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The submental island pedicled flap and supraclavicular artery island flap in a free flap practice

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Abstract

Reconstruction of head and neck defects is a delicate endeavor that poses numerous intrinsic and extrinsic challenges, which are currently magnified by rising health care costs and limitations in system resources. Current trends in the United States heavily favor the use of free tissue transfer over locoregional pedicles flaps (LRPF); however, the latter group is often undervalued, offering high utility, practicality, and cost-efficiency whilst providing equivalent results. The submental island flap and supraclavicular artery island flap are two LRPF that should be in the arsenal of the modern reconstructive surgeon.

Keywords: Head and neck reconstruction, free tissue transfer, locoregional pedicled flap, cost efficiency, oral cavity, oropharynx

INTRODUCTION

The reconstruction of oral cavity and oropharyngeal defects is often the most challenging aspect of surgical management of head and neck disease. Given the immense variability in intrinsic tumor biology, size and anatomical location, patient-specific factors, and health system resources, there is no standardized algorithm for reconstruction, and treatment must be tailored on a case-by-case basis. Furthermore, given that functional rehabilitation often requires a prolonged course, patient "buy-in" and adherence are additional factors that must be considered on an individual basis for long-term success.

Generally speaking, the primary goal of reconstruction involves restoration of both function and form, while at the same time minimizing donor site morbidity. Options for reconstruction generally include locoregional pedicled flaps (LRPF) and microvascular free tissue transfer (FTT). Over the past several decades, the treatment paradigm has shifted several times in the United States. Although the concept of a reconstructive ladder historically provided a systematic manner to approach surgical techniques from simplest to most complex based on defect and pathology, reconstruction in the modern era is less stringent and FTT is often employed for defects across the spectrum of complexity.

Historically, the use of LRPF in head and neck reconstruction was first popularized by McGregor[1] in the 1960s with the axial-pattern forehead flap supplied by the superficial temporal artery. This flap provided a robust option for reconstruction of many sites including the oral cavity, face, and pharynx, and was considered the workhorse flap for head and neck reconstruction up until the late 1970s[2]. During this period, increasing concern regarding donor site morbidity and cosmesis led to anatomic studies into independent myocutaneous vascular territories in the body, which ultimately paved the way for the first localized myocutaneous rotational flaps[3]. Since its inception in 1979, the pedicled myocutaneous pectoralis major flap, as described by Ariyan, remains a popular option today for locoregional reconstruction[4].

Although the first report of end-to-end microvascular anastomosis dates back to 1887 by Eck[5], it was not until the 1970s that free tissue transfer gained traction as a viable option for reconstruction[2,6]. McLean and Buncke[7] described the use of vascularized omentum for scalp reconstruction in 1972 and the first cutaneous free flap was described in 1973 by Daniel and Williams[8]. In addition, Chinese surgeons during this period are often credited for the development of the radial forearm free flap; however, their work remained unknown to the western hemisphere for a number of years due to political isolation[9]. Despite these advances, the momentum and surgical trend towards FTT in head and neck reconstruction somewhat stagnated with the introduction of the previously described pectoralis major flap, which provided reliability without the need for special microvascular skills.

It was not until the mid-1980s that there was renewed interest in FTT. The radial forearm free flap, which had been described more than a decade prior, gained popularity amongst head and neck surgeons owing to its pliability and ease of harvest, and was widely considered the workhorse of soft tissue reconstruction by the 1990s. In addition, the introduction of the composite fibular flap by Hidalgo[10] in 1989 solved many of the problems with hardware exposure with pedicled myocutaneous flaps. This, along with the osteocutaneous flaps of the subscapular system, vastly improved the functionality aspect of head and neck reconstruction.

As of the present, the current paradigm in head and neck reconstruction is being challenged. Although FTT represents the state-of-the-art standard for addressing substantial defects of the head and neck, nearly three decades of experience with LRPF has led to technical advances and a better understanding of maneuvers to improve outcomes. Furthermore, increasing economic pressures have strained healthcare systems in the United States and have challenged surgeons to improve efficiency and cost-effectiveness. With these factors in mind, it is important to reconsider the utility of LRPF in an era where FTT is often considered the gold standard for composite defects. Herein we describe and discuss two high-yield options for LRPF and implications for a reconstructive practice.

SUBMENTAL ISLAND PEDICLED FLAP

History

The submental island pedicled flap was first described in 1993 by Martin *et al.*[11] in their search to identify an alternative LRPF for the reconstruction of the face. At the time, the various cervical flaps used for facial reconstruction were based on random supply and posed several drawbacks including equivocal reliability, reach limited to the lower third of the face, and donor site morbidity[11]. The submental island flap (SIPF) solved many of these issues owing to its ease of harvest, excellent reliability, and long pedicle. Furthermore, given its location posterior to the mandibular arch and pliability of skin in the area, closure of the donor site was noted to be relatively tension free with a well-hidden, favorable scar. Sterne *et al.*[12] first described the use of this flap for intraoral defects in 1996, and for the past two decades, it has remained a popular technique owing to its pliability, wide arc of rotation, and single operative field. Patel *et al.*[13] further refined the technique in 2007, with early dissection of facial vessels and inclusion of the mylohyoid muscle providing additional protection to the distal submental pedicle and cutaneous perforators, which improved reliability, ease of harvest, and led to enhancement of trainee education. Furthermore, this important modification has been independently observed to significantly reduce the rate of flap-related complications[14].

Surgical technique and pearls

Depending on the nature of the expected surgical defect and the presence of a one *vs.* two surgeon team, we generally opt to harvest and mobilize the flap prior to performing any extirpative surgery. Generally, a unilateral hemiapron incision is designed laterally, merging into the lateral apex of the planned submental skin flap. Generally, a "D" or crescent-shaped paddle is designed. The choice of paddle size is variable; however, efforts should be taken to prioritize primary closure of the donor site, which can be predicted with a pinch test. Following marking of the planned incisions, the neck is sharply opened and subplatysmal flaps are elevated. Although incisions are also made around the periphery of the flap, we initially do not violate the subcutaneous tissue and fascia underlying the skin paddle. The marginal mandibular nerve and its associated branches are then located and carefully dissected, and retracted superiorly. At this point, meticulous dissection of the submandibular gland is performed, with particular care given to preventing undue sheering on the facial artery and submental pedicle. Arterial branches into the submandibular gland are carefully clipped and ligated. Once the gland has been removed from the field, the submental vessels are dissected a short distance to the lateral border of the mylohyoid, and further dissection is terminated. The flap is then raised from the contralateral side in a subplatysmal plane and the midline of the mylohyoid muscle is approached. At this point, the sacrifice of the ipsilateral anterior belly from its origin at the digastric fossa facilitates inferior displacement of the submental artery pedicle and provides clear visualization of the mylohyoid muscle. The mylohyoid is then transected at the midline and detached from the mandible and the hyoid, without violating the underlying geniohyoid muscle. This maneuver then allows complete mobilization of the flap. At this point, dissection of the vascular pedicle can proceed proximally towards the great vessels to increase total pedicle length and arc of rotation. The flap may then be tunneled subcutaneously or intraorally as needed. The donor site can then be readily closed primarily.

Pitfalls

Although the SIPF is widely regarded as a robust locoregional option for head and neck reconstruction, several important points have been made regarding its utility. Of note, the most common criticism is its role in patients with advanced oral cavity cancer with locoregional disease. The entirety of the oral cavity, including the tongue, lips, and floor of the mouth, has a robust lymphatic system with a drainage pathway that incorporates the level I lymph node basin. Given that dissection of the SIPF involves including the lymphatic packet of level IA, there remains a concern that occult disease may inadvertently be transposed into an oncologically "clean" defect. For this reason, we generally feel that any clinical or radiographic evidence of deeply invasive tumor or level IA locoregional disease should be a firm contraindication for proceeding with a SIPF. Sporadic level IB disease is considered a relative contraindication but can be safely dissected away from the vascular pedicle. Retrospective studies have otherwise demonstrated a high degree of oncologic safety when these factors are accounted for[15].

Another disadvantage in male patients is the persistence of hair-bearing skin in the recipient bed, which can be both mechanically irritating and aesthetically unfavorable. The use of Nd:YAG laser therapy has shown to be > 90% efficacious in the treatment of intraoral hair secondary to flaps from hairy donor sites and may be an excellent mode of therapy[16]. Furthermore, radiation-induced alopecia from patients undergoing adjuvant treatment may also be a welcomed adverse effect in the post-surgical period[17].

SUPRACLAVICULAR ARTERY ISLAND FLAP

History

The concept of cutaneous flaps from the shoulder dates back to 1842, as described by Mütter[18], who made use of random supply flaps for burn reconstructions. In 1903, the Austrian anatomist, Carl Toldt described a preserved vessel originating from the thyrocervical trunk exiting between the sternocleidomastoid and trapezius muscles and named it *arteria cervicalis superficialis*. From this initial work, the so-called "in charretera" flap was developed by Kirschbaum[19], which provided a viable option for the reconstruction of chest and neck defects. Later, the flap technique was slightly modified and became known as the cervicohumeral flap, as popularized by Mathes and Vasconez[20] in the 1970s. Over the next decade, the reliability of the flap was challenged, as evidenced by nearly a 40% incidence of distal flap loss, and investigations were undertaken to better understand the vascular anatomy of the region[21]. In 1979, Lamberty[22] described the supraclavicular artery as a distinct, preserved branch of the transverse cervical trunk and proposed an axial flap taken from the area superior to the clavicle. Despite his meticulous descriptions, interest in the flap waned until it was revisited by Pallua *et al.*[23], Pallua and Magnus Noah[24] in the 1990s, who formally named it the supraclavicular island flap and described a method for tunneling the pedicle which reduced the length of the donor site scar and improved distal skin reliability. Following this body of work, there was renewed interest in the flap, and the first report of it as a method for reconstruction of head & neck oncologic defects was proposed by Chiu *et al.*[25] in 2009. For the past decade, the supraclavicular artery island flap (SCAIF) has remained a popular option for defects of the lower face, neck, pharynx, and oral cavity.

Surgical technique and pearls

Adequate perfusion of the supraclavicular artery is paramount to the success of the SCAIF. If there is any question regarding the integrity of this artery, CT angiography or duplex studies may be performed preoperatively. Intraoperatively, the location of the supraclavicular artery is routinely found in the triangle formed anteriorly by the clavicle, medially by the posterior border of the sternocleidomastoid muscle, and laterally by the external jugular vein. In most cases, the artery will be identified at the middle third of the clavicle and a doppler ultrasound probe can be used to confirm flow through the vessel. In addition, a doppler may be used to trace the artery as it courses laterally towards the acromion, where the signal will fade as it pierces the deep fascia of the deltoid muscle. The skin paddle is then designed with usually a 6-7 cm width and a total length around 20-22 cm from the fulcrum point at the origin of the pedicle. Additional skin distal to the acromion may be incorporated; however, the deltoid tuberosity is usually considered the maximum limit of the flap to avoid distal necrosis. The flap is generally raised in a distal to proximal fashion at the subfascial plane of the deltoid muscle, with special care taken as the acromion is approached in order to prevent inadvertent injury to the pedicle. In this area, we routinely switch to bipolar cautery to facilitate meticulous dissection. Anteriorly, the flap is raised to the clavicle, where the clavicular periosteum may be harvested to further protect the pedicle. Posteriorly, the flap is raised to the anterior border of the trapezius, where branches of the spinal accessory may be encountered. Generally, it is preferred to avoid excessive skeletonization of the pedicle; however, level V adipose and nodal tissue may be dissected if a longer arc of rotation and reach is needed. If the flap is to be tunneled, the proximal skin paddle must be de-epithelized. Prior to inset, the distal edge of the flap is judiciously trimmed to ensure adequate perfusion. After the flap has been transposed and tunneled into the defect to be reconstructed, the donor-site defect is widely undermined in order to facilitate tension-free primary closure. Typically a single drain is placed into the donor site bed to prevent hematoma and seroma formation.

Pitfalls

Overall, the SCAIF is a versatile, reliable locoregional flap that can be easily tailored to address a variety of oncologic defects. Despite these characteristics, there are a few limitations to its utility. First, given that the flap is often relatively far from its area of inset, efforts to elongate the cutaneous paddle increase the risk of distal flap necrosis. In a retrospective case series of 45 patients, Kokot *et al.*[26] reported that a total flap length greater than 22 cm was correlated with flap necrosis. Similar findings are also reported in studies evaluating the SCAIF for post-burn neck reconstruction[27]. In addition to a maximal length of a flap that may be harvested, another important consideration is the feasibility of flap harvest in the setting of a level V lymph node dissection. Surgery in this area has the potential to disrupt the vascular pedicle supplying the flap. However, this challenge may be overcome by meticulous dissection. Furthermore, a history of radiation to the cervical region in the setting of salvage surgery has the possibility of both disrupting the vascularity of the flap, as well increasing the technical difficulty of harvesting the flap secondary to radiation-induced fibrosis[25].

OUTCOMES COMPARED TO FREE TISSUE TRANSFER

Renewed interest in LRPF has led to increased investigations into its utility and functional outcomes compared to FTT. A number of recent studies have challenged the traditional notion that more intricate, complex reconstruction with FTT is required to achieve the best functional outcomes.

A recent retrospective study by Kozin *et al.*[28] directly compared the SCAIF and FTT for a variety of head and neck defects and found that the former offered decreased total operative time, length of hospitalization, and cost, with comparable rates of wound healing and post-operative complications, including wound infections, dehiscence, and hematoma. In addition, Zhang *et al.*[29] compared functional outcomes between the SCAIF and radial forearm flap (RFFF) for hemiglossectomy defects and found no significant differences in post-operative speech and swallow function at six months. Additionally, the SCAIF group was noted to have a significantly lower rate of donor-site complications with a reduced length of hospitalization.

Similar investigations have been undertaken for the SIPF. A recent meta-analysis by Jørgensen *et al.*[30] compared the SIPF to the RFFF and anterolateral thigh flap and found no significant difference between the groups in terms of complete flap loss and need for debulking procedures. Of note, total operative time and length of hospitalization were found to be significantly lower. Furthermore, there was no difference in local, regional, and distance recurrence of tumor, highlighting the oncologic safety of transposing tissue from the level I region[30]. Finally, much like the SCAIF, studies have demonstrated comparable speech and swallow outcomes between the SIPF and FTT[31,32].

ECONOMIC IMPLICATIONS FOR A RECONSTRUCTIVE PRACTICE

Worldwide, FTT has become the mainstay of the oral cavity and oropharyngeal reconstruction over the past two decades, offering precise tailoring of defects with specific tissue types, while delivering superior wound healing and overall outcomes. However, the amount of resources needed to successfully and efficiently perform FTT are immense, necessitating surgeons with microvascular training, specialized equipment and instrument trays, and an intensive care unit (ICU) with nurses familiar with flap monitoring protocols. In a health care system with limited resources, these costs may lead to fewer patients receiving timely surgical care and potential diversion to external treatment centers. Numerous studies have demonstrated the adverse effects of prolonged wait times for treatment of head & neck cancers, including tumor progression, TNM upstaging, and local recurrence[33,34]. The undertreatment of these patients may ultimately contribute to the rising cost of head and neck cancer care, which is projected to exceed five billion US dollars annually during this decade[35].

One measure which has been advocated for to reduce the cost of FTT is the utilization of post-operative step-down units instead of ICUs. Admission to the ICU has been previously associated with nearly a $23,000-$35,000 increase in costs per admission and has also been shown to increase total hospitalization length[36-38]. A number of studies over the past two decades have demonstrated that monitoring of flaps can safely be performed outside of the ICU without adverse outcomes on flap survivability[39-42]. Despite these results, a recent survey conducted by Kovatch *et al.*[38] of ACGME-accredited otolaryngology programs found that more than 75% of institutions routinely admit patients to the ICU following FTT. Although this discrepancy may be partially attributed to historical trends and surgeon preference, there remains the question of the availability of specialty-specific step-down units, with dedicated one-to-one nursing staff who are able to proficiently monitor flaps. In an institution where FTT may be infrequent, it may not be economically feasible to develop and maintain these types of units when a general ICU may make more financial sense.

By its very nature, LRPF provides ways to overcome many of the economic burdens of FTT. Since no microvascular anastomosis is required, the need for specialized training and equipment is obviated and procedures can often be performed in a shorter period of time. In addition, since pedicled flaps do not require close monitoring in the immediate post-operative period, the need for ICU-level care may be obviated (on a case-by-case basis), which can account for thousands of dollars in savings.

CONCLUSION

Reconstruction of head and neck cancer defects is a taxing endeavor, both in terms of intrinsic challenges posed on a case-by-case basis, but also because of rising health care costs and limitations in resources. The current paradigm challenges the reconstructive surgeon to find a cost-effective solution that can be delivered in a timely manner with satisfactory outcomes. Although LRPF has taken a back seat compared to FTT over the past decade, there is renewed interest in utilizing these techniques as they may provide superior results at a reduced cost in certain scenarios.

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Authors' contributions

Made substantial contributions to conception and design of the review and authorship of the manuscript: Hussaini AS, Patel UA

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