Applications of Extracellular Matrix Biomaterial in Tongue Reconstruction

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Abstract: Tongue neoplasms are common in the head and neck region and are primarily treated through surgical interventions. Various reconstruction techniques, such as primary closure, skin grafts, skin substitute biomaterials, and free tissue transfer, are used to address the resulting defects. This study provides an overview of our experience utilizing extracellular matrix-based biomaterials (ECM) for the reconstruction of tongue defects and evaluates the mean volumetric size of postsurgical tongue. This retrospective case series evaluated subjects with tongue defects secondary to benign or malignant resections who underwent reconstruction with ECM-based biomaterials at Ascension Hospital from July 2022 to May 2023. Descriptive variables were collected, and descriptive statistical analyses were conducted. The primary outcome was the volume of postsurgical defect reconstructed. Twenty-five subjects were included: 10 had benign pathology and 15 had malignancy. The mean reconstructed defect volume was 12.65 cm^3, ranging between 2 and 35 cm^3. Postoperative bleeding, mainly linked to anticoagulation medication, occurred in 20% (n = 5) of the cases, and the rate of need for additional procedures was 8%. In conclusion, ECM-based biomaterials are suitable for reconstructing varying sizes of postsurgical tongue defects with no donor-site morbidity. Carefully considering patient factors, including anticoagulation medication use and defect volume, is essential in optimizing outcomes.

Key Words: Allograft, biomaterial, grafts, head and neck, oncologic surgery, reconstructive surgery, tongue reconstruction

Oral cavity cancer is one of the most common malignancies in the head and neck region, with a rate of new cases of 3.6 per 100,000 men and women per year, and ~0.4% of men and women will be diagnosed with tongue cancer at some point during their lifetime.[1] The primary treatment modality for oral cavity tongue neoplasm remains surgery with or without neck dissection based on clinical and radiologic features such as the size of the tumor, suspicious or positive nodes, and depth of invasion.[2,3]

The defects resulting from partial tongue resections can be reconstructed with primary closure, skin grafts, skin substitutes, and local or free tissue transfer, being the last one of the most commonly performed procedures for medium to large-size defects at institutions with a microvascular surgery unit.[4]

Skin grafts are routinely used to cover significant superficial mucosal defects after tongue resection; conventional split or full-thickness skin grafts are associated with donor site morbidity, including pain, infection, and hypertrophic or hyperchromic scar formation.[4,5]

Surgical bio-scaffolds for wound regeneration have been reported to manage acute wounds, and extracellular matrix (ECM)-based biomaterials have established place as medical devices for wound healing and tissue regeneration with biochemical diversity as an alternative for collagen-based biomaterials.[6] Using ECM-based biomaterials offers a treatment option that might prevent scarring and contracture of typical STSG and avoids the morbidity associated with graft harvesting.[4]

This study provides an overview of our experience utilizing ECM-based biomaterials to reconstruct tongue defects and evaluates the mean volumetric size of reconstructed postsurgical tongue defects.

METHODS

Study Design/Sample

The authors implemented a retrospective case series study, which was approved by Ascension Macomb-Oakland Hospital's Institutional Review Board; it was designed to include all subjects who underwent tongue reconstruction with extracellular matrix biomaterial between July 1, 2022 and May 1, 2023, with medical data 30 days postoperatively. Inclusion criteria allowed only primary reconstructions for benign or malignant pathology. Subjects were excluded if they had incomplete data in medical charts.

Variables and Analysis

Variables collected describing the sample included demographics (age, sex), medical (BMI, history of hypertension, diabetes, heart disease, lung disease, and history of chemotherapy or radiation to head and neck), social history (smoking and alcohol use), and reason for surgery, defined as "benign" for subjects who underwent tongue resections for benign pathology or "malignancy" for subjects who underwent surgery due to a cancer diagnosis. The primary outcome of the study was the volume of postsurgical defect reconstructed; this was calculated using data about specimen size (length×height×depth = volume) obtained from the final pathology report. Secondary outcome variables included complication rate, defined as infection, delayed healing or postoperative bleeding, and need for additional procedures.

Descriptive statistics (mean, frequency, range, SD) were computed for each study variable. Calculations were done utilizing IBM SPSS Statistics Version 29 (IBM Corp., Armonk, NY).

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Protocol for Using ECM-Based Biomaterial

The extracellular matrix-based biomaterial is available in sheet form (Myriad) soft tissue matrix, which is a 3-layered or 5-layered perforated matrix that provides a biological scaffold to support cell infiltration and migration. The ECM-based matrix is infiltrated by fibroblast and endothelial cells, allowing for neovascularization.[6]

In our protocol, the 5-layered ECM matrix was used. The tongue lesion is resected with the necessary margins, and hemostasis is achieved with electrocautery. Next, Myriad ECM is applied and secured to the wound edges with 3-0 Vicryl sutures (Ethicon Inc.) Additional quilting sutures can be done to secure the central portion of the matrix to the wound bed (Fig. 1). The matrix is then covered with a Xeroform (Covidien) bolster to aid in adhesion to the wound bed as well as to promote vascular tissue ingrowth, and the bolster is secured with 2-0 silk sutures. In 1 to 2 weeks postoperatively, the bolster is removed in the clinic.

RESULTS

The subject's demographics are presented in Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/SCS/G556. A total of 25 subjects were included in the study. Ten subjects had benign pathology and 15 had malignancy. The summary of the study's variables and demographics stratified by type of pathology are presented in Supplemental Table 2, Supplemental Digital Content 1, http://links.lww.com/SCS/G556. Subjects in both groups were roughly similar in age and sex distribution. The mean age was 68.6 ± 11.7, slightly higher for the benign group (72.8) versus the malignancy group (65.8). Both groups were roughly homogeneous with no statistical difference in history of hypertension, diabetes, heart and lung disease, and alcohol use. The malignancy group presented more subjects with a history of smoking (60%) versus the benign group (30%). Forty percent of subjects in the benign group were on anticoagulation medication compared with 26.7% in the malignancy group; however, there was no statistical difference ($P = 0.48$). In the malignancy group, 33.3% of the subjects received a simultaneous neck dissection.

The analysis of the defect volume and follow-up time between groups is shown in Supplemental Table 3, Supplemental Digital Content 1, http://links.lww.com/SCS/G556. The mean volume defect size was 12.65 cm^3, ranging between 2 and 35 cm^3. The volumetric size of the defect in the malignancy group was slightly larger, 14.17 ± 8.7 cm^3, compared with 10.36 ± 8.8 cm^3 in the benign group.

The overall need for additional procedures was low (8%). Five subjects (20%) presented postoperative bleeding as the only reported complication, as shown in Supplemental Table 4, Supplemental Digital Content 1, http://links.lww.com/SCS/G556.

The multivariate analysis showed that 60% of the subjects who presented postoperative bleeding were on anticoagulation medication ($P = 0.13$) and had a larger defect volume size mean; 16.37 cm^3 for the subjects with postoperative bleeding versus 11.72 cm^3 for the noncomplication group ($P < 0.001$), as shown in Supplemental Table 5, Supplemental Digital Content 1, http://links.lww.com/SCS/G556 and Supplemental Table 6, Supplemental Digital Content 1, http://links.lww.com/SCS/G556.

DISCUSSION

Oral cavity cancer, particularly tongue neoplasm, represents a prevalent and clinically challenging subset within the broader spectrum of head and neck malignancies,[1,2] requiring effective treatment modalities and reconstruction techniques to address not only the functional but the esthetic deficits resulting from surgical resections. Oral functions related to tongue mobility, like speech, are compromised after ablative surgery. The remaining tongue plays a vital role in speaking for partial tongue resections. The defects from partial tongue resections can be reconstructed with primary closure, skin grafts, skin substitutes, and local or free tissue transfer.[4] The selected reconstruction option can enhance or reduce this compensatory effort from the remaining tongue tissue.[7]

Surgical bio-scaffolds for wound regeneration have been reported to manage acute wounds, and extracellular matrix (ECM) based biomaterials have established a place as medical devices for wound healing and tissue regeneration.[6] The ECM provides a framework for cell adhesion at the site of the defect, allowing local cells to migrate into the matrix and undergo differentiation.[8] This effect is related to the presence of stimulatory factors and adhesion molecules that promote the proliferation of native cells. EMCs present a low infection rate due to their inherent antimicrobial activity[9] and ability to rapidly revascularize the affected area.

An essential aspect of assessing the suitability and effectiveness of tongue reconstruction with ECM-based biomaterial was evaluating the size of defects successfully reconstructed. Our findings suggest that these biomaterials can reconstruct a range of defects, a critical consideration in clinical practice. The mean volumetric size of defects reconstructed was 12.65 cm^3, ranging between 2 and 35 cm^3. ECM-based biomaterials can feasibly address both minor to medium defects arising from malignancy resections and smaller defects resulting from benign pathologies. This versatility underscores the potential applicability of these biomaterials across a spectrum of defect sizes.

The overall need for additional procedures was very low, reflecting the low postoperative contraction rate and good restoration of mobility. While the complication rate was low, postoperative bleeding was identified as the primary complication. Most subjects who experienced postoperative bleeding were on anticoagulation medication and had a significantly larger mean defect volume, highlighting the importance of careful patient selection and monitoring in cases involving more significant defects.

The use of ECM-based biomaterials for tongue reconstruction presents several advantages compared with conventional split or full-thickness skin grafts.

Advantages

- Less morbidity due to no additional surgical donor site.
- Extracellular matrix-based biomaterial structure supports cell migration, differentiation, and rapid revascularization.

Disadvantages

- Higher cost.
- Limited availability in certain clinical settings.
- Risk of postoperative bleeding in patients on anticoagulation medication.

In conclusion, this study contributes to the growing evidence supporting using ECM-based biomaterials for tongue reconstruction. Our findings suggest that these biomaterials can effectively reconstruct varying sizes of postsurgical defects. However, carefully considering patient factors, including anticoagulation medication use and defect volume, is essential in optimizing outcomes. These biomaterials offer significant ad-

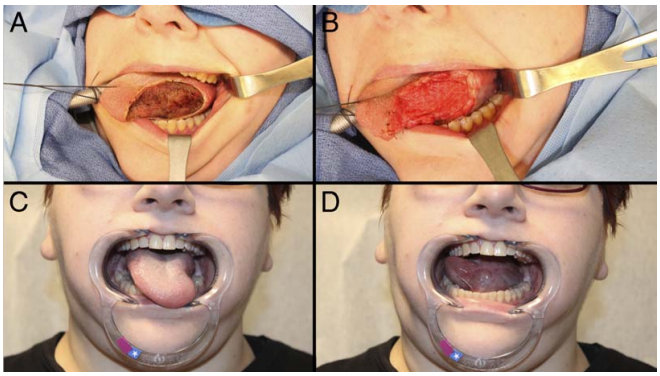

FIGURE 1. Case of partial glossectomy reconstructed with extracellular matrix-based biomaterial. (A) Average size of defects resection of benign lesions. (B) Extracellular matrix-based biomaterial sutured in place to reconstruct the defect. (C) Postoperative picture showing good healing with minimal contraction. (D) Postoperative picture showing good tongue range of motion with minimal tethering to the floor of the mouth.

vantages over traditional skin grafts, including the elimination of donor site morbidity and enhanced patient quality of life. Their antimicrobial properties and rapid revascularization further support their use in clinical practice. These findings highlight the value and versatility of ECM-based biomaterials for tongue reconstruction.

While our study provides valuable insights into using ECM-based biomaterials for tongue reconstruction, it has limitations. The retrospective design and relatively small sample size may limit the generalizability of our findings. Further investigation should evaluate the response between patients reconstructed with EMC-based biomaterials and traditional split or full-thickness skin grafts and evaluate postoperative functional outcomes such as swallowing and speech.

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