Classification of tongue cancer resection and treatment algorithm

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Background and Objectives: Reconstruction of tongue cancer defects is challenging due to the complex anatomy and physiology of the tongue. Here, we classify patterns of tongue tissue loss and describe a treatment algorithm for achieving good functional and oncologic outcomes.

Methods: We retrospectively reviewed 50 tongue squamous-cell carcinomas surgically treated between January 2010-June 2015. Cancer resection and tongue reconstruction were stratified according to the missing anatomical subunits.

Results: A type 1 defect is a unilateral and marginal defect, not crossing the midline, and not extending to the posterior-third of the tongue. Type 2 involves the two-anterior-thirds of the mobile body, not crossing the midline, without posterior-third evolvement. Type 3 involves the two-anterior-thirds of the mobile body of the tongue with contralateral extension. Type 4 extends to the tongue base. Type 5 defect comprises any of the previous defects along with involvement of the floor of the mouth. Type 2 and 3 defects were the most common. Microvascular reconstruction was performed in 23 out of 50 patients. Complications included infection, partial necrosis, dehiscence, and microvascular thrombosis.

Conclusions: Our classification system and treatment algorithm represent a reliable method of addressing management of tongue defects.

KEYWORDS
functional and aesthetic outcomes, reconstructive options, tongue cancer, tongue defect classification, tongue reconstruction algorithm
subsite involved, influences the severity of the subsequent functional impairment.8,9

Owing to advancements in microsurgical techniques, more extensive resections are now possible in both young and old patients.10 The appropriate selection of reconstructive techniques should facilitate the healing of both donor and recipient regions, with maximization of patients’ capacity for rehabilitation. Since 1983, the free radial forearm flap (FRFF) has been considered the first choice for the restoration of soft tissue ablation in the oral cavity,11 despite several disadvantages concerning the donor site, including the sacrifice of radial artery. Recently, the anterolateral thigh flap (ALT), has challenged the superiority of FRFF because it does not necessitate a skin graft and does not involve the sacrifice of an artery or possible damage to the tendons of the and.12,13 Moreover, in case of extensive and complex defects involving multiple anatomical and functional subunits, the use of double flaps has shown objective benefits in the reconstruction.14–16

These patients are often left with a complex, large defect that necessitates restoration of form to achieve successful rehabilitation. However, recent publications have provided conflicting data regarding functional outcomes after microvascular reconstruction of the tongue, and there is little guidance in the literature on flap selection for tongue reconstruction. Although a one-flap approach seems to be preferred by most authors,17,18 we believe that treatment planning should involve a more strategic approach with a wider variety of flap options.

In the present study, we retrospectively analyzed 50 patients affected by tongue squamous-cell carcinomas (TSCC), including tongue base cancers. We described the use of a novel classification system that simplifies the patterns of tongue tissue loss during composite cancer resection and provide a decision algorithm for immediate reconstruction.

The main aim was to elucidate the indications for the use of different reconstructive techniques and flaps, in both early and advanced tongue cancers, based on our personal experience and the latest literature updating.

2 | METHODS

2.1 | Study population

Between January 2010 and June 2015, a total of 62 patients affected by TSCC were surgically treated at the Maxillo-Facial Unit of Florence. All the participants signed an informed consent agreement before undergoing surgery. The indications for treatment included the presence of a tongue mass, either of the tongue body or of the tongue base, with a pre-operative biopsy report indicative for squamous-cell carcinoma with or without clinical evidence of cervical lymph node metastasis. The study was approved by the local institutional review board (IRB). All patients were reviewed and retrospectively restaged in accordance with the AJCC4 and World Health Organization (WHO: 2005)19 guidelines.

The exclusion criteria were as follows: previously treated for head and neck cancer; previously undergone any head and neck surgical procedures; previously received radiotherapy and/or chemotherapy; did not consent to be enrolled in the study; or incomplete charts.

Patient, tumor, and treatment characteristics were extracted from patients’ records. During the follow-up, speech, swallowing, and cosmetic evaluations were performed at 1, 3, 6, and 12 months after the operation. Speech evaluation was performed using a numeric scale as follows: normal = 4, intelligible = 3, and slurred speech = 2, tracheostomy required = 1. Swallowing function was classified using the following scale: normal = 4, soft = 3, liquid = 2, and requiring nasogastric or gastric feeding tube (NGFT or GFT) = 1. Patients rated their own appearance using the following scale: excellent = 4, good = 3, fair = 2, and poor = 1.

2.2 | Surgical classification

The mobile body of the tongue can be divided into three segments. The anterior and middle segments are divided by the median raphe, which represents a physiological barrier to tumor spread. Meanwhile, the tongue base represents the posterior third of the tongue, including the circumvallate papillae and its lymphatic tissue (Figure 1a).

Our novel classification system for tongue defects focuses on the functional subunits that require reconstruction. It is based on intra-operative findings of tongue defects, which we classified into five groups in ascending order of reconstructive complexity:

1. Type 1 defect: a unilateral and marginal defect, rarely involving the tip of the tongue without crossing the midline, not extending to more than one third of the mobile tongue body and not extending to the posterior third of the tongue (Figure 1b);
2. Type 2 defect: a unilateral defect not crossing the midline without posterior third involvement, extending to more than one third of the tongue (Figure 1c);
3. Type 3 defect: a defect that involves the two anterior thirds of the mobile body of the tongue with contralateral extension (Figure 1d);
4. Type 4 defect: extends to the tongue base, and is further divided into variant 4A, involving less than 50% of the tongue base, and variant 4B, involving more than 50% of the tongue base (Figure 1e);
5. Type 5 defect: any type of defect along with involvement of the floor of the mouth without (5A)/with bone resection (5B) (Figure 1f).

Subsequently, the choice of reconstruction technique in our algorithm was determined by the estimated volume of tongue to be replaced, with the aim of restoring the tongue’s natural form and volume, and preserving its remaining mobility in order to ensure a good functional outcome.

Under this system, type 1 and 2 defects mainly require restoration of the tongue form, considering that more than 50% of the mobile body
can be preserved with good following functional expectations. In contrast, type 3 and 4 defects require wide tongue resection, causing complex tissue loss. In such cases, more than 50% of the whole tongue body needs to be replaced, with a significant reduction in swallowing and speech function in cases of wide tongue base resection (type 4B). Type 5 defects, the main reconstructive issue is to keep saliva secretions from entering the neck space, together with the other functional and aesthetic goals. Here, tumor involvement could include the mandible bone, and any reconstruction should attempt to restore its profile and function as well.

All head and neck surgical procedures were performed by a senior surgeon (G.S.), and tongue cancer resection included neck dissection in accordance with AJCC stage.4

We did not perform any type of dynamic tongue reanimation, nor did we make use of gastro-omental free flap along with free gracilis muscle flap, although these have been reported to be suitable for achieving functional dynamic tongue reconstruction.20,21

2.3 | Statistical analysis

Categorical variables were calculated in terms of frequencies and percentages for all of the patients included in the study. The Kruskal-Wallis test was used for statistical comparisons with the software program STATA version 12.1 (StataCorp. 2011. Stata Statistical Software: Release 12, College Station, TX, StataCorp LP), and a value of $P < 0.05$ was considered statistically significant.

3 | RESULTS

Twelve out of sixty-two patients were excluded from our study: seven had already undergone a head and neck surgical procedure, or were affected by cancer relapse or second primary head and neck tumor (11%); two had already received chemo-radiotherapy for other malignancies (one for breast cancer and one for leukemia) (3%); one did not give his consent to be enrolled in the study (2%); and two had incomplete charter notes (3%). Thus, a final number of 50 patients were included in our study.

Type 2 defects were predominant ($n = 17$), followed by type 3 ($n = 15$), type 1 ($n = 10$), and type 4 ($n = 5$), while type 5 defects were the most uncommon ($n = 3$). Patients received either pedicle flap or free flap, while 11 patients (22%) did not undergo any flap reconstruction; four patients (8%) underwent double flap reconstruction.

Type 1 defects ($n = 10$; 20%) were reconstructed by primary closure. Type 2 defects ($n = 17$; 34%) were reconstructed using the...
following techniques: eight suprafascial-ALTF (47%), six RFFF (35%), one facial artery musculo-mucosal flap (FAMM; 6%), and one pectoralis major myocutaneous flap (PMMCF; 6%); one patient did not receive any reconstruction because of severe co-morbidities (6%). Type 3 defects (n = 15; 30%) were reconstructed using the following methods: nine received ALTF flaps (53%), five RFFF (40%), and one PMMCF (7%). Of the five patients with type 4 defects (10%), two received rectus abdominis muscle free flaps (RAMFF) (40%) and three received double flaps: myocutaneous-ALTF flap plus RFFF (60%). Of the three patients with type 5 defects (6%), one received a RAMFF (33%), one with severe co-morbidities underwent a pedicle flap reconstruction (PMMCF) (33%), and one received double flaps, PMMCF plus RFFF (33%).

There were two complete and one partial flap failures out of 43 flaps harvested, giving a success rate of 93%. The overall rate of post-operative complications was 16%. The mean number of reoperations per patient was 0.06. Specifically, both cases of complete flap necrosis required surgical revision, and one PMMCF and one ALTF were harvested; in addition, one out of the three wound complications needed a surgical revision. These details together with those of the complications are listed in Table 1.

The mean follow-up duration was 27.24 ± 14.71 months (95% confidence interval [CI] 23.02-31.47, range 0-60, median 25), four patients (8%) experienced loco-regional recurrence, while two patients died from disease (4%) and one from immediate post-operative complication (2%). The overall survival (OS) rate was 94% and the disease-free survival (DFS) rate was 80%.

Forty-nine patients were evaluated at 1, 3, 6, and 12 months after surgery regarding functional outcomes. At one year post-operative follow-up, thirty-two patients (65%) achieved normal speech, 13 patients (26%) achieved intelligible speech, and 4 (9%) had slurred speech. None of the patients required permanent tracheostomy. Compared to type 4 and 5 patients, type 1 and 2 patients had significantly better speech recovery (P < 0.05), where none of them underwent adjuvant radiotherapy. In the swallowing assessment, 29 patients (59%) were able to eat normally, 14 patients (29%) managed a soft diet, and six patients (12%) were dependent on a liquid diet. There was no significant difference concerning swallowing function among the five groups (P = 0.39). The aesthetic results were rated excellent in 28 patients (58%), good in 13 patients (28%), and fair in eight patients (14%). There was no statistical significant difference among the groups (P = 0.76).

4 | DISCUSSION

The ideal tissue for tongue reconstruction should be versatile in design, adequate in tissue stock, provide consistent texture with minimal donor site morbidity, and ensure large and long pedicle feeding of different tissue types; further, its harvesting should be easy, fast and safe. Because of these numerous requirements, the surgical management of tongue cancer is challenging, as it is influenced by not only the particular anatomy and physiology of the tongue, but also by specific donor site characteristics and the patient’s expectations. In fact, the tongue represents one of the most difficult structures of both oral cavity and oropharynx to reconstruct, because of its central role in speech, swallowing, and airway protection.22 Each tongue subunits (see Figure 1a) plays a role in

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Reconstructive details and complication of the 50 enrolled patients</th>
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<tbody>
<tr>
<td>Defect type 1</td>
<td>Defect type 2</td>
</tr>
<tr>
<td>No. of cases (%)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Primary closure (%)</td>
<td>10 (100)</td>
</tr>
<tr>
<td>Pedicle flap (%)</td>
<td>None</td>
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<tr>
<td>Free flap (%)</td>
<td>None</td>
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<tr>
<td>Double flaps (%)</td>
<td>None</td>
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<tr>
<td>Partial flap loss (%)</td>
<td>None</td>
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<tr>
<td>Complete flap loss (%)</td>
<td>None</td>
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<tr>
<td>Hemorrhage (%)</td>
<td>None</td>
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<tr>
<td>Wound infection (%)</td>
<td>None</td>
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<tr>
<td>Wound dehiscence (%)</td>
<td>None</td>
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<tr>
<td>Other complications (%)</td>
<td>None</td>
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<tr>
<td>Total complications (%)</td>
<td>None</td>
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<tr>
<td>NGFT removal (days)</td>
<td>Mean 1 ± 0.67 SD</td>
</tr>
<tr>
<td>Tracheostomy tube removal (days)</td>
<td>Mean 0.5 ± 0.71 SD</td>
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<tr>
<td>Hospital stay (days)</td>
<td>Mean 2.50 ± 0.53 SD</td>
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determining tongue form, volume, and action. Speech and swallowing recovery requires large volumes of reconstructed tissues for minimal scarring, and residual bulk is needed to compensate for long-term shrinkage.9,23,24

Therefore, reconstructive options should attempt to maintain mobility23–31 or to provide bulk.32–35 Since 1979, when Ariyan developed the pectoralis major myocutaneous flap (PMMCF),36 the major contribution to head and neck reconstruction has been microvascular free tissue transfer. Concerning reconstruction choice, most authors focused mainly on single flap or on a comparison between two different flaps for the reconstruct a limited range of tongue defects.18,24,30–39; here, through a retrospective review of a single-center case series in accordance with the latest literature updated findings, we propose an algorithm for both tongue resection options and reconstructive selections based on tumor extent and tissue loss (Figures 2 and 3).

For type 1 defect patients, primary closure was the best choice to achieve restoration of the primary tongue form after a "wedge-shaped tongue resection," considering that the mobility and volume were not affected. These patients experienced a complete recovery of functions, with a normal speech and swallowing in the early follow-up period. None complained of any cosmetic dissatisfaction. Similar functional results were recorded in type 2 defect patients. In these patients, surgeons had to manage a wider tongue resection, "hemiglossectomy," involving the mobile portion of the organ, but without a consistent tissue lost. This allowed the use of thin free flaps (eight suprafascial-ALT and six RFF; 82% of cases), which have good pliability and versatility; they restore almost half of the tongue volume loss while preserving its complex mobility.24,39,40 In case of contraindications for microsurgery, accordingly to literature, pedicle flaps such as PMMC and FAMM, or submental artery island flap (SAIF) might be considered as good reconstructive options for this type of defect.41–44

In comparison to type 2 defects, patients with type 3 defects require more extensive and complex resection, involving more than 50% of tongue volume ("Extended hemiglossectomy"). In other words, multiple tongue subunits are removed, sometimes requiring mandibulotomy or lip split for access, thus affecting form and mobile function considerably. Here, the surgeons' aim was first to provide bulk in order to ensure a good swallowing recovery; maintaining tongue articulation ability was secondary. ALT flap with its muscular component provides large skin territory together with high reliability, versatility, and bulkiness when combined with the vastus lateralis or the tensor fasciae latae muscles.24 ALTFF and RFFF can act not only as spacers, but also allow the remaining tongue a certain degree of movement, confirmed by a median time of tracheostomy tube and NGFT removal of 4 and 5 days, respectively, with a median hospital stay of 7 days. Five patients out of 15 had normal speech (33%) and only one patients needed to maintain liquid diet (6%). Pedicle flaps still represent a good alternative reconstructive options when

**FIGURE 2** Proposal of guidelines for tongue cancer resection design based on our surgical classification
contraindications to free flaps exist, and in case of free flap failure, PMMCF is a good salvage option.

Type 4 and 5 defects require multiple approaches, because of the almost complete tongue involvement and the need to avoid communications between the oral cavity and neck spaces. Here, mandibulotomy or lip split for access, as well as mandibulectomy in case of mandible invasion (Figure 3), were always performed. For instance, type 4 defects or type 5 soft tissue defects required very bulky flaps; tongue resections were mainly involved subtotal glossectomy or total glossectomy, which were often reconstructed by free bulky soft tissue transfer such as myocutaneous-ALTFF or rectus abdominis muscle free flaps (RAMFF), in accordance with recent publications. However, the complexity of type 5 defects arises from the presence of through-and-through defects that require composite resection of the tongue, floor of the mouth, cheek, and/or the mandible. In these cases, fibula osteocutaneous free (FOSCF) flap has been commonly proposed as the main choice for reconstruction, but due to the limitations in harvesting soft tissue and skin along the fibula bone, combined RFFF, or ALTFF is usually performed instead.

In summary, we recorded a final complication rate of 16%, median tracheostomy tube removal time of 4 day, median NGFT removal time of 5 days, median hospital stay length of 7 days, and an updated DFS rate of 80% during a median follow-up time of 25 months. These findings suggest that our novel classification system and treatment algorithm is a consistent and reliable method of addressing tongue defects by focusing on both oncologic and functional outcomes.

5 | CONCLUSION

Our study identified a strategic approach for different types of tongue defects, represented by a classification system and treatment algorithm based on subunit reconstruction, which has ensured good final functional outcomes comparable to other studies (Figures 2 and 3).

This algorithm could be a useful tool for patient counseling and treatment selection, which might allow a more tailored patient care protocol together with a high success rates in terms of oncologic, functional, and aesthetic results.

We have shown that the use of double flaps, whether pedicle and free or two free flaps, achieved optimal functional outcomes by allowing wide and complex cancer resection. Such a combination permitted better three-dimensional multiple subunits reconstruction and better rehabilitation. However, further research is needed to elucidate the relation between the incidence of complications and the specific characteristics of the reconstruction technique.

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REFERENCES

The main aim of this original article was to elucidate the indications for the use of different reconstructive techniques and flaps, in both early and advanced tongue cancers. A treatment algorithm for managing tongue cancer with/without oral cavity floor defects and the subsequent reconstruction was developed. Our classification system and treatment algorithm of tongue defects represent a reliable method of addressing management of tongue cancer patients, with good oncologic and functional outcomes.