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ORIGINAL RESEARCH

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Reconstruction of oral cavity defects using myogenous-only scapular tip free-flaps

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Abstract

Background: Oral cavity reconstruction is very challenging anatomical subsite to reconstruct. Large defects often require free tissue reconstruction to provide the best chance of form and function. Additionally, free tissue reconstruction aids to prevent fistula formation. We aimed to determine outcomes of oral cavity defect reconstruction using scapular tip free flaps with a myogenous intraoral component.

Methods: All patients with a mandibular or maxillary bony defect that included a disruption of the intraoral mucosa component between 07/1/14 and 07/31/17. Patients were reconstructed with a scapular tip free flap, which included a muscular component that was used to recreate the oral mucosa. The primary study outcomes were flap success rates, development of orocutaneous or oronasal fistula, rate of resuming oral diet as well as the occurrence of medical and surgical complications in the first month following surgery. The tested hypothesis was formulated before data collection began.

Results: Twenty-five patients were identified by the study criteria. There was one (4%) flap that failed, while orocutaneous fistula occurred in two patients (8%). Prior history of osteoradionecrosis was a statistically significant predictor of overall complication ($p < .05$).

Conclusions: Intraoral myogenous reconstruction allows for re-mucosalization of the oral cavity defect and is associated with high viability and low-complication rates. In patients with amenable oral mucosal defects, a myogenous scapular tip free flap is a suitable reconstructive option.

KEYWORDS
free flap, mucosalization, myogenous, oral cavity reconstruction, scapula tip

1 | INTRODUCTION

Large defects of the oral cavity has continued to be one of the most challenging anatomic subsites to reconstruct. The oral cavity has

Level of evidence: 4

cutaneous, mucosal, and bony components closely associated with each other that poses many challenges to reconstructive surgeons. The introduction of osteo-cutaneous free tissue transfer in combination with titanium reconstruction plates in the 1980's has been transformative; it allows for primary bony and mucosal reconstruction which re-establish facial contour and, even in select cases, provides adequate bone stock for dental implantation. The iliac crest flap was first introduced for this indication, but was quickly followed by the fibular and scapular free flaps.[1–4]

A variety of possible flap designs exist based off of the subscapular vascular system. These allow for chimeric inclusion of scapular lateral border bone, scapular tip bone, scapular (horizontal) or parascapular (axial) or thoracodorsal artery perforator (TDAP) skin, a myogenous or myo-cutaneous element from the latissimus as well as serratus muscle. This great versatility has led to the continued popularization of this donor site for composite defects of the oral cavity.[5,6] The addition of myogenous elements has been touted for its ability to prevent salivary fistulas.[7] Additionally, designing the bony reconstruction based on the angular artery to the scapular tip has increased the available pedicle length.[8] The scapular bone has been also lauded for its natural contour which seems to easily replace angle and body mandibular defects as well as maxillary and palatal defects.[6]

Free, regional, or local tissue transfer with cutaneous or mucosal elements remain the mainstay of oral cavity reconstruction. However, there is mounting support in the literature as to the utility of myogenous reconstruction for oral mucosal defects.[9–14] The use of myogenous only reconstruction can be considered for smaller intraoral mucosal defects where one subsite (alveolus) required reconstruction, or as a backup if an adequate perforator for TDAP was not found or if the subcutaneous tissue was deemed to be too thick. Myogenous pedicled flaps with the masseter and temporalis have been reported, as well as myogenous free tissue transfer with latissimus or vastus lateralis.[9–12]

Seminal reports have recently begun to emerge also demonstrating good outcomes with myogenous closure or the oral mucosa in conjunction with osseous free tissue reconstruction of the mandible and maxilla.[5,13,14] Intriguingly, Gennaro et al. report comparable salivary fistula rates comparing cutaneous covered free tissue reconstructions of the maxilla and mandible to those covered by only a 5–20 mm cuff of surrounding muscle (sutured to the oral mucosa).[14] We herein report the largest case series to our knowledge using myogenous closure of oral cavity in mandibular and maxillary free tissue reconstruction using the scapular tip based off of the angular artery. Patient factors, surgical technique, complications, and reconstructive outcomes are presented and discussed.

2 | MATERIALS AND METHODS

2.1 | Data source and study population

Approval from the University of North Carolina at Chapel Hill Biomedical Internal Review Board for human research was requested and granted for retrospective chart review of head and neck free tissue transfer at our institution. All patients provided documentation for medical photographs and the use of their nonidentifying photographs in publications. Chart review of all cases of free tissue transfer performed by the senior author at a single academic referral center over the study period, January 1, 2014–July 31, 2017, was performed.

Exclusion criteria for this study were donor sites other than the scapula tip based off the angular artery, resection not resulting in a combined osseous and mucosal defect requiring reconstruction, and resections outside of the oral cavity. Twenty-five cases were identified after exclusions were applied.

2.2 | Analysis

Patient demographics, patient comorbidities, smoking history, surgical descriptors, complications, tumor factors where applicable, the type of muscular elements included in the free tissue transfer and dimensions of the muscular elements. All data was manually extracted from the medical record.

TABLE 1 Clinical characteristics of overall study population of 25 patients

Age, mean (SD)	57 (13)
Female sex, *n* (%)	13 (52)
Race	
African American, *n* (%)	9 (36)
Caucasian, *n* (%)	15 (60)
Other, *n* (%)	1 (4)
Current smoker, *n* (%)	6 (24)
Past smoker, *n* (%)	13 (52)
Pack/years, mean (SD)	26.5 (17.8)
Comorbid conditions	
Diabetes mellitis, *n* (%)	7 (28)
Hypothyroidism, *n* (%)	3 (12)
Chronic obstructive pulmonary disease, *n* (%)	1 (4)
Coronary artery disease, *n* (%)	3 (12)
Surgical indication	
Malignancy, *n* (%)	11 (44)
Benign tumor, *n* (%)	2 (8)
Osteoradionecrosis[a,b], *n* (%)	11(44)
Trauma, *n* (%)	1 (4)
T4 stage, *n* (%)	7 (70)
Stage III–IV, *n* (%)	8 (80)
Osseous site involved	
Mandible, *n* (%)	19 (76)
Maxilla, *n* (%)	6 (24)

[a]Includes one case of bisphosphonate-related osteonecrosis.
[b]Significant predictor of complication $p < .05$.

Continuous variables were summarized by the mean ± SD. Nominal variables were summarized by the frequency and percentage. All statistical analyses were performed using the R-project and Excel.

Representative intraoperative and postoperative photographs were obtained with patient consent from the medical record. Descriptive analysis of the cosmetic and functional results were performed based on the surgeon's postoperative evaluations and postoperative photographs.

3 | RESULTS

3.1 | Surgical technique

Patients were positioned as previously described by Clark et al.[15] Briefly, patients were placed in a modified lateral decubitus position, with the aid of a suction bean bag. The ipsilateral arm was placed in a sterile stockinet wrapped with self-adhering bandage and secured in a natural position during the ablative portion of the case. The arm was mobilized at harvest initiation to aid access to the axilla. This surgical setup allows for simultaneous harvest and resection with two present surgical teams.

The technique and relevant anatomy of scapula tip flap harvest has been previously described.[15] Harvest is approached from an incision following the anterior border of the latissimus. An effort is made to maintain all major vessels until the angular artery and other critical vasculature based on design are clearly identified. The pedicle is extended by dissection of the thoracodorsal or even subscapular arteries and veins proximally into the axilla. The inferior-lateral border of the scapula is harvested to include the tip with 90-degree cuts when reconstructing the mandible. A horizontal cut releasing the entire tip is used for maxillary reconstruction. The bony cuts are made with reciprocating saw after division of the muscular attachments of the scapula tip to the serratus. The pedicle is then divided as the last step of the harvest. The donor sites are closed primarily in layers in all cases and typically two suction drains are placed to minimize the occurrence of postoperative hematoma or seroma.

3.2 | Patient outcomes

The demographic and patient factors from the cohort of 25 cases are summarized in Table 1. Indications for reconstruction were most commonly osteoradionecrosis and postablative defect after surgery for malignancy. Of the patients undergoing oncologic resection the great majority were advanced tumor stage (Table 1). Nineteen patients received reconstruction of the mandible and six received reconstruction of the maxilla. 24% of patients were smoking at the time of surgery and 52% had significant history of smoking in the past. The most common comorbid condition was diabetes mellitus (Table 1). Interestingly, one patient in our series had sickle cell trait, which was found after free flap failure on postoperative day 6.

TABLE 2 Surgical descriptors and complications

Surgical time, mean (SD)	10 h (1.7)
Primary muscle elements incorporated	
Teres major, *n* (%)	7 (28)
Latissimus, *n* (%)	18 (72)
Length of bone harvested, mean (SD)	7.3 cm (1.8)
Minimum	4.0 cm
Maximum	10.2 cm
Number of osteotomies	
1. *n* (%)	4 (16)
2. *n* (%)	1 (4)
Hospitalization length, mean (SD)	11.5 (4.8)
Average time to ambulation, mean (SD)	3 (1.9)
Oral intake in < 10 days, *n* (%)[a]	10 (40)[a]
Patients with complications, *n* (%)	6 (24)[b]
Return to OR within 30 Days, *n* (%)	5 (20)
Hematoma, *n* (%)	2 (8)
Fistula/infection, *n* (%)	1 (4)
Flap failure, *n* (%)	1 (4)
Total flap failure	1 (4)
Removal of hardware/partial flap debridement	2 (8)
Salivary fistula	2 (8)

Abbreviations: OR, operating room; SD, standard deviation.
[a]One patient required G-tube.
[b]One patient had an NSTEMI POD2.

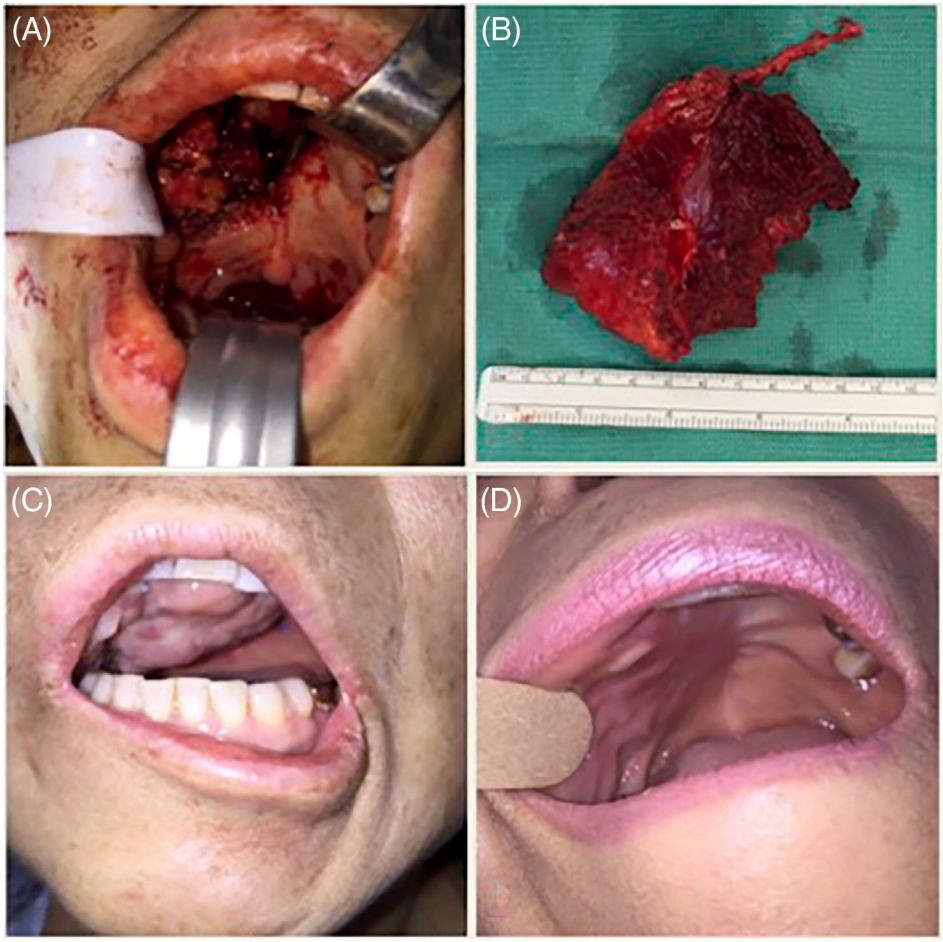

FIGURE 1 Patient status-postpartial maxillectomy for palatal hemangioma. Intraoperative defect (A) filled with scapular tip and subscapularis muscle (B). (C) 3 month follow-up, note persistent edema. (D) At 6 months, muscle is atrophied and fully re-mucosalized.

Descriptors of the surgery and postoperative course are summarized in Table 2. Osseous elements as long as 10.2 cm were harvested. Osteotomies were used in five cases and were not associated with an increased number of complications. In 18 of 25 cases, a chimeric myogenous component (latissimus muscle only) was utilized in the oral closure (Table 2). In seven (six maxilla, one mandible reconstruction) cases the oral closure was performed using the primarily the teres major muscle attached to the scapula bone. Forty four percent of patients resumed oral diet in less than 10 days and on average resumed ambulation at POD 2. Shoulder range of motion was ascertained from postoperative ambulatory physical examination documentation in the medical record. One free flap failure was reported; a second free flap was later performed to reconstruct the defect and was successful using contralateral scapula incorporating the teres major muscle for oral reconstruction. Two patients developed orocutaneous salivary fistula, one of which required reoperation for debridement and washout. Both fistulas resolved following conservative management and prolonged enteral feeding. Relation between preoperative comorbidity and outcomes did not approach statistical significance except in the case of prior history of osteoradionecrosis in relation to overall complication ($p < .05$).

Median follow-up time for patients was 12.4 months with a range of 1.5–63.1 months. Two patients with mandibular reconstruction were found to have intraoral plate exposure at four- and nine-months postop follow-up. Both of these patients had their hardware removed and primary closure of their intraoral defect. One patient with mandibular reconstruction had external neck skin granulation tissue that tracked to the plate. The tract was excised 5 years after the initial operation with complete closure postoperatively. One patient with mandibular reconstruction had external hardware exposure that was removed 10 months after the initial surgery.

Subjective information on long term shoulder function was available for 21 patients. Twelve had no limitation in shoulder range of motion. Of the nine patients where shoulder range of motion remained asymmetric, the limitation was typically very mild and not bothersome to the patient.

4 | DISCUSSION

In review of the series of patients, several important aspects of scapular tip reconstruction are evident-it allows for versatility in bony reconstruction, the incorporated muscles reliably swell, atrophy, and re-mucosalize, and the surgeries have both a low-complication rate and donor site morbidity. The application of this myogenous-only method of relining the oral cavity is not widely utilized as an

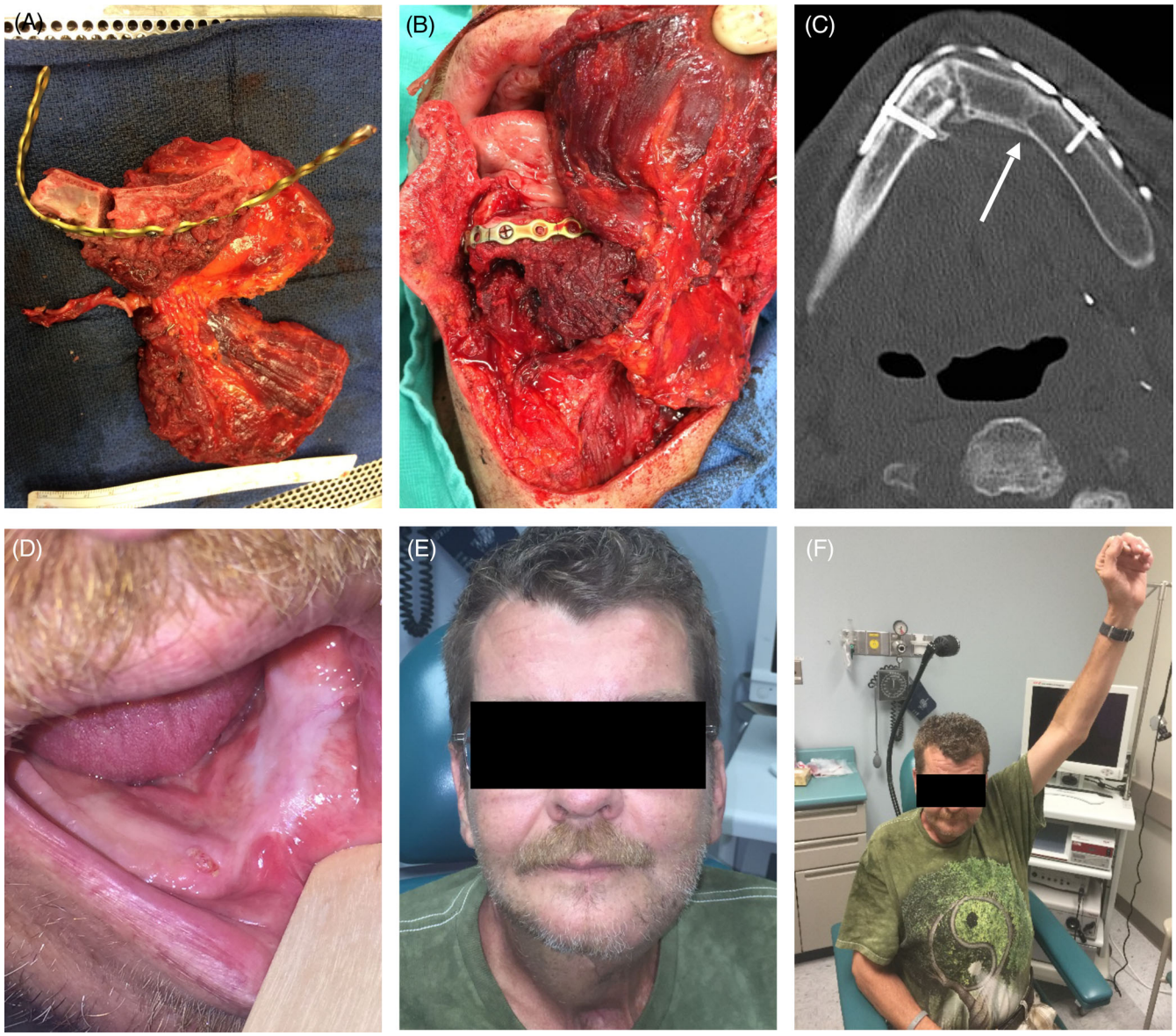

FIGURE 2 (A) Single osteotomy scapula. (B) Latissimus muscle for intraoral component. (C) Postoperative CT, scapula (image-right) mirrors native mandible, arrow at union. (D) One-year later, intraoral muscle re-mucosalized, (E) Edema resolved, and (F) Full shoulder ROM.

alternative choice when incorporating bone flaps for composite reconstruction. There are times when the patient's anatomy precludes a usable or reliable myocutaneous, fasciocutaneous, or perforator skin flap therefore the muscle-only portion of the flap is an appropriate option in these scenarios. Key properties of this method are exemplified in the following cases:

The first is a female who underwent a right partial maxillectomy and tracheostomy for resection of a slowly growing palatal hemangioma. A 6 × 3 cm maxillary defect remained (Figure 1A). Her right scapular tip was harvested, as described above, and designed to incorporate a large cuff of teres major muscle for the intraoral aspect (Figure 1B). The pedicle was re-anastomosed to the ipsilateral facial artery and vein. She ultimately had a 7-day hospitalization which included decannulation on POD 6 and resumption of a postoperative (oral) diet on POD 7 prior to discharge. At her 3-month follow-up visit intraoral swelling of the teres major was seen as well as full re-mucosalization of the muscle (Figure 1C). The edema decreased and muscle continued to atrophy to a near-normal appearance, at her 1-year follow-up (Figure 1D). The myogenous component used for all maxillary reconstruction was the teres major muscle.

The second case is a male who developed osteoradionecrosis of his mandible 2 years following chemoradiation of a Stage IVA base of tongue squamous cell carcinoma. He underwent a left segmental mandibulectomy from the mandibular body to right parasymphysis. His left scapular tip was harvested to include teres major and subscapularis muscles and the thoracodorsal artery was incorporated to include a section latissimus muscle. An osteotomy was required for mandibular symphysis and body reconstruction, with care taken to

leave periosteum intact on the inner aspect of the bone.[16] The plated bone flap can be seen in Figure 2A, the bone was then inset to native mandible with the latissimus muscle used for intraoral closure of the alveolus (Figure 2B). Anastomosis was made to the ipsilateral facial artery and external jugular vein. During his 9-day hospitalization the patient received a laparoscopic gastrostomy tube on POD 8 and was decannulated POD 9 with discharge later that day. He underwent a swallow study on POD 16 and began slowly advancing an oral diet. Unfortunately, he then presented in respiratory distress due to supraglottic lymphedema requiring replacement of the tracheostomy on POD 25. The patient was successfully decannulated 16 days later. The rest of his postoperative course remained without further significant event. At his one-year follow-up CT shows bony union formation (Figure 2C) complete intraoral remucosalization (Figure 2D) and atrophy to be near-symmetric to his right alveolus (Figure 2E). The patient had also returned to his preoperative left shoulder range of motion following harvest (Figure 2F) as well oral diet with removal of his gastrostomy tube. All mandible reconstruction used latissimus muscle for closure of the intraoral defect, except one case where teres major was used.

As evidenced in the series, scapular tip bone can reconstruct complex maxillary and mandibular defects.[5,7] The intrinsic curvature of the bone allows for reconstruction of the mandibular body without the need for osteotomies. In this study, an osteotomy was not needed in 20 of the 25 patients. However, in patients where osteotomies were required, all flaps survived despite concerns raised in prior studies and further corroborating results seen recently.[7,17]

This patient cohort demonstrates that free flap reconstructions based on the scapular tip offer a unique variability in terms of soft tissue reconstruction. All flaps included in the study incorporated muscle only to re-mucosalize the oral cavity. We found this useful and necessary in cases where excess flap bulk (subcutaneous tissue and skin) would be deleterious, but primary closure of mucosal defect would be impossible. Closure of a mucosal defect along the mandibular alveolus when performing mandibulectomy for osteoradionecrosis exemplifies this situation as these mucosal defects can be very large or very small depending on disease extent. The free muscle can fill this void as necessary. Similarly, we found that the bony reconstruction of the maxilla allows for maintenance of bony projection, prevents wound contracture and myogenous component provides excellent mucosal closure while limiting undesirable cutaneous flap bulk.

The initial general concern surgeons may have is the ability to achieve watertight closure to prevent postoperative fistula. As suggested by Syme et al. we found that the implanted musculature initially swells and becomes edematous.[13] We believe this is instrumental in aiding in a watertight closure, by sealing potential areas for fistula formation. The edema slowly resolves and within a year the muscle atrophies and contracts, closely resembling the surrounding mucosa (Figures 1C and 2D). Postoperative fistula in our group had a low-occurrence rate of 8% (2 patients). One was a delayed postoperative fistula on POD 15 after the patient was cleared to resume an oral diet on POD 11. She required readmission for gastrostomy tube and the fistula spontaneously closed following a month of NPO status. The second fistula occurred in a patient who was status-post extensive mandibular repair after self-inflected gunshot wound. She had intraoral breakdown allowing salivary leakage into the neck. This was treated with aggressive operative debridement and primary closure as well as G-tube for prolonged enteral feeding. The fistula had completely healed and closed by her 1 month postoperative visit. The low-fistula rate of 8% noted in this study is also comparable to rates experienced by other authors (12% of 33 muscle-only fibular and iliac crest flaps,[14] 1 of 3,[13] 1 of 17[18] and 0 of 15[7] osteomyogenous scapular flaps). In comparison to these studies our series remains the most comprehensive.

Furthermore, another concern can be contracture of the oral cavity using muscle-only flaps. We avoided the myogenous-only approach where the expected contracture would be deleterious. When there is significant involvement (>50%) of oral cavity sites adjacent to the alveolus, such as buccal mucosa, lip mucosa or floor of mouth and tongue, muscle contracture can cause trismus and lip or tongue tethering. In these scenarios, it may be prudent to include a skin component along with the muscle.

The postoperative complication rate related to flaps in the study (20%) was comparable to that of others.[7,13,14] Five patients required a second operation within 30 days. Four of these patients required emergent re-operation within the first week - two for postoperative hematomas, one for a postoperative orocutaneous fistula, and one due to a failed flap. The other re-operation was the patient requiring the replacement of tracheostomy on POD 25 due laryngeal edema secondary to lymphedema. One patient also experienced an NSTEMI on POD 2. All complications occurred in patients with osteoradionecrosis; which was found to be statistically significant in predicting possible complication ($p < .05$). Long term follow-up of our patient cohort showed excellent mucosalization of the intraoral defects. Our study was not able to quantify the length of time it took for remucosalization to occur, however the authors note that it would be expected to be completely remucosalized in 4–6 weeks depending on the surface area.

The one flap failure occurred in a maxillary reconstruction with a left scapula osseomyogenous tip. The patient had a history of sickle cell trait, with osteoradionecrosis of the left maxilla following chemoradiotherapy for left maxillary sinus adenocarcinoma.[19] The patient emergently returned to the operating room on POD 6 finding that the flap was not salvageable. An obturator was made in the interim until the patient returned a year later for reconstruction. The patients second surgery was reconstructed with the contralateral chimeric osteomyogenous scapula tip and myocutaneous latissimus flap, with the scapular bone and teres major muscle reconstructing the palatal mucosal defect and the myocutaneous latissimus flap for infraorbital cheek skin reconstruction. This operation was a success and as of the 8-month follow-up the patient continues to do well - the palatal defect has re-mucosalized and the flap remains viable.

Also inferred from the study was the low sequelae of donor site morbidity. Our protocol is to implement an out-of-bed and ambulation

order on POD 1. As the average age of the patient cohort was 57 ± 13 years, early ambulation was important in order to limit the potential for pneumonia or postoperative thrombotic occurrences. All patients were out of bed to chair on POD 1, and 18 (72%) of patents ambulated by POD 3. Four patients that did not achieve ambulation by POD 3 were either noncompliant or limited by medical factors. Ambulation data was not clearly delineated on the remaining three patients. Many patients had peripheral vascular disease and their advanced age made them poor candidates for fibular free flap.[19] Postoperatively all patients worked with physical and occupational therapy in order to return to preoperative shoulder range of motion levels as well as to decrease the changes of shoulder pain syndrome in the patients that required a neck dissection. The majority of the patients, 57%, regained their full range of motion. The eight who did not, while limited, were not debilitated by their decreased range and continued to regain function while working with physical therapy. Previous studies with the disabilities of the arm, shoulder, and hand (DASH) validated questionnaire showed that the shoulder function of patients after scapular tip free flap is comparable to that of the population at large.[20] In this series, upper extremity range of motion and strength were examined subjectively during routine postoperative examinations. Shoulder abduction was found to be compromised in 7 of 25 patients at 1-month follow-up. Further studies regarding objective measurements of shoulder morbidity are warranted. Since this series, we have instituted use of the DASH survey to better quantify donor site morbidity.

This study has several inherent limitations, primarily in its low-sample size. Unfortunately, there are no standardized patient outcome measures to quantify postoperative oral function or comprehensive donor site morbidity. Sample bias was also introduced in the cohort through patient-specific comorbidities and desires. Further sample bias was created by the characteristic of the defects and the surgeon's preferences while considering the reconstruction plan. We continue to collect data on patients receiving flaps and aim for future studies with enough patients to demonstrate statistical significance. There are also errors introduced inherent to retrospective cohort studies such as information bias, as not all participants included in the study had all study parameters recorded. This has been addressed as our database grows in recording potential areas of interest in subsequent operations.

5 | CONCLUSION

The scapular tip flap with a chimeric muscle-only component is a reliable source for re-mucosalization of the oral cavity. The flap has a high-success rate, low rate of fistula formation, and is an excellent candidate in oral cavity reconstruction due to its robust vasculature and low-donor site morbidity. It is yet another option in the reconstructive surgeon's armamentarium and should be considered for intraoral mucosal defects involving either the maxilla or mandible.

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CONFLICTS OF INTEREST

No conflicts of interest have existed in previous 24 months.

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