

Efficacy and Safety of Microsurgical Pharyngolaryngeal and Pharyngoesophageal Reconstruction: A Systematic Review of the Literature

Konstantinos Gasteratos, MD,
MSc*

Nikolaos Vlachopoulos, MD,
MSc†

George Kokosis, MD‡

Jeremy Goverman, MD, FACCS§

Background: Restoration of function and complication management after pharyngolaryngectomy remains a challenging task. The aim of our study was to compare the functional and clinical outcomes of pharyngolaryngeal and pharyngoesophageal reconstruction using free flaps, namely jejunal (FJF), anterolateral thigh, and radial forearm, and describe a reconstructive approach for these defects following tumor resection.

Methods: We performed a systematic literature review on PubMed (Medline), Embase and Cochrane Library over the last two decades for articles reporting the surgical reconstructive modalities available after total or partial pharyngeal and/or laryngeal resection using a structured search strategy and strict inclusion and elimination criteria.

Results: Our search identified a total of 677 articles, 112 full texts were fully reviewed for eligibility, and 39 met the inclusion criteria. The use of both FJF and fasciocutaneous flaps is safe. The FJF has optimal swallowing outcomes and a low incidence of major recipient-site complications. Nevertheless, free fasciocutaneous flaps exhibit comparable functional results, while they seem linked with fewer cases of perioperative mortality and flap failure. However, none of the currently available techniques can combine all potential benefits.

Conclusions: Despite these procedures being mainly palliative in nature, the advent of microvascular techniques and utilization of fasciocutaneous free flaps has allowed optimal restoration of function combined with a reduced rate of perioperative and longterm complications. Both FJF and fasciocutaneous flaps can be viable treatment options, depending on the expertise of the surgeon and patient selection, to ensure the best outcomes. (*Plast Reconstr Surg Glob Open* 2023; 11:e4958; doi: [10.1097/GOX.0000000000004958](https://doi.org/10.1097/GOX.0000000000004958); Published online 27 April 2023.)

INTRODUCTION

Pharyngolaryngeal carcinomas account for 8%–10% of head and neck malignancies with an annual incidence of 1:100,000 in North America and up to 14.8 per 100,000 in Europe. They tend to carry an overall poor prognosis, recurring an average of 9.7 months postexcision. Death

typically occurs within twelve months from treatment, due to the advanced stage (III or IV) of the disease at the time of diagnosis for the majority of the patients (70%–85%).¹ Smoking and heavy alcohol consumption are among the major predisposing factors with a male-to-female predominance of 5–20:1.²

These tumors pose a unique challenge; they can infiltrate the trachea and/or the laryngeal apparatus, often requiring a combined approach consisting of chemotherapy, radiation therapy, and surgical resection. Depending on the staging of the disease, a salvage total pharyngolaryngectomy may be necessary.³ In some selected cases, a hypopharyngeal resection and partial resection of the cervical esophagus with larynx preservation may suffice

From the *Antiagers Clinic, Athens, Greece; †251 Hellenic Air Force General Hospital, Athens, Greece; ‡Division of Plastic and Reconstructive Surgery, Rush University Medical Center, Chicago, Ill; and §Sumner M. Redstone Burn Center, Department of Surgery, Massachusetts General Hospital, Boston, Mass.

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to achieve locoregional disease control. Despite these organ-preserving treatment modalities, residual malignancy, recurrent disease, nonfunctional larynx, and damaged surrounding skin may ensue, rendering the disease quite debilitating.³ Being mainly palliative in nature, the ultimate goal of treatment is the improvement in the long-term quality of life (QoL) of the patients.⁴ The challenging task of restoring the function of swallowing, breathing, and speaking rests with the reconstructive team.²

Although thoracic and general surgeons typically use pedicled visceral flaps, such as gastric transposition (gastric pull-up) and colonic or jejunal interposition flaps, the plastic surgeon is usually involved in more complex cases where free tissue transfer is required for hypopharyngeal and esophageal reconstruction.² Apart from the widely used free jejunal flap (FJF), free fasciocutaneous flaps [eg, radial forearm flap (RFF), anterolateral thigh flap (ALT)] and pedicled myocutaneous flaps (eg, pectoralis major flap) have been popularized over the last two decades and are now considered first-line treatment options, either for partial-circumferential defects or tubed in total-circumferential defects.¹ In general, compared with pedicled flaps, free tissue transfer provides more versatile and robust reconstructive options and offers a variety of advantages with optimized postoperative outcomes.

The aim of our study was to provide a comparison of functional and clinical outcomes of commonly utilized surgical reconstructive options (FJF, ALT, and RFF transfer) for pharyngolaryngeal (PL) and pharyngoesophageal (PE) reconstruction after tumor resection. The indications, benefits, and drawbacks, as well as QoL outcomes for each technique, are discussed, and a reconstructive approach for PL defects is described.

METHODS

Literature Review

We performed a literature search on PubMed (Medline), Embase, and Cochrane Library from January 1, 2000 to June 1, 2022 for articles reporting the surgical reconstructive modalities available after total or partial PL and PE resection using the following search strategy: (((“Pharyngeal Neoplasms”[MeSH Terms] OR “Laryngeal Neoplasms”[MeSH Terms]) AND (reconstruction OR surgery)) AND (jejunal free flap OR anterolateral thigh flap OR radial forearm flap)). We used the following as limits: full text, English language, and humans.

Screening Process and Eligibility Criteria

An online screening process was performed with two independent reviewers (K.G., N.V.) using the Covidence tool based on the following criteria. The screening procedure involved the elimination of results based on titles and abstracts. The remaining articles were screened against the eligibility criteria for inclusion. Conflicts in the selection process were resolved by discussion between the two reviewers.

Takeaways

Question: Are the free jejunal flap and fasciocutaneous flaps effective and safe methods for pharyngolaryngeal and pharyngoesophageal reconstruction?

Findings: Both methods are safe. The free jejunal flap combines optimal swallowing outcomes together with a low incidence of major recipient-site complications. Nevertheless, free fasciocutaneous flaps exhibit comparable functional results.

Meaning: Both the free jejunal flap and fasciocutaneous flaps can be viable treatment options depending on the expertise of the surgeon and patient selection to ensure the best outcomes.

For inclusion in this review, each study had to meet all of the following criteria: (a) English language; (b) full-text studies reporting the use of free flaps for PL and PE reconstruction; (c) retrospective review/case series reporting free jejunal, radial forearm and anterolateral thigh flaps. Excluded studies included (a) non-English literature; (b) studies evaluating the use of free flaps not specific to PL and PE defects, but in general for head and neck reconstruction surgery; (c) correspondence, letters to the editor, case reports, literature reviews; (d) studies not reporting morbidity and/or functional outcomes; (e) studies not explicitly distinguishing outcomes among the different types of reconstruction; (f) studies using an additional pectoralis major myocutaneous flap (PMMC) or other pedicled flap together with free tissue transfer.

Quality Assessment

A risk of bias (quality) assessment was conducted for the included retrospective case series/reports. The Methodological Index for Non-Randomized Studies (MINORS) scale was used.⁵ In this assessment tool, eight criteria are used to evaluate the level of evidence of non-comparative studies, and criteria are graded from 0 to 2 (0: not reported; 1: reported but inadequate; 2: reported and adequate); thus, noncomparative studies can achieve an ideal maximum score of 16. This quality assessment was conducted by two independent investigators (K.G., N.V.), and discrepancies were resolved through a mutual agreement.

Data Analysis

Categorical data were described as numbers and percentages. Chi-squared or Fisher exact tests were used to evaluate the differences in complication rates and functional outcomes of surgical procedures. All statistical tests were two-sided, and a *P* value less than 0.05 was considered statistically significant. Analyses were performed using R software, version 4.1.3.

RESULTS

Our search identified a total of 377 articles (after the removal of duplicates), which were screened by title and abstract. Of these articles, 112 were fully reviewed for

eligibility, and 39 met the inclusion criteria. These studies included 13 FJF, six RFF, and 14 ALT flaps, as well as nine mixed cohorts in which two different fasciocutaneous flaps were used (five papers for ALT/RFF, one for FJF/RFF and three for FJF/ALT). Whenever mixed cohorts were reported, only the subset of data on FJF, RFF, or ALT was used. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram generated by Covidence is shown in Figure 1.

The data extracted from the eligible studies included patient demographics, functional outcomes (speech and swallowing), mortality rates, and postoperative complications (fistulas, strictures, flap failures, and recipient- and donor-site complications). These parameters of interest are presented separately for each flap in Supplemental Digital Content 1–3 and are aggregated and compared in Table 1. (See table, Supplemental Digital Content 1, which displays the studies reporting outcomes after FJF

transfer. <http://links.lww.com/PRSGO/C522>.) (See table, Supplemental Digital Content 2, which displays the studies reporting outcomes after RFF transfer. <http://links.lww.com/PRSGO/C523>.) (See table, Supplemental Digital Content 3, which displays the studies reporting outcomes after ALT transfer. <http://links.lww.com/PRSGO/C524>.) MINORS scores ranged from 8 to 16; most (31 of 39) were graded more than 12 and were considered to have low-risk bias. Statistical significance was observed in some of the parameters analyzed with the Chi-squared test.

Patient Demographics

The total number of patients reported on all eligible studies was 1973 for FJF, 583 for ALT, and 279 for RFF. The mean age of patients was found to be 62.2 (range 61–64.9), 57.7 (range 51.1–63), and 60.6 (range 51.8–64) in FJF, RFF, and ALT groups respectively, reflecting

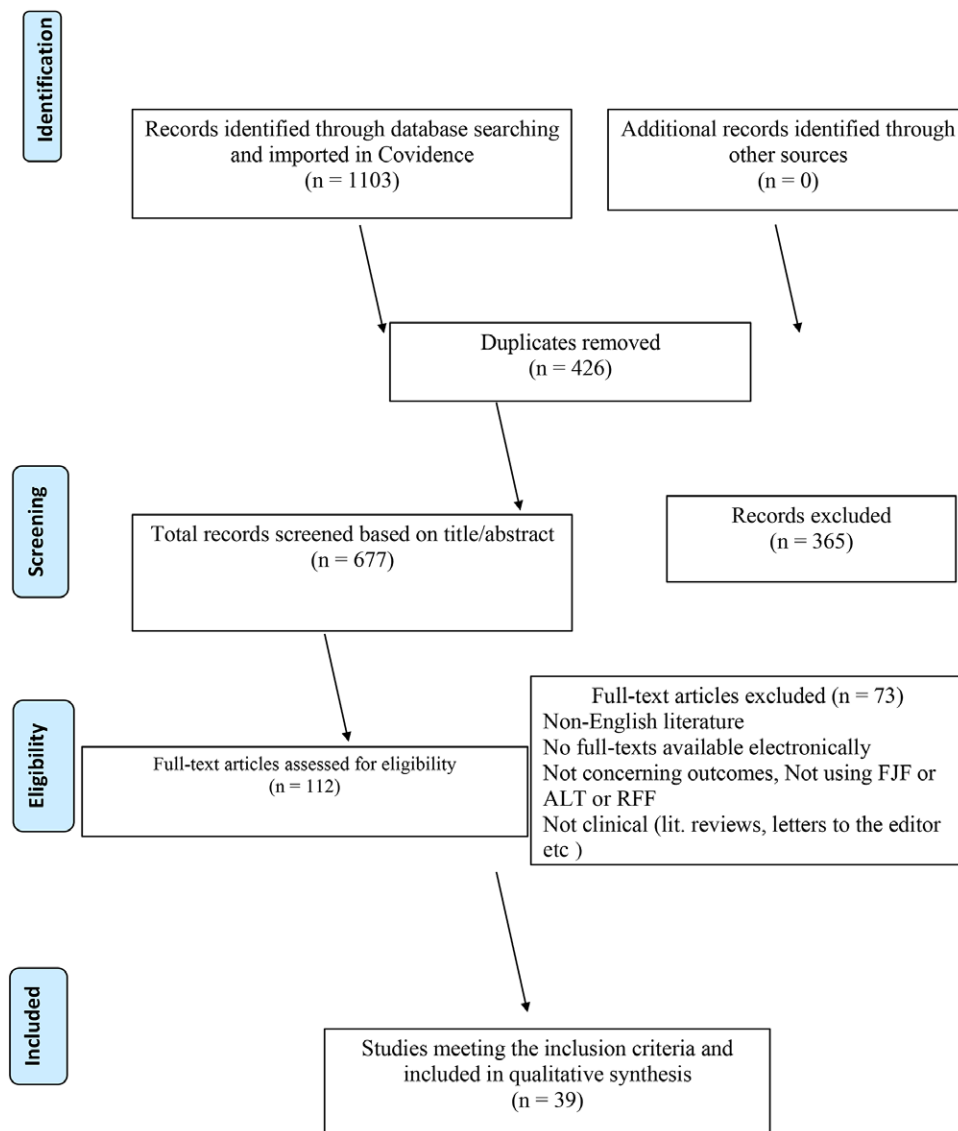


Fig. 1. PRISMA flowchart.

Table 1. Comparison of Outcomes between Different Reconstructive Techniques

Free Flap for Reconstruction	Patient Demographics			Functional Outcomes			Complication Rates					
	No Eligible Studies	Mean Age (y)	Male Gender (%)	Tracheoesophageal Puncture	Speech	Swallowing	Perioperative Mortality	Fistula	Strictures	Flap Failure	Recipient Site	Donor Site
FJF	16	62.4	1381 (83%)	189/478 (39.5%)	199/263 (75.7%)	990/1080 (91.7%)	36/1973 (1.8%)	181/1889 (9.6%)	153/1449 (10.6%)	58/1980 (2.93%)	155/1361 (11.4%)	77/1449 (5.3%)
ALT	21	60.6	443 (86%)	153/285 (53.7%)	118/153 (77.1%)	459/514 (89.3%)	3/496 (0.6%)	86/561 (15.3%)	75/559 (13.4%)	22/583 (3.8%)	54/338 (16.0%)	25/357 (7.0%)
RFF	11	57.7	109 (87%)	42/56 (75%)	38/42 (90.5%)	133/157 (84.7%)	1/279 (0.36%)	62/279 (22.2%)	49/217 (22.6%)	6/279 (2.2%)	27/66 (40.9%)	—
			1933 (84%)									

the average age of patients with laryngopharyngeal carcinomas. A total male-to-female ratio of 5.1:1 was reported in the studies (4.7:1 in FJF, 6.1:1 in ALT, and 6.4:1 in RFF).

Functional Outcomes

Two parameters were used to evaluate and compare functional outcomes among different flaps used for PE and PL reconstruction: speech rehabilitation and oral alimentation (swallowing ability/feeding tube independence). Less than 40% of the eligible studies reported speech outcomes, whereas 79.5% of the studies evaluated oral alimentation.

Tracheoesophageal puncture, defined as a surgical opening between the trachea and the esophagus to restore a person's ability to speak after the removal of the vocal cords, was mostly described in studies reporting speech outcomes after RFF transfer, achieving satisfactory speech rehabilitation in 90.5% of these cases. In the FJF cohort, comprehensive speech was described in significantly fewer cases (75.7%, *P* = 0.044).

Swallowing ability after PE resection and reconstruction can rarely be fully restored, with prolonged transit time being the norm, even in the absence of stenosis.¹ Oral alimentation was evaluated in relation to a feeding tube dependency. When a feeding tube was not required, patients were considered to have successfully restored their swallowing ability regardless of the type of diet tolerated (soft, liquid, or solid). In all studies, satisfactory swallowing rehabilitation was reported in more than 65% of the patients, while four studies reported tube independence in all patients. Better oral alimentation results were described after FJF transfer (tube independency in 91.7% of patients). Of note, in the largest cohorts of each group, which included 366 FJF,⁶ 114 ALT,⁷ and 52 RFF patients,⁸ successful swallowing rehabilitation was achieved in more than 90% of cases.

Fistula and Stricture

Pharyngocutaneous fistula is considered to be the most common and significant complication because it can unfavorably affect the functional outcome (voice and swallowing). Swallowing ability is also related to the occurrence of postoperative stenosis and strictures. Statistical analysis showed significantly more cases of fistula (22.2%) and stricture (22.6%) formation after RFF transfer, more than two times higher than after FJF transfer. The FJF group demonstrated the lowest frequency of fistula (9.6%) and stricture formation (10.6%), with a slightly higher frequency of these complications in the ALT group (15.3% and 13.4%, respectively). Nevertheless, the largest cohort including patients after ALT transfer⁷ showed a satisfactory low fistula and stricture formation rate of 9% and 6%, respectively.

Morbidity, Mortality, and Flap Failures

There were 40 (1.4%) perioperative deaths reported in all the studies reviewed. Although no statistical significance was observed, most cases of perioperative mortality were reported in the FJF group (36 cases, 1.8%), likely due to

the higher probability of serious donor-site complications (ileus, wound cellulitis, wound dehiscence, small bowel obstruction). Nevertheless, the ALT group demonstrated a higher frequency of minor donor-site complications compared with the FJF group (7% versus 5.3%). Partial or total flap failure had a relatively low incidence, ranging from 0% to 13% (higher in the ALT group, without statistical significance compared with the other two groups). Even though recipient-site complications (dehiscence, wound infection, bleeding, abscess, hematoma, venous obstruction, or thrombosis) were found to be three to four times more frequent after RFF transfer, articles differed in the definitions of their studied complications with some studies being more selective and others less specific. For instance, regarding RFF, Kao et al⁹ described such complications in 73% of patients, whereas Scharpf and Esclamando et al¹⁰ in 12% and Genden and Jacobson¹¹ in 18%. Thus, these results should be interpreted with caution.

DISCUSSION

The ideal treatment option for PE and PL reconstruction is a single-stage procedure with high reliability and a low perioperative and long-term complication rate. This procedure would effectively reconstitute the conduit between the oropharynx and the esophagus, would permit adequate swallowing ability and quick speech rehabilitation, and would offer improved functional, aesthetic, and QoL results soon after surgery.¹ None of the currently available techniques, however, encompasses all of these benefits. Furthermore, as each patient is unique, the treatment plan and the goals of reconstruction should be individualized.¹²

Our study suggests that both FJF and fasciocutaneous flaps can be viable treatment options. The FJF can be valuable for PE reconstruction, combining optimal swallowing outcomes (91.7% tube independence) with a low incidence of major recipient-site complications (9.6% PEF, 10.6% strictures). Nevertheless, fasciocutaneous flaps (ALT and RFF) exhibit comparable functional results (89.3% and 84.7% tube independency, 77.1 and 90.5% speech rehabilitation, respectively), and are associated with less perioperative mortality and partial or total flap failure. RFF and ALT flaps, therefore, can be considered viable options, especially in those patients in whom FJF is contraindicated.

Free Jejunal Flap

In some centers, the FJF remains a reliable method of PE reconstruction due to its high success rate (90%–100%) and ability to restore function.² This procedure allows for rapid return of oral feeds and swallowing. The vast majority of patients (85%–95%) resume swallowing and can maintain adequate nutrition without the need for tube feeds.¹³ The FJF is also radioresistant, has a long vascular pedicle, and is approximately the same as the cervical esophagus. Respiratory complications are rare; however, the jejunal mucosa is sensitive to ischemia, and microsurgical expertise is required to reduce ischemic time. The FJF has its own peristaltic action; therefore

isoperistaltic orientation is maintained after transfer to the neck.¹⁴ However, peristaltic activity was not found to be coordinated with the oral, pharyngeal, or esophageal phase of swallowing.³ The “wet” tone of the voice resulting from jejunal mucosal mucus production is another drawback.³

The indication for FJF transfer is a full- or near-full-circumferential (>50%) defect located within the pharynx and hypopharynx, and reconstruction is typically performed in a single-stage procedure.^{8,14} A two-stage operation using free jejunum/ileum flap transfer is also considered a safe and reliable option for esophageal reconstruction in cases where gastric pull-up is unavailable.¹⁵ Previous abdominal surgery does not necessarily exclude this as an option, but the general surgery team needs to confirm the patient’s candidacy preoperatively.¹³ FJF is contraindicated in patients with chronic intestinal diseases (eg, Crohn disease), grave medical conditions, and chronic liver disease with ascites.¹³ For a partial pharyngectomy defect, a “patch” of a free cutaneous flap is preferred over an FJF; although the FJF has been used to cover smaller defects of the cervical esophagus (<50%), fasciocutaneous free flaps are preferred for these situations.¹³

The most common recipient-site complications are strictures and fistula formation (8%–10%), and a history of preoperative radiation therapy increases the risk of local complications.^{8,13} Laparoscopic harvesting of the flap, when feasible, can lead to decreased donor-site morbidity.¹ Compared with other techniques, the microvascular jejunal transfer has a decreased flap failure, fistula and stricture formation, hospital length of stay, and earlier resumption of oral alimentation.^{13,16} Nevertheless, speech function is reported to be better for ALT and RFF flaps versus FJF.¹⁷

Radial Forearm Free Flap and Anterolateral Thigh Flap

In general, the primary indication for RFF and ALT flaps is a patient who is not a candidate for more extensive procedures utilizing abdominal viscera.² More recently, however, their use has expanded and is now recommended as first-choice options in the reconstruction of various clinical scenarios. Both RFF and ALT flaps can be used with great success to cover partial-circumferential (<50%) defects,¹⁴ allowing improved functional speech quality at the expense of increased fistula rates. Additionally, there are two more ways of utilizing a fasciocutaneous flap; pharyngeal (fascia-only/ adipofascial) interposition graft, and patch graft (with a skin paddle) to reinforce the primary pharyngeal closure, and the pharyngeal mucosa defect, respectively.³ Additionally, these flaps can be dissected and tubed to replace a total esophagectomy defect.² Furthermore, the ALT flap can be harvested as a chimeric flap, restoring concomitant laryngoesophageal defects as a result of the primary tumor resection.⁴

In contrast to the FJF, the free tubed RFF has a longer pedicle, is easier to dissect, and is more resistant to ischemia than the FJF (flap loss 1.8% versus 7.5%, respectively).¹ Another advantage is that it is pliable and matches

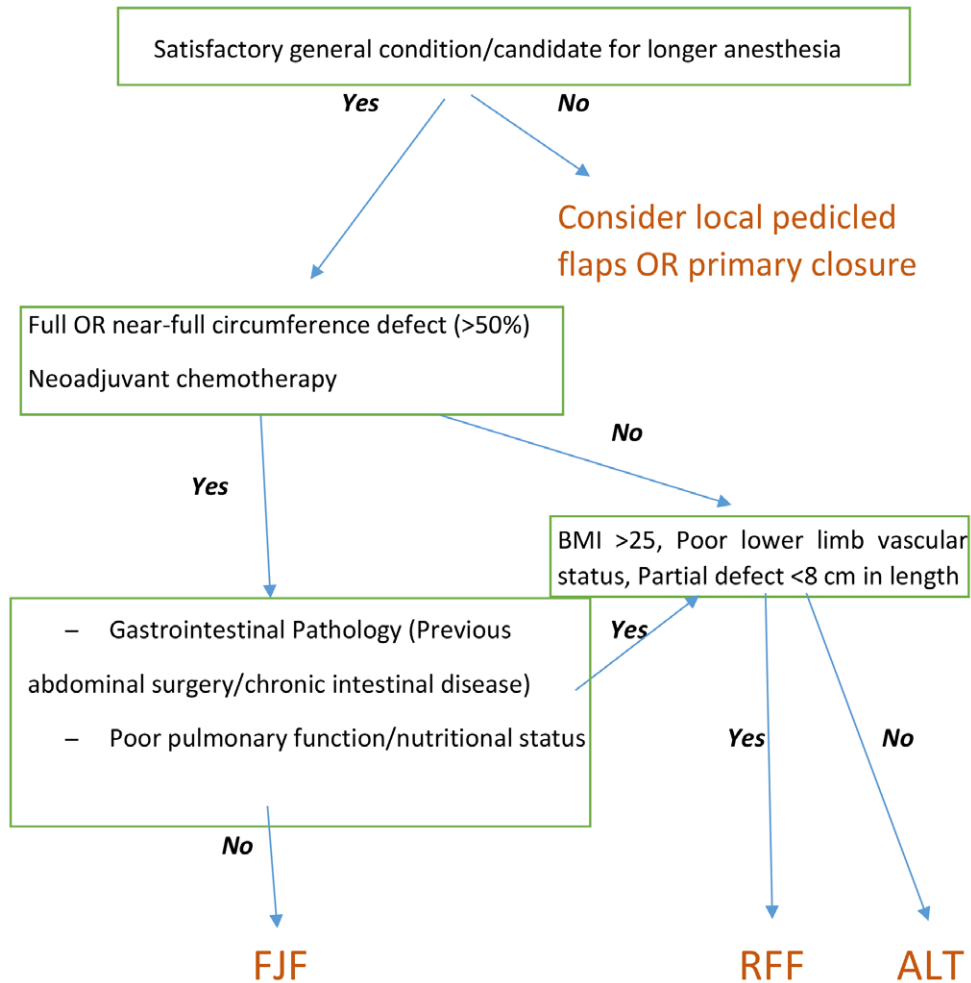


Fig. 2. Simplified reconstructive algorithm for pharyngoesophageal reconstruction. Treatment plan should always be individualized.

the thickness of the pharyngeal wall.³ Anastomotic leak from the suture-line trifurcation and subsequent fistula formation are more common with the tubed RFF (23% versus 17%). Similarly, stenosis is a greater risk with RFF (16% versus 9.1).¹ In general, the literature suggests that RFF has a slightly higher stricture rate compared with ALT flaps,^{17,18} and this is also corroborated by our study (22.2% versus 15.3%). Additionally, the RFF donor-site defect requires a skin graft for coverage.

The advantages of the free ALT flap are minimal donor-site morbidity, versatility, quicker spontaneous healing of small fistulas and strictures, high-quality speech restoration, full initiation of oral diet, fewer postoperative complications, and shorter intensive care unit stay.^{19,20} The disadvantages include the variability of its vascular anatomy and its inconsistency of subcutaneous adipose tissue. Although the flap is raised as a perforator suprafascial flap, the thickness of the subcutaneous tissue determines whether or not it can be tubed.^{4,21} Research shows that a BMI more than 25 is a key factor for selecting the RFF flap over the ALT.¹⁸ Piazza et al propose a useful practical algorithm in which the use of ALT is recommended only

when the defect is over 8 cm in length, and for smaller defects, the RFF or other flaps are indicated.²² In regard to postoperative outcomes, Bianchi et al reported acceptable cosmesis (75%), whereas 50% resumed soft diet in a group of 92 patients (hypopharynx reconstruction, n = 4) undergoing head and neck reconstruction with an ALT flap.²³ Other studies also favor the use of the ALT flap based on good outcomes and low complication rates achieved.²¹

Reconstructive Algorithm (Fig. 2)

Appropriate flap selection is critical, and flap choice is based on several factors, including the extent and the superior margin of the resection, the ability to maintain an adequate anterior neck skin envelope, and the quality and proximity of the recipient vessels.¹ First and foremost, it is the type of defect that is considered to be the most important.³ Disa et al applied a useful algorithmic approach in a large cohort of 165 patients, using RFF for partial-circumference defects and FJF for near total-circumferential defects, achieving an overall flap success rate of 98% and a reduced complication

rate (fistula formation 7%, strictures 4%).⁸ Selber et al proposed the ALT as the flap of choice for most defects limited to the neck and the supercharged jejunum as the flap of choice when the defect extends into the thoracic esophagus.²⁴

Nevertheless, the type of defect is not the only determining factor for flap selection; patient characteristics such as age, preoperative physical status, comorbidities, and previous surgery or gastrointestinal pathology also play a crucial role in the decision-making process, as well as surgeon comfort, preference and/or experience, institution infrastructure, and donor-site morbidity.^{2,22,25} Patients with impaired pulmonary function and/or poor nutritional status are at risk for complications when pedicled intestinal flaps that pass through the thorax or mediastinum are used.² Preoperative radiation significantly increases the risk of flap complications and should be avoided when possible.²⁶

Strengths, Limitations, Future Perspectives

In our study, we used a systematic, structured approach to combine all currently available quantitative data regarding PE and PL reconstruction using FJF, ALT and/or RFF transfer. In total, our study included 2835 patients who underwent this type of reconstruction; however, the methodological heterogeneity between studies can be considered a limitation of our review. A meta-analysis of the included studies was not a viable option. We did not focus on the donor-site complications. Last, we did not include pectoralis major flap transfer for PE and PL reconstruction, despite being an appropriate alternative, especially for partial thickness deficits, as this was beyond the scope of our study. Due to the complexity of our study, a breakdown in anatomical areas (eg, hypopharynx-, larynx-, and pharyngolaryngeal reconstruction with/without esophageal reconstruction) would be difficult, and therefore, it would reduce the cohorts dramatically.

The future of PE reconstruction is promising, with the advent of minimally invasive transoral robotic surgery using either local or free flaps.²⁷ Until the era of robotics prevails, current evidence considers the free fasciocutaneous flaps and the FJF as the standards after pharyngeal resection.²⁸ Importantly, microvascular reconstruction is relatively cost-effective and is associated with greater QoL compared with locoregional flaps, especially in early-stage malignancies.²⁹

CONCLUSIONS

Pharyngolaryngeal and pharyngoesophageal reconstruction remain a challenging task. Despite these procedures being mainly palliative in nature, the advent and ample use of FJF and fasciocutaneous flaps have allowed for enhanced restoration of functions (swallowing, breathing, and speaking) combined with a reduced rate of perioperative and long-term complications. Both FJF and fasciocutaneous flaps can be viable treatment options, depending on the expertise of the surgeon and patient selection, to ensure the best outcomes.

Jeremy Goverman, MD, FACS

Summer M. Redstone Burn Center

Department of Surgery, Massachusetts General Hospital

Boston, MA

E-mail: jgoverman@mgh.harvard.edu

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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