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RECONSTRUCTION OF MAXILLOFACIAL CANCER DEFECTS BY SUPRACLAVICULAR FLAPS

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ABSTRACT

INTRODUCTION: Rebuilding head and neck defects is a chief challenge to the maxillofacial surgeons especially after cancer resection, trauma, infection and craniofacial deformities. Earlier, the use of obturators for many years has been a successful treatment plan. However, recently several surgical modalities are available for the restoration of such defects as locoregional or microvascular free flaps. Objectives: To evaluate the reliability of the supraclavicular flap in the reconstruction of the maxillofacial defects. **METHODOLOGY:** Eleven patients were included in the study who required reconstruction of the maxillofacial defects due to squamous cell or mucoepidermoid carcinoma through harvesting of the supraclavicular flap (SCF). The patients were followed-up for at least 6 months. The mean harvesting time, length/width of the flap, range of mouth opening, general complications after the surgery and the complications related to the flap were assessed. Results: The mean harvesting time of the flap was 45.45±4.16 minutes. The flap mean length was 22.64±1.12 cm, whereas the mean width was 6.14±1.14 cm. The flap survived in 9 patients while two patients had complete flap loss. Conclusion: The pedicled SCF represents a safe and feasible option that can be used to reconstruct a wide array of maxillofacial oncologic defects.
KEYWORDS: Surgical flaps, Supraclavicular flap, Maxillofacial Reconstruction.
RUNNING TITLE: Supraclavicular Flap in Maxillofacial Reconstruction.

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INTRODUCTION

Head and neck reconstruction is one of the main challenging tasks to the maxillofacial and plastic surgeons especially after cancer resection, trauma, infection and craniofacial deformities (1, 2). Those defects can negatively affect the quality of life of the patients in the form of impairment of speech, mastication and deglutition disorders as well as psychological and social problems caused by disfigurement, dysfunction, malformation, and morbidity if not adequately repaired (3).

Surgeons worldwide have constantly made huge attempts to locate elite reconstructive techniques for repairing those defects (3). Earlier, the use of obturators for many years has been a successful treatment plan allowing immediate dental restoration without further surgery with some the limitations of poor retention, oronasal incompetence or being unsuitable for tongue defects or those at the floor of the mouth (4). Lately, a number of surgical options are accessible for the reconstruction of the maxillofacial defects as non-vascularized bone grafts, locoregional or microvascular free flaps (5).

Locoregional flaps such as submental, pectoralis or supraclavicular flap had attracted attention in the last few years in maxillofacial reconstruction mainly when free flaps could not be the first choice in some conditions (6).

For many years, reconstructive surgeons have used myocutaneous and fasciocutaneous flaps for closure of defects following resection of oral cancers. Pectoralis major myocutaneous flap is the workhorse for reconstruction of these defects in developing countries. The pedicled flaps are easy to harvest and are very reliable. However, these flaps can be too bulky and can also lead to donor site morbidity. With advancements in knowledge of vascular anatomy and physiology of skin, several forgotten flaps like supraclavicular flap were rediscovered. Few studies in literature have described the usefulness of this flap in oral reconstructions. It is a reliable fasciocutaneous pedicled flap in suitable patients which can reduces surgical time and morbidity (7).

The supraclavicular flap (SCF) is an efficient and reliable locoregional flap with some pros including but not limited to alike skin color of the recipient

area, wide rotation of the arc and fairly rapid harvesting time with minimal donor site morbidity providing effective and robust cover (8, 9).

Despite the advances in the use of the locoregional flaps, some complications as ischemia can occur after the transfer of the flap due to tissue hypoperfusion resulting in partial or complete loss of the flap (10).

Given the rise in the incidence of maxillofacial cutaneous malignant neoplasia, the provision of satisfactory treatment to repair the resulting facial defects can pose a significant surgical challenge (11). In the past two decades, previous studies have demonstrated the reliability of supraclavicular artery island flap (SCAIF) for refractory defects from trauma, medication/radiation-induced osteonecrosis, and cancer ablation. Nevertheless, utilization of this flap is currently rather limited among surgeons (12). Thus, the aim of this study was to evaluate the reliability of the supraclavicular flap in the reconstruction of the orofacial defects.

PATIENTS AND METHODS

Ethical approval and Registration

This study was performed at the Department of Maxillofacial and Plastic Surgery, Faculty of Dentistry, Alexandria University from September 2021 to June 2022. The study protocol was approved by the Research Ethics Committee of Faculty of Dentistry, Alexandria University under the number IRB No. 001056–IORG 0008839-0280-09/2021.

Sample size calculation

Sample size was estimated assuming 5% alpha error and 80% study power. According to Li et al (13), 88.5% of Supraclavicular Flaps were survived without any signs of complications and 11.5% had complications. Using a sample size calculator for a single proportion where the null percentage of success is 50% based on chance, the minimum required sample size was calculated to be 11 patients. Sample size was based on Rosner's method (14) calculated by Brant's sample size calculator at the University of British Columbia (https://www.stat.ubc.ca/~rollin/stats/ssize/n2.html) .

Study Participants

Eleven patients were included in the study for maxillofacial reconstruction and signed an informed consent before participating in the surgical procedure. The follow-up of the patients was at least 6 months.

Eligibility Criteria

The patients were included if they required reconstruction of oral cavity defects or soft tissue and skin defects of lower and middle thirds of the face.

The patients were excluded if they had previous neck dissection, previous surgeries in the shoulder region that might compromise the flap vascularity or previous radiotherapy in the maxillofacial region.

Doppler Ultrasonography (DUS)

All patients underwent pre-operative doppler ultrasonography of the donor shoulder using HI-dop vascular doppler (BT-200V, Bistos Co.Ltd, Korea) equipped with a linear probe (2-8 MHz) to auscultate the location of the supraclavicular artery in the neck posterior triangle.

Harvesting of the supraclavicular flap

After the tumor resection, the flap was harvested immediately after the resection of the tumor for the reconstruction of the defect. Briefly, the patient's neck was turned away from the side of harvesting the flap and a sandbag was placed under the patient's shoulders to expose the region. The flap was then designed with a marker on the patient's shoulder extending anteriorly to the clavicle, posteriorly to the trapezius muscle, and laterally to the deltoid muscle. Doppler was performed to detect the supraclavicular artery and ensure the integrity of the pedicle. The flap was raised from the distal side, involving the skin, subcutaneous tissue and fascia. Minimal dissection was done medial to the external jugular vein to allow flap rotation into the defect and then the donor site was closed primarily after wide undermining. After the flap was harvested, the recipient site was prepared by resection of the tumor with the safety margins making sure that the margins and bed was adequately perfused by blood by bleeding of the margins while the donor site was covered with a warm saline gauze and the blood supply of the distal end of the flap was evaluated. De-epithelialization of the proximal portion of the flap was performed in the part that will be tunneled. The flap was tunneled under the skin of the neck to reach the defect. The donor site was sutured over a suction drain. The surgical technique for the harvesting of the supraclavicular flap and reconstruction of the maxillofacial defect was shown in **Fig. 1i and Fig. 1ii**.

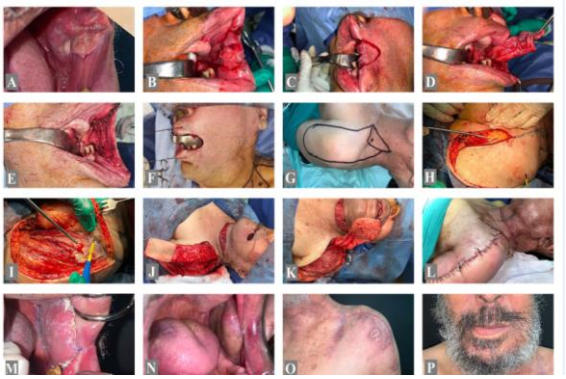

Fig. 1i: The surgical technique for harvesting of the supraclavicular flap and reconstruction of the maxillofacial defect.

A 68-year-old patient was diagnosed with cheek squamous cell carcinoma with involvement of the commissure of the mouth. (A) Intra-oral view of the lesion involving nearly the whole buccal mucosa reaching the commissure. (B) Intra-oral marking of the lesion with the safety margin before resection.

(C) Marking the extra-oral part of the commissure that would be resected. (D) The mass before complete separation from the posterior buccal mucosa. (E) Complete removal of the lesion. (F) Extra-oral defect after complete resection. (G) Flap design with marking of the supraclavicular artery inside the triangle after being detected by doppler ultrasound. (H) Incisions at the distal part of the flap. (I) Complete elevation of the flap and de-epithelialization of the proximal part of the flap. (J) Elevation of the distal part of the flap at the sub-fascial plane. (K) Flap reaching the corner of the mouth before tunneling. (L) Direct closure of the doner site using sutures and stapler. (M) Intra-oral picture of the flap two weeks after surgery (N) Intra-oral picture of the flap three months after surgery. (O) Follow-up of the donor site three months after surgery. (P) Extra-oral picture of the patient three months after surgery.

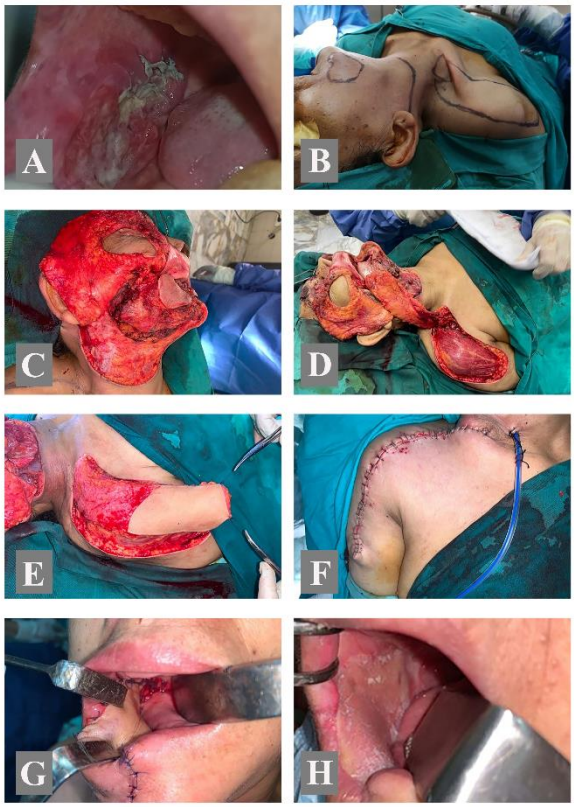

Figure 1ii: Second Case for the surgical technique for harvesting of the supraclavicular flap and reconstruction of the maxillofacial defect.

A 62-year-old patient was diagnosed with squamous cell carcinoma in the mandible. (A) Intra-oral photo of the squamous cell carcinoma invading the right side of the mandible. (B) Marking the skin that would be resected with the tumor with showing the supraclavicular flap design. (C) Elevation of the neck flap leaving the invaded skin attached to the tumor. (D) The distal part of the flap after incision and elevation reaching the corner of the mouth before tunneling. (E) De-epithelialization of the proximal part of the flap. (F) Direct closure of the doner site using sutures and stapler. (G) Intra-oral picture of the flap two weeks after surgery. (H) Intra-oral picture of the flap three months after surgery.

Postoperative care

The patients were admitted to the intensive care unit (ICU) with their neck tilted towards the side of the flap. All patients received the same parenteral antibiotic (Maxipime, Cefepime, 2 gm, Smith Kline Beecham, Giza, Egypt) as well as non-steroidal anti-inflammatory (Ketolac, Ketorolac Tromethamine 30 mg/2 ml, Amriya Pharmaceuticals, Alexandria, Egypt) twice daily for seven days. The flap was monitored twice daily for the first two weeks after surgery to examine the color, texture, temperature, capillary refill, and scratching of the flap. Good oral hygiene was maintained for patients with intra-oral flaps.

Post-operative complication assessment

Postoperative complications were evaluated and classified as general complications after the surgery as dehiscence, infection and fistula formation or flap-related complications as distal flap necrosis, referred pain in the shoulder, shoulder drop or hypertrophic scar. The patients were followed-up for at least 6 months.

Primary Outcome

The primary outcome of the study was to evaluate the reliability of the supraclavicular flap in the maxillofacial region in terms of harvesting time, possible length and width of the flap to be harvested without flap failure and the range of mouth opening after reconstruction with the flap.

Statistical Analysis

Statistical analysis was done using SPSS (IBM Statistical Package of Social Science, version 24.0. Armonk, NY: IBM Corp. The mean and standard deviation were used to present normally distributed quantitative variables (Age, time of flap harvesting, flap length, flap width, mouth opening. All qualitative variables are displayed using frequency and percentage. Shapiro Wilk test and Q-Q plots were used to check the normality of the data.

RESULTS

This study included eleven patients, four females and seven males with a mean age of 62.91±10.34 years (Range between 41 and 75 years) who completed the study. The supraclavicular flap was most related to squamous cell carcinoma in 10 patients (90.9%), while one patient had mucoepidermoid carcinoma (9.1%). The mean defect size was 40.82±16.89 cm^2. As for the comorbidities, two patients had diabetes mellitus (18.2%) while 4 patients (36.4%) had a history of cigarette smoking being a risk factor.

Seven flaps (63.6%) were on the left side of the shoulder while four flaps (36.4%) were harvested from the right side. The doppler signals were

identified in the pedicle of all the patients before raising the flap. The mean harvesting time was 45.45±4.16 minutes. The length of the flap ranged from 20-24 cm, with an average length of 22.64±1.12 cm, whereas the average width of the flap was 6.14±1.14 cm. The mean post-operative drainage days were 5.27±0.65 days and then the drain was removed after those 5 days. The patients had mouth openings ranging from 15-45 mm with a mean of 36.18±10.12 mm. Further details of the Demographic Data and flap outcomes were presented in **Table 1.**

Table 1: Demographic Data of the patients and outcomes of the flap

Variables		**N=11**
Mean Age (Years)		62.91±10.34
Gender	Male	7(64%)
	Female	4(36%)
Primary Disease	Squamous Cell Carcinoma	10(91%)
	Mucoepidermoid Carcinoma	1(9%)
Defect Area (cm^2)		40.82±16.89
Comorbidities	Diabetes	2(18%)
Smoking		4(36%)
Side of the flap: n (%)	Right	4 (36.4%)
	Left	7 (63.6%)
Flap outcome: n (%)	Complete Flap Loss	2 (18.2%)
	Distal End Necrosis	2 (18.2%)
	Survived	7 (63.6%)
Complications of the flap		
Referred pain in shoulder (Donor site): n (%)	Yes	2(18.2%)
	No	9 (81.9%)
Hypertrophic Scar (Donor Site): n (%)	Yes	5 (45.5%)
	No	6 (54.5%)
Shoulder Drop: n (%)	Yes	1 (9.1%)
	No	10 (90.9%)
General Complications after surgery		
Infection: n (%)	Yes	3 (27.3%)
	No	8 (72.7%)
Dehiscence: n (%)	Yes	3 (27.3%)
	No	8 (72.7%)
Fistula: n (%)	Yes	1 (9.1%)
	No	10 (90.9%)
Sensation in flap (Recipient Site): n (%)	Yes	8 (72.7%)
	No	3 (27.35)
Time of flap harvesting (min)	Mean±SD	45.45±4.16
Flap length (cm)	Mean±SD	22.64±1.12
Flap Width (cm)	Mean±SD	6.14±1.14
Mouth opening (Cm)	Mean±SD	3.73±0.79

At the time of operation, the donor-site was primarily closed in all the patients (100%). The flap survived in 7 patients (63.6%) while distal end necrosis was detected in 2 patients (18.2%) and complete flap loss was identified in another 2 patients (18.2%). Sensation in the flap was determined in all the patients except three (27.4%). Only 2 patients suffered from referred pain in the shoulder (18.2%). Following the surgery, only one patient suffered from shoulder drop (9.1%). Five patients (45.5%) developed a hypertrophic scar after the surgery. Three patients had infection and dehiscence (27.3%) where one only had the defect to be closed by skin graft (9.1%) while another patient had fistula formation (9.1%).

DISCUSSION

Many modalities have been practical in the reconstruction of the facial defects which were challenging with the microvascular free flaps being the most popular (15). However, those modalities are not appropriate for every patient nor achieve good outcomes (16). Moreover, surgeons frequently deal with patients previously treated and presented with a recurrent disease or old patients suffering from severe medical comorbidities which may impede or impose a microvascular procedure (15).

There has been an ongoing interest in the use of pedicled regional flaps for the reconstruction of oral cavity cancer defects (17). Our initial experience in this study confirmed that the supraclavicular axial flap was extremely reliable flap gaining popularity as a definitive option in the reconstruction of the orofacial region. The SCF is safe, capable of being rapidly and easily harvested in addition to being valuable for reconstructing a variety of maxillofacial defects. It is considered to be the 'workhorse' popular locoregional maxillofacial reconstruction flaps being thin with short harvesting time, reliable vascular supply, wide arc of rotation, as well being close to the skin of the face both in the sense of texture and pliability with matching color to the maxillofacial region and also does not require microsurgical training (18, 19). In our study, we have assessed the reliability of the supraclavicular flap in the orofacial region. Supraclavicular flaps proved to be effective for the reconstruction of the maxillofacial defects in a study by Alves et al, 2012 which reconstructed mostly oral cavity (20).

Some contributors such as diabetes or smoking can cause failure of the local pedicled flap. Our analysis indicated an association between diabetes and the increased risk of flap necrosis. Diabetes had a negative impact on the survival of the supraclavicular flap in the study as it causes modification of proteins that decrease endothelial function due to the formation of toxic and antigenic glycation end products (21).

Not only diabetes played role in the flap necrosis but also cigarette smoking in our study. This is due to the fact that cigarette smoking results in poor post-operative wound healing (22) owing to tissue hypoxia, thrombogenesis compromised flap vessels and cellular dysfunction (23) which was proved in a study by Hwang et al, 2018 that have attributed flap failure to cigarette smoking (24).

The mean harvesting time of our supraclavicular flap was 45.45±4.16 minutes which was similar to other studies by Alves et al, 2012 and Shenoy et al, 2013 that reported harvesting time to be within 50 minutes or less than 1 hour (20, 25)

We have proved that there is a positive correlation between the distal end flap necrosis and flaps longer than 22 cm. In our study, the flaps with the length of 22 cm and above increased the risk of distal necrosis while using the modified technique for harvesting the flap has resulted in better results even in flaps more than 22 cm. In accordance with our results, Kokot et al, 2013(26) testified that flap length greater than 22 cm resulted flap necrosis. On the other hand, a study reported that there was no statistical correlation found between flap necrosis (27). From our results, the flap width was between 5 and 9 cm with a mean width of 6.14±1.09 cm. This coincides with a study of Ismail et al, 2016 (28) indicating a maximum width of 11 cm. Alternatively, another study by Balakrishnan et al, 2012 (29) reported a flap width extending up to 27 cm with a mean width of 21.8 cm due to the involvement of the middle supraclavicular nerve and the external jugular vein in the flap. The normal mouth opening is around 30-50 mm in healthy individuals while patients are considered to have reduced mouth opening if it is 20 mm maximum (30). The average mouth opening in this study was 36.18±10.12 mm which is similar to the results of a study of Weber et al, 2010 (31) and higher than that found by another study by Scott et al, 2008 (32) where the average mouth opening was 32 mm. It is normal to have limited mouth opening or the mouth opening is less than before the surgery. The reason for such adequate limitation of the mouth opening is that in ablative procedures are associated with various degrees of tissue contracture and scarring (33).

In a study by Hunt et al, 2014 (34), it was reported that the donor site can be closed primarily without skin graft if the flap width was less than 10 cm which was in accordance with our study. There are several factors affecting the harvesting of the flap.

Another remarkable finding is that the sensation at the recipient site was retained in the SCF in most patients due to the preservation of the cutaneous branches of the cervical plexus at the flap edges near the posterior aspect of the neck which usually results in sensation in the flap reflected in a study by Atallah et al, 2015 (35). In our study, a minor complication accompanied the use of the SCF in very few patients which was the referred sensation to the shoulder region from the flap. This might be attributed to the flap being transferred with an intact sensory neural innervation of the middle supraclavicular nerve (34). Using the SCF did not result in shoulder morbidity in the form of shoulder drop in our study except in only one patient. This was in the same direction of a study that reported in patients receiving SCF, normal mobility of the shoulder joint (36). The SCF did not result in any shoulder morbidities reported in another study by Herr et al, 2014 (37).

It is noticeable that some of our patients in the study have developed hypertrophic scars due to contracture in the wound healing process after flap harvesting. This might be attributed to closure of the wound with excessive tension, position of the wound in areas of skin with high natural tension such as the shoulders or infection of the wound (38).

There was a minimal rate of complications in this study following the use of the supraclavicular flap in the reconstruction of the defects which was managed conservatively. Our results were comparable to those studies published indicating partial or complete flap necrosis in minor number of patients and a relatively low incidence of complications supporting an overall success using the supraclavicular flap as an option in maxillofacial reconstruction. Of those complications, partial or complete flap necrosis, fistula formation, wound dehiscence or infection have been reported which was in line with other previously published studies by Razdan et al, 2015 and Wong et al, 2019 while none of our patients died of flap-related complications (19, 39).

In our study the advantages of the flap were ease of flap elevation, pliability and thin texture, minimal donor site morbidity and short operating time which was in accordance to Padiyar et al, 2018 (7). The only drawback limiting its utility would be the length of the flap as it is a rotational flap being less capable of reconstructing some complex head and neck defects (26).

The main limitation of our study was related to the limited number of patients for evaluating the supraclavicular flap.

CONCLUSION

Local and regional flaps remain a useful means for maxillofacial reconstruction with exceptional characteristics not available with free flaps. The success of those flaps would be improved by the better understanding the vascular anatomy and recent basic science. On top of the list for locoregional flaps, the pedicled SCF represents a good and feasible option used to reconstruct a wide range of the maxillofacial defects due to malignancies. It is easy to raise with minimal donor site morbidity and short harvesting time. It is advisable to investigate the relation between the SCF and the limitation of the mouth opening in addition to larger sample size with a specific area affection affecting the cheek and muscle of mastication.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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