Standardization of Flap Design for Oropharyngeal Reconstruction after Cancer Ablation Surgery

Dae-Hyun Lee, Eun-Chang Choi, and Kwan-Chul Tark

Departments of Plastic and Reconstructive Surgery and Otolaryngology, Yonsei University College of Medicine, Seoul, Korea.

A variety of residual defects containing many sulci and fossae in the oropharyngeal cavity make it extremely difficult to achieve an adequate flap design as well as the functional reconstruction of the complex defects after ablation surgery for oropharyngeal tumors. This study attempted to standardize flap design for the different types of defects in order to produce a better functional reconstruction of intra-oral defects. The oropharyngeal defects were classified into 6 Zones. When the defect involves only the mouth floor, it was classified as Zone 1. A hemi tongue was classified as Zone 2. A defect involving the mouth floor and a part of the tongue was classified as Zone 3. A defect involving the mouth floor and a part of the tongue and the tonsil was classified as Zone 4. A defect involving the mouth floor, a part of the tongue, tonsil and soft palate was classified as Zone 5. A defect involving the pharyngeal wall was classified as Zone 6. The following four types of forearm free flap designs were applied to each defective Zone accordingly: Type I flap design - an unilevel design for reconstructing Zone 1, 2 and 6 defects, Type II design - unilevel design for reconstructing Zone 3 defects, Type III design - trilevel design for reconstructing Zone 4 defects and Type IV design for reconstructing Zone 5 defects. During 1999 to 2002, 91 patients with oropharyngeal defects underwent a reconstruction using these standardized forearm free flap designs. The Type I design was used in 41 cases, the Type II design in 18 cases, the Type III design in 10 cases and the Type IV design in 22 cases. In all patients, the decannulation was successful, and the swallowing and deglutition functions were within the normal parameters. There was less nasal escape of the voice and the regurgitation of food than that observed using the conventional flap design method. Effective and functional reconstructions with minimal morbidities are possible with the application of the standardized forearm free flap design in oropharyngeal defects.

Key Words: Oropharyngeal defect, standardization of flap design, forearm free flap

INTRODUCTION

Microsurgical techniques enable an extensive resection of an oropharyngeal tumor to be performed, and consequently improves the prognosis of the patients and reduces the recurrence rate. However, if the defect is very large and complex, an effective functional reconstruction is not easy. Furthermore, the oral and pharyngeal region takes charge of various basic functions that are essential for the human life; aeration, deglutition, speech, taste, food swallowing, nutrition etc. Patients with oral and pharyngeal tumors submit to a disruption of these functions after the tumor resection. Therefore, preserving those essential functions is the primary goal in an oropharyngeal reconstruction. Reconstructive surgeons must consider not only the anatomical coverage of the resected area, but also the restoration of the lost functions.

Functional reconstructions using free tissue transfers require an adequate volume of tissue to be transferred as well an adequate thickness to carry out such a dynamic functions. In addition to these difficulties, intraoral structures contain many sulci and fossae, which make it difficult to create an ideal design corresponding to the defects. Nevertheless a standardized design of flaps for an oral and pharyngeal region reconstruction has not been established.

This study attempted to classify the defects that
developed after an oropharyngeal tumor resection into 6 zones according to the location and shape of the defects. Based upon these classification the design of the forearm free flap was designed accordingly.

MATERIALS AND METHODS

Patients

Between March 1997 and August 1998, 44 patients underwent an oropharyngeal tumor. Subsequently, the radial forearm free flaps were transferred to reconstruct the defects. The location and shape of the defects were retrospectively analyzed. As a result, oropharyngeal defects were classified into six zones (Fig. 1). Based on these preliminary studies, the authors standardized the radial forearm free flap design into 4 types and applied them to 91 patients for an oropharyngeal reconstruction during the last 3 years from January, 1999 to January, 2002. All the patients were Asians.

Classification of oro-pharyngeal defects

Oral and pharyngeal defects were classified into six zones. Zone 1 is a defect of the mouth floor only. A defect involving only the hemi tongue was classified as zone 2. A combined mouth floor and hemi tongue defect was classified as zone 3. Any zone 3 defect associated with a tonsillar defect was classified as zone 4. Any zone 4 defect that extended into the soft palate was defined as zone 5. Finally, a pharyngeal wall defect was defined as zone 6 (Fig. 1).

Classification of flap design and its application

The radial forearm free flap design was categorized into four basic types according to the pattern and involving areas of the oropharyngeal defects to be reconstructed (Fig. 2).

Type I Flap (Unilobed Flap): Zone 1, 2 and 6 defects (isolated mouth floor, hemi tongue, hypopharynx defect) were reconstructed with a type 1. Zone 6 defects were reconstructed with a rolled unilobed flap. Zone 2 defects of the hemi tongue were reconstructed with a folded unilobed flap.

Type II Flap (Bilobed Flap): In Zone 3 defect, the design was made as a two lobed flap inserting a concave slit that will form a groove between the mouth floor and the tongue. One lobe of the bilobed flap was used for the mouth floor and the other one for the tongue.

Type III Flap (Trilobed Flap): In Zone 4 defects, a trilobed flap was designed by adding a third lobe to the area corresponding to the mouth floor on the bilobed flap. This portion was used for the tonsil reconstruction.

Type IV Flap (Extended Trilobed Flap): Zone 5 defects were reconstructed with an extended trilobed flap in which one more lobe was extended from the tonsillar area of the trilobed flap. The extended lobe was folded and the nasal side

Fig. 1. Schematic drawing of the Classification of oro-pharyngeal defects resulting from tumor ablation surgery. Dark grey color indicates the defects.

Fig. 2. Four basic flap designs and their application. This drawing is for right side defects. Mirror image design can be applied for left side defects. (T, Tongue; MF, Mouth Floor; TS, Tonsil; SP, Soft Palate)
of the soft palate was created using the distal portion of the extended lobe and the oral side of the soft palate with a proximal portion.

The radial forearm free flap donor sites were repaired using a split thickness skin graft after a local soft tissue advancement and sliding in order to reduce the skin grafting area and to cover the exposed tendons on the volar aspect of the wrist.

**Evaluation of the results**

The postoperative mastication, swallowing and speech functions were evaluated by subjective and objective tests with a serial follow up. In 5 cases of a zone 5 defect, the degree of velopharyngeal incompetence was assessed with a nasometer by a speech pathologist. The amount of nasal escape was measured using a nasometer 3 months after the reconstruction and the nasality was calculated. In order to calculate the nasality, the nasal pressure during the phonation of “Ah”, “MaMa” and “FaFa” was divided by the sum of the oral and nasal pressures.

In zone 6 defects, the patency of the reconstructed pharyngeal wall was evaluated with an esophagogram one month after surgery.

**RESULTS**

The majority of oral and pharyngeal defects were zone 6 defects (39%), which was followed by zone 3 defects with zone 4 defects being the least common (Fig. 3). Based upon this oropharyngeal defect classification, the flap design was chosen among the four basic standard design patterns. Among 91 patients, 41 patients were reconstructed using a type I unilobed flap and 18 patients were reconstructed using a type II flap design. Type III trilobed flaps were applied in 10 patients and 22 patients were reconstructed using a type IV extended trilobed flaps (Table 1). In two patients with a zone 4 defect, the type II flap design was applied because a small tonsillar defect could be repaired primarily without tension.

Complications such as flap necrosis or vascular thrombosis were not observed. However, in 2 cases of a zone 6 reconstruction, a minor fistula was noted in the proximal portion. Both patients eventually healed with a secondary revision and VAC® (Vacuum Assisted Closure Therapy, KCI, San Antonio, Texas, USA) therapy. The reconstructed pharyngeal walls maintained a good patency and had no further fistula or complications.

![Fig. 3. Distribution of the oropharyngeal defects according to the authors’ classification (1996-1998). Zone 1: Mouth floor defect, zone 2: Hemi tongue defect, zone 3: Combined mouth floor and hemi tongue defects, Zone 4: Any zone 3 defect with an associated tonsillar defect, Zone 5 defect: Any zone 4 defect that extends into the soft palate, Zone 6 defect : Pharyngeal wall defect.](image)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Oropharyngeal defects</th>
<th>Flap design</th>
<th>No. of case</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>Mouth floor defect</td>
<td>Type I</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Hemi tongue defect</td>
<td>Type I</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Mouth floor + part of tongue</td>
<td>Type II</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Zone 4</td>
<td>Mouth floor + part of tongue + tonsil</td>
<td>Type III</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Zone 5</td>
<td>Mouth floor + part of tongue + tonsil + soft palate</td>
<td>Type IV</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Zone 6</td>
<td>Pharyngeal wall</td>
<td>Type I</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>91</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
No mechanical injury occurred on the transferred flap during chewing or mastication after the zone 2 or 3 reconstructions. However, in two cases, an ulceration of the dorsal portion of the reconstructed tongue was noted. These healed spontaneously within 2 weeks. The tongue mobility was restored to near normal within 3 months after surgery.

In the patients with zone 5 oropharyngeal defects, a nasality evaluation conducted during the phonation of ‘Ah’, ‘MaMa’ and ‘FaFa’ words. The normal nasality of these voices were 32.6%, 54.7% and 19%, respectively. In patients who received a soft palate reconstruction, it was 23.3%, 65.9% and 56.1% respectively. The mean nasality was 35.4% in the normal group and 48.4% in the reconstructed group. All the patients communicated successfully with the other person on the phone.

DISCUSSION

Among the many functions of the oropharynx, deglutition is the most essential. Deglutition is divided into three phases. In the first phase, an oral preparatory phase, food is introduced into the oral cavity and chewed by a movement of the jaw and the mobile anterior portion of the tongue. In the second phase, the oral phase, the tongue propels the bolus through the pharynx from the oral cavity. The propelled bolus is driven into the esophagus during the final pharyngeal phase. At this time, the base of the tongue comes in contact with the posterior pharyngeal wall. An anterior upward movement of the larynx and hyoid produces a negative pressure in the pharynx, which acts as a suction pump for the passage of the food bolus into the esophagus, and prevents the aspiration into the trachea and nasal cavity. Therefore, a reconstruction of a mobile neo-tongue with a voluminous tongue base is essential for the restoration of the good deglutition function.

The functional results of the oropharyngeal reconstruction are influenced by two major factors. One is mainly related to the process of a tumor resection. The other is closely related to process of reconstruction. Factors related to a tumor resection include the extent and site of the resection, the mobility of the residual tongue, the residual volume of the structures and the degree of the residual function of the nerves and muscles. Factors associated with reconstruction are the selection of an adequate donor site, the pedicle length, the flap volume and size, the design of the flap etc. The location of the resected area is more important than the residual structure volume. For example, a wide resection of the mouth floor or tonsils does not influence deglutition. However, the amount of tongue resected affects deglutition considerably.

For the reconstruction of the oral and pharyngeal regions, a radial forearm free flap appears to be the best of choice as a donor flap because of its thinness, pliability, less post operative atrophy, long pedicle and durability against radiation therapy. We made many anatomical modifications and functional considerations were made during an oral and pharyngeal reconstruction using a bilobed flap. Urken originally designed the bilobed flap. In order to prevent a tethering of the neo-tongue, the flap was split into two parts corresponding to the defect amount of the mouth floor and tongue. In a reconstruction of the tongue base, some fatty tissue and fascia should be included on the proximal undersurface of the flap to make the base of the tongue more voluminous, which facilitates contact between the tongue base and the posterior pharyngeal wall during deglutition.

The early restoration of the neo-tongue sensation depends on amount of preserved lingual nerve during the initial resection of the tumor, and whether the lateral antebrachial cutaneous nerve of the flap is anastomosed with the recipient nerve or not. The resultant early recovery of sensation might protect the reconstructed tongue from mechanical injuries caused by chewing or external environment.

The tonsil and soft palate are important structures in performing speech. Many efforts to restore these structures and functions have been made. Various local flaps such as the superiorly based pharyngeal flap, and the palatal island mucoperiosteal flap have been used to reconstruct the soft palate defect. Besides local flaps, a radial forearm free flap and the jejunal free flap can be also used. Generally, a reconstruction of the soft palate in a zone 5 defect is achieved with
combined flaps i.e. the local pharyngeal flap for nasal side of soft palate and free flap for oral side of the soft palate and other defects. The authors reconstructed the base of the tongue, tonsil and soft palate three-dimensionally using a type IV extended trilobed flap without a local pharyngeal flap.

The extended trilobed flap was divided into two parts, one part was used to reconstruct the nasal side soft palate, and the other part was used to reconstruct the oral side soft palate by folding the mid portion of the extended trilobed flap. After folding, it was fixed to the resection margin of the soft palate. The simultaneous reconstruction of the oral and nasal side soft palate using one flap greatly reduced the surgery time. In obese patients, a defatting procedure is needed to thin out the extended lobe.

The type IV flap can reduce the hyper nasality. A nasometric study showed that a forearm flap itself increases the nasality by up to 23% compared to the normal control group.

In conclusion, an effective anatomical and functional reconstruction of the oropharyngeal defects can be achieved using a standardized flap design method.

REFERENCES