carcinoma</td>
<td>No</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>5/71/M</td>
<td>3</td>
<td>Adenocarcinoma</td>
<td>Yes/9</td>
<td>Yes</td>
<td>7</td>
</tr>
<tr>
<td>6/51/F</td>
<td>3</td>
<td>Adenoid cystic carcinoma</td>
<td>Yes/6</td>
<td>Yes</td>
<td>6</td>
</tr>
<tr>
<td>7/59/F</td>
<td>4</td>
<td>Salivary duct carcinoma</td>
<td>Yes/1</td>
<td>Yes</td>
<td>4</td>
</tr>
<tr>
<td>8/54/M</td>
<td>2</td>
<td>Metastatic SCC</td>
<td>Yes/10</td>
<td>Yes</td>
<td>5</td>
</tr>
<tr>
<td>9/56/F</td>
<td>2</td>
<td>Paraganglioma</td>
<td>Yes/4</td>
<td>No</td>
<td>3</td>
</tr>
</tbody>
</table>

Abbreviation: SCC, squamous cell carcinoma.

* Mean (SD) patient age was 62.6 (9.2) years.
the benefit of cable grafting. The duration of paralysis before nerve reconstruction also affects reconstructive options. Muscles undergo fibrosis after a prolonged period without neural input, and a reconstructive option that restores neural input sooner will be beneficial.15

The masseteric nerve has emerged as a popular option for reanimating the paralyzed face by having several characteristics that make it a suitable choice for facial reanimation. The proximity of the masseteric nerve to the facial nerve allows tension-free coaptation without the need for cable grafting. The close proximity and the need for a single neurorrhaphy translate into faster recovery of function because the regenerating axons have a short distance to travel to reach the facial muscles.15 The masseteric nerve has a significantly higher axonal count compared with the buccal branch of the facial nerve and provides strong oral commissure excursion when transposed.16,17 Coombs et al17 showed that the masseteric nerve is a motor nerve with a mean of 1542 myelinated axons compared with 100 to 200 fibers at the distal end of the cross-facial nerve graft. The masseter muscle works together with the temporalis muscle for jaw closure, and masseteric nerve transfer has minimal donor morbidity.16

The combined approach for nerve reconstruction offers several advantages compared with cable grafting alone. The masseteric nerve provides fast return of function; in this series of patients, oral commissure movement was noted as early as 2 postoperative months. This fast return of function is important in patients with a guarded prognosis. Moreover, the quicker return of function provides neural input and reduces muscle fibrosis while waiting for neural input to regenerate through the cable graft (“babysitter” procedure).18 Owing to its high axonal count, the masseteric nerve produces strong oral commissure excursion with clenching. Cable grafting has a lower axonal count but produces a spontaneous smile. In combining the 2 options, the masseteric nerve augments the smile restored with cable grafting.

Synkinesia is a sequela of nerve repair and is particularly disturbing when it involves the lower and upper face. Regenerating axons are misdirected owing to disruption of the endoneurium, resulting in simultaneous activation of multiple muscle groups.19 Patients typically report closure of the eyes or involuntary squinting when smiling. The combined approach decreases synkinesis by providing 2 separate nerve inputs. The cable grafting restores tone to critical areas in the lower eyelid and midface along with some volitional movement, whereas the masseteric nerve transfer is targeted to the lower facial muscle group, which allows independent movement of the oral commissure controlled with clenching.

Conclusions

Combining masseteric nerve transfer with cable grafting in the reconstruction of facial nerve defects minimizes synkinesis with fast return of oral commissure movement. This approach should be considered when faced with reconstruction of complex facial nerve defects after radical parotidectomy. Planned future studies will compare combined facial nerve repair with cable grafting only in a larger series of patients using electromyographic studies and outcome questionnaires to better assess timing of recovery and to quantify smile excursion.
REFERENCES


