



## Reconstruction after salvage laryngectomy

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### ABSTRACT

Both early and advanced stage laryngeal cancers are treated with organ-preserving strategies including radiation alone or concurrent chemoradiotherapy. While organ-preserving modalities have proven effective in eradicating cancer while also preserving laryngeal function, there remains a proportion of cases where residual or recurrent cancer prevails, or conversely, where radiotherapy renders a larynx dysfunctional. In these circumstances, salvage total laryngectomy is often the surgical treatment. The effects of radiotherapy to the neck, amplified by chemotherapy, can create an inhospitable surgical environment, making the salvage laryngectomy an operation fraught with the potential for major complications such as the dreaded pharyngocutaneous fistula.

The introduction of vascularized tissue from outside the irradiated field decreases the risk of major wound complications. Free tissue transfer, with a variety of donor sites available, is commonly employed to reconstruct either a patch or a circumferential segment of the pharynx. When there is enough pharyngeal mucosa for primary closure, a vascularized onlay graft or a pharyngeal interposition graft can be used to reinforce the closure. This has been demonstrated to both reduce the severity of pharyngocutaneous fistula and decrease the risk of developing a pharyngocutaneous fistula compared to primary closure alone.

Beyond mitigating the risk for perioperative complications, flap selection may have implications on the long-term outcomes after salvage total laryngectomy and these must be considered preoperatively. The purpose of this review is to examine the various options for reconstruction after salvage total laryngectomy and to examine some of their advantages and disadvantages in the short and long-term.

### Introduction

Over the past few decades, the treatment paradigm of laryngeal cancer has shifted away from upfront surgery and towards organ-preserving non-surgical modalities in the form of radiotherapy and concurrent chemoradiotherapy [1]. The findings of the 1991 VA larynx trial demonstrated that treating patients with advanced stage laryngeal cancer using radiotherapy and chemotherapy had comparable survival outcomes to patients treated with upfront surgery and adjuvant radiotherapy. The major advantage achieved with the induction chemotherapy and radiotherapy regimen was that 64% of patients treated non-surgically retained their larynxes [2]. In 2003, the RTOG-91-11 study provided further evidence that using chemoradiotherapy was effective in curing laryngeal cancer while achieving laryngeal preservation, and it also demonstrated that concurrent chemoradiotherapy for the treatment of advanced laryngeal carcinoma conferred the highest rate of organ preservation at 84% [3,4].

These landmark trials have largely relegated the role of total

laryngectomy to those cases where laryngeal cancer has extra-laryngeal spread or in the salvage setting [5]. Salvage total laryngectomy is performed in cases of recurrent tumor, residual tumor after completion of treatment, or when the toxicities of radiation or chemoradiation have rendered a larynx non-functional.

The literature has demonstrated that radiation and chemotherapy impair wound healing making these salvage operations fraught with the potential for complications. Obliterative endarteritis and fibrosis dominate the histologic landscape after head and neck irradiation and these effects are only magnified with the addition of chemotherapy [6–8]. Consequently, the RTOG-91-11 study reported major wound complication rates of 60% and a pharyngocutaneous fistula rate of 30% in patients who underwent salvage laryngectomy [4].

The main goals of reconstruction after salvage laryngectomy include both reconstituting the conduit between the oropharynx and the cervical esophagus as well as reducing the risk of wound complications such as pharyngocutaneous fistulae. The other important goals of reconstruction are to optimize the anatomy for voice rehabilitation and deglutition.

*Abbreviations:* PMMC, pectoralis major myocutaneous; PMMF, pectoralis major myofascial; SCIAF, supraclavicular island artery flap; RFFF, radial forearm free flap; PIG, pharyngeal interposition graft; ALT, anterolateral thigh; TPFF, temporoparietal fascia free flap; SAFF, serratus anterior free flap; GFMF, gracilis free muscle flap; TEP, tracheoesophageal prosthesis

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## Discussion

### Defect type

The pharyngeal defect in salvage laryngectomies can be divided into three broad categories: (1) defects with sufficient pharyngeal mucosa to close primarily; (2) defects where a posterior strip of pharyngeal mucosa remains, but it is insufficient to close on itself; and (3) complete circumferential defects where a 360-degree segment of pharyngeal mucosa is lacking.

Hui et al. are credited for demonstrating that primary closure can be achieved with acceptable swallowing outcomes with a minimum of 1.5 cm of relaxed or 2.5 cm of stretched pharyngeal mucosa remaining [9]. Interestingly, the majority of patients in this study who underwent primary closure had at least 3 cm of relaxed pharyngeal mucosa remaining after salvage laryngectomy. The conclusion that primary closure can be successfully performed with a minimum of 1.5 cm is drawn from a single patient in this study being able to swallow successfully. No study thus far has definitively elucidated the minimum pharyngeal width required for primary closure with acceptable swallowing outcomes. We generally prefer at least 3 cm of pharyngeal mucosa to consider primary closure. In circumstances where there is sufficient mucosa to close a pharyngeal defect primarily, the current evidence generally favors overlaying vascularized tissue on top of the suture line in order to reduce the rates of fistula rates [7,10].

When a strip of pharyngeal mucosa remains after ablative surgery, a patch reconstruction is required to reconstitute the anterior pharyngeal wall. The flap is sutured to the remaining mucosal strip to create the horseshoe-shaped neopharynx. With a circumferential defect, a tubed flap reconstruction is required to maintain the continuity of the pharynx. Numerous reconstructive options exist for each of these defect types. Both pedicled flaps and free tissue transfer techniques can be used for reconstruction. This article discusses some of the available options and provides a critical appraisal of these reconstructive options.

### Free tissue transfer

In contemporary head and neck reconstruction, free tissue transfer is often considered the first-choice for reconstruction after salvage laryngectomy. Where pharyngeal reconstruction is necessary, free flaps can serve as a patch graft or tubed reconstruction. Aside from reconstituting the neopharynx, the introduction of a free flap harvested from outside the irradiated field helps improve vascularity in the wound bed and may aid with healing and decrease the risk of wound complications. This benefit is also the rationale for including a free flap as an onlay graft in situations where primary closure of the pharynx is otherwise possible.

### Radial forearm free flap

The radial forearm free flap (RFFF) is a popular reconstructive option for pharyngeal reconstruction. Its ease of harvest, long pedicle, good vessel caliber, and thin, pliable tissue affords the reconstructive surgeon a great deal of latitude in pharyngeal reconstruction [11]. It can be harvested as a fascia-only flap and used as a pharyngeal interposition graft to reinforce primary pharyngeal closure, or with a skin paddle as a patch graft where there is insufficient mucosa for primary closure, or as a tubed pharyngeal reconstruction. When used to reconstruct the pharynx, one of the major advantages of the RFFF is that its inherently thin and pliable skin paddle matches the thickness of the pharyngoesophageal wall [11]. The theoretical advantage is that it may better match the natural resonance of the pharynx versus other thicker flaps.

If there is sufficient mucosa to close the pharynx primarily, the RFFF can be harvested without a skin paddle as a fascia-only flap to reinforce the pharyngeal suture line. Fung et al. introduced the term “pharyngeal interposition graft” (PIG) which consists of fascia-only free flaps to

improve tissue vascularity in the salvage laryngectomy setting [7]. In the original article, RFFFs made up most of the PIGs. Interestingly, although their group did not find a difference with the rate of wound complications or pharyngocutaneous fistula with a PIG versus primary closure alone, there was a trend towards fewer major wound complications and major pharyngocutaneous fistulae with the PIG group.

If a skin paddle is harvested with the RFFF, the forearm donor site generally requires skin grafting which can be complicated by tendon exposure or forearm stiffness. The forearm scar can also be cosmetically undesirable for the patient. This is especially the case with total circumferential laryngopharyngectomy defects. Using the RFFF to reconstruct these defects necessitates harvesting a large area of the forearm, yielding an aesthetically conspicuous scar. If a fascia-only free flap is used, the donor site morbidities are lesser.

We have commonly employed the RFFF for both tubed and patch graft reconstructions of the pharynx. Advantages of this flap include its ease of harvest as well as its thin pliable skin, which allows it to be easily folded on itself. In situations where primary closure of the pharynx can be achieved, the adipofascial RFFF is the preferred onlay graft because of its ease of harvest, ability to approach with two teams, and large caliber vessels.

### Anterolateral thigh free flap

Traditionally, circumferential pharyngeal defects were reconstructed with either the jejunal flap or a tubed RFFF. The anterolateral thigh free flap (ALT) has been increasingly used in pharyngeal reconstruction. As with the RFFF, the ALT can be used as a PIG, a patch graft, or a tubed flap. The ALT has greater vascular variability compared to the RFFF and it also has greater heterogeneity in flap thickness, depending on a patient's body habitus. The excess adipose tissue can be removed to within 2 cm of the perforating vessels to limit the thickness of tissue included in the reconstruction [12]. The flap thickness is of vital importance as excessive flap thickness can be prohibitive to close inelastic, irradiated skin over top a bulky ALT.

Depending on the needs of the reconstruction, the vastus lateralis can be incorporated into the ALT. If the skin perforators are septocutaneous or if a perforator-based ALT is harvested, then the vastus lateralis is not incorporated into the flap. The ALT can also be raised as an adipofascial-only flap and be used as an onlay graft to reinforce the line of primary closure. When the ALT is raised in this manner, the patient's body habitus no longer has a significant impact on flap thickness.

Although the inclusion of the vastus lateralis as part of the ALT can make skin closure more challenging, the muscle can serve to provide coverage of the great vessels in the case of concurrent radical neck dissections, fill in neck contour defects, or as a vascularized bed to facilitate skin grafting for the external neck. The addition of the vascularized muscle as well as the fascia lata has been credited for the lower rate of pharyngocutaneous fistula seen with the ALT compared with the RFFF. These additional layers of closure may help to reinforce the suture line and anastomotic closure [13].

There is a greater surface area of skin available with the ALT compared to RFFF. Two separate skin paddles can be harvested to reconstruct the external skin in addition to the pharyngeal reconstruction [14]. If the reconstruction does not call for reconstruction of the external skin, a distal skin paddle can be harvested and brought out to the external skin to serve as a monitoring paddle [15]. The donor site is typically closed primarily without the need for skin grafting, while the only lasting sequelae include a vertically oriented scar along the thigh and thigh numbness.

At our institution, in the setting of salvage laryngectomy, we most commonly use the ALT as a tubed flap and occasionally as a patch graft. The ability to harvest a generous width with this flap allows for a larger pharyngeal reconstruction. Moreover, we have found the donor site morbidity to be minimal with virtually all of our patients being able to ambulate in the early postoperative period.

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