

- Chen SY, Mancuso D, Lalwani AK. Skin necrosis after implantation with the BAHA attract: a case report and review of the literature. *Otol Neurotol*. 2017;38:364-367.
- Barbut J, Deveze A, Masson C, Ogam E. Analysis of bone conducted sound over the cranial vault. *Comput Methods Biomech Biomed Engin*. 2015;11:1-2.
- Dimitriadis PA, Farr MR, Allam A, Ray J. Three year experience with the cochlear BAHA attract implant: a systematic review of the literature. *BMC Ear Nose Throat Disord*. 2016;16:12.
- Holgers KM, Tjellström A, Bjursten LM, Erlandsson BE. Soft tissue reactions around percutaneous implants: a clinical study of soft tissue conditions around skin-penetrating titanium implants for bone-anchored hearing aids. *Am J Otol*. 1988;9:56-59.
- Devèze A, Rossetto S, Meller R, Sanjuan PM. Switching from a percutaneous to a transcutaneous bone anchored hearing system: the utility of the fascia temporalis superficialis pedicled flap in case of skin intolerance. *Eur Arch Otorhinolaryngol*. 2015;272:256 3-2569.

Received: 17 April 2018 | Revised: 1 October 2018 | Accepted: 17 October 2018

DOI: 10.1111/coa.13279

# Comparison of radial forearm free flap and gastric pull-up in pharyngo-oesophageal reconstruction

## 1 | INTRODUCTION

Resection of advanced carcinoma of larynx, hypopharynx and oesophagus often times results in large defects that present a unique challenge to the reconstructive surgeon. The earliest described reconstruction was referred to as the Wookey operation, which involved recreating a tubed neopharynx with local tissue.<sup>1</sup> There have been multiple modifications and improvements in the procedure since it was first performed. In the present day, reconstructive options include primary closure, local flap closure, pectoralis myocutaneous flap closure, free tissue transfer (including radial forearm, free jejunum flap and anterolateral thigh flap) and gastric pull-up.<sup>2</sup> The main reconstructive goal is to create a conduit from the oropharynx to the cervical oesophagus. The ideal reconstructive method minimises perioperative morbidity, does not delay initiation of adjuvant therapies and allows optimal restoration of swallow function.

Gastric pull-up (GP) was first described by Ong et al as a single-stage reconstruction of cervical oesophageal defects in 1960. Initial mortality rates from the procedure were high, estimated at 27%.<sup>3</sup> However, the technique has been refined over the past several decades and studies from the past 20 years estimate mortality around 6%.<sup>4</sup> Typically, a two-team approach is used to mobilise the stomach pedicled on the right gastro-epiploic vessels and tubed by resecting a portion of the lesser curvature before transfer into the neck. After pharyngo-oesophagectomy is performed, the tubed stomach is passed through the posterior mediastinum and the neck defect is anastomosed to the proximal portion of the stomach. Gastric pull-up has gained popularity for reconstructing pharyngo-oesophageal defects because it offers a robust blood supply, fills the defect well and only requires one mucosal anastomosis without the need for microvascular anastomosis.<sup>5,6</sup> Morbidity from the procedure remains high, and as patients with head and neck cancer often have a long history of tobacco and alcohol use, reconstructive procedures involving laparotomy, laparoscopy or any abdominal dissection can

further deplete their low functional reserve and increase their risk of an anastomotic leak, sepsis, gastritis or cardiopulmonary event in the perioperative period.

Fascio-cutaneous flaps have also been employed to reconstruct the hypopharynx and cervical oesophagus. The radial forearm free flap (RFFF) was first described in 1981 by Yang et al<sup>7</sup> and was first applied to hypopharyngeal reconstruction in 1985 by Harii et al.<sup>8</sup> RFFFs have been used frequently over the past 30 years to successfully reconstruct hypopharyngeal and cervical oesophageal defects. The flap can be harvested simultaneously with the primary resection which eliminates the need for abdominal and thoracic surgery. However, there is a need for donor site skin grafting as well as proximal, distal and microvascular anastomoses.

Despite multiple reconstructive approaches proposed over the past several decades, there remains no consensus on the optimal method of reconstructing pharyngo-oesophageal defects. In this paper, we compare surgical outcomes of tubed RFF and GP.

## 2 | METHODS

### 2.1 | Ethical considerations

This study was conducted in line with the ethical guidelines of the JPS Institutional Review Board.

### 2.2 | Study design

We performed a retrospective analysis of patients who underwent pharyngo-oesophageal reconstruction by a single surgeon (Y.D) between December 1997 and March 2017. Minimum follow-up was 6 months. All defects included hypopharynx and cervical oesophagus. Demographics, radiation status, surgical intervention and complication rates were analysed. Specifically, rates of stricture formation, fistula and return to oral feeding were considered. Preoperative physical

status using the American Society of Anesthesiologists (ASA) scoring was also considered. Patients were grouped according to method of reconstruction (RFF vs GP). Comparisons were made between RFF and GP, as well as between radiated and non-radiated patients. The chi-squared test was used for all comparisons. P-values and 95% confidence intervals (CI) were reported as (P, 95% CI).

### 3 | RESULTS

The total number of patients was 153, with 110 males (range: 43-88 years, mean: 71.4) and 43 females (range: 38-85 years, mean: 69.3). Eighty-six patients (25 females, 61 males, mean ASA score: 3.2) underwent RFFF reconstruction. Sixty-seven patients (18 females, 49 males, mean ASA score: 3.4) underwent GP reconstruction. Patients who underwent GP had lower rates of stricture formation (<0.01, 19.7-41.6), regardless of whether or not they had preoperative radiation. Patients in the GP group also had lower rates of fistula and higher rates of return to oral feeding (Table 1). In the GP group, 11.9% of patients had ileus and delayed feeding portending the need for total parenteral nutrition in the perioperative period. One patient had ileus requiring bowel resection. Zero patients had chylothorax. 91.6% of patients that remained J-tube dependent had preoperative external beam radiation. Patients who underwent preoperative radiation had higher rates of stricture and fistula formation (0.02, 2.8-28.2; <0.01, 5.5-29.9, respectively). Non-radiated patients also had higher rates of return to oral diet (<0.01, 10.8-33.3) (Table 2). There were no mortalities in either the RFF or the GP group.

### 4 | DISCUSSION

The choice of modality in reconstructing pharyngo-oesophageal defects is usually affected by multiple factors, including patient physical status, surgeon preference and availability of other surgical specialties (eg, general surgery and thoracic surgery). There is

**TABLE 1** Comparison of outcomes between radial forearm free flap and gastric pull-up

	RFF	GP	P, 95% CI
Number (m, f)	86 (25,61)	67 (18,49)	
Prior radiation %	74.4	64.2	0.24, -7.1 to 27.6
Stricture % (radiated)	43.8	2.9	<b>&lt;0.01, 25.5 to 53.3</b>
Stricture % (non-radiated)	22.7	0	<b>&lt;0.01, 4.01 to 43.3</b>
Fistula % (radiated)	29.6	25.6	0.65, -13.6 to 20.1
Fistula % (non-radiated)	9.1	8.3	0.92, -17.8 to 20.5
Oral diet % (radiated)	70.3	74.4	0.64, -13.4 to 20.3
Oral diet % (non-radiated)	86.3	95.8	0.26, -8.8 to 29.5

<sup>a</sup>Statistically significant values are depicted in bold.

#### Keypoints

- Despite multiple reconstructive approaches proposed over the past several decades, there remains no consensus on the optimal method of reconstructing pharyngo-oesophageal defects. In this paper, we compare our experience with tubed radial forearm free flap (RFF) and gastric pull-up (GP).
- Patients who underwent GP had lower rates of stricture formation, regardless of preoperative radiation status.
- Patients who underwent preoperative radiation had higher rates of stricture and fistula formation.
- Non-radiated patients also had higher rates of return to oral diet.
- Gastric pull-up offers lower rates of stricture and fistula formation, as well as high rates of return to oral diet. Patients who underwent preoperative radiation suffered higher rates of stricture and fistula regardless of reconstructive method.

**TABLE 2** Comparison of radiated and non-radiated patients

	Radiated	Non-radiated	P, 95% CI
N	107	46	
Stricture %	28	10.8	0.02, 2.8-28.2
Fistula %	28	8.6	<b>&lt;0.01, 5.5-29.9</b>
Oral diet %	71.9	95.5	<b>&lt;0.01, 10.8-33.3</b>

<sup>a</sup>Statistically significant values are depicted in bold.

much controversy in the literature regarding the optimal choice for reconstruction of these defects. Herein, we compared our experience with radial forearm free flap and gastric pull-up.

There is innate heterogeneity in the nature of defects amenable to closure by RFF and GP. In order to eliminate this heterogeneity, only patients who underwent laryngo-pharyngectomy with hypopharyngeal defects extending past the oesophageal introitus into the cervical oesophagus were included in this study.

We noted lower rates of strictures and fistulas, as well as a higher rate of return to oral diet in the GP group. 95.8% of non-radiated patients in the GP group were able to return to oral diet. This is comparable to rates of 83%-98% reported in the literature.<sup>9,10</sup> The stricture formation rate of 2.9% was also very low in the GP group. The non-radiated patients in this group had no stricture formation.

It should be noted that despite the lower rates of strictures, the GP group had similar rates of return to oral diet when compared to the RFF group. The long-term swallow functionality in the two groups appeared to be similar, although the GP group was slightly but not significantly higher. Anastomosing the epidermis of the radial forearm to the stratified squamous epithelium of the oesophagus is a likely reason for stricture formation. This issue is avoided in gastric pull-up, as the epithelial milieu of the pharynx is similar to that of the oesophagus.

Multiple versions of triangular flaps have been designed to prevent circular contracture at the anastomotic sites of radial forearm free flaps, but no manoeuvre has been widely accepted in the literature.

As expected, radiation confers increased risk of postoperative complications. There were significantly higher rates of strictures and fistulas, as well as lower rates of return to oral swallowing in patients who had preoperative radiation. This information is vital in counselling patients about their likelihood of developing postoperative complications and long-term function.

Speech rehabilitation after laryngo-pharyngectomy remains an important goal of therapy. While not directly compared in this study, the RFF has been reported to have better speech results compared to the wet nature of GP speech. This should be considered in preoperative decision-making and patient counselling.

One of the main advantages of gastric pull-up in hypopharyngeal reconstruction is the ability to reconstruct larger defects after margins are cleared distally. In order to obtain clear margins on the resection, aggressive excision of the proximal oesophagus is performed. In our technique, the oesophageal margin is then cleared on frozen section. Our general surgery colleagues then staple or sew the proximal oesophageal stump to a 1-inch penrose drain. After oesophagus is freed, (the general surgeon finger dissects from below after clipping or diathermy of the short gastrics) it is then pulled into belly wound. The general surgeon staples across the GE junction and then sews the penrose to the gastric fundus. The head and neck team then pull up fundus into the neck, and fish mouths it to sew to base of tongue. This is an inherent advantage over the radial forearm reconstruction technique, due to the ability to reconstruct a large defect after obtaining clear margins.

There are multiple risks associated with gastric transposition into the thoracic cavity. Chylothorax, pancreatitis, hepatic failure and death have been reported as complications. However, the risk of complications and mortality has consistently decreased each decade.<sup>3</sup>

Our data suggest a slight superiority of GP over RFF when strictures, fistula and return to oral diet are considered. This finding may be somewhat unsettling to the microvascular reconstructive surgeon, but may be instructive in preoperative decision-making and patient counselling.

Weaknesses of this study include the fact that this is a single surgeon experience, with possible lack of external validity, as well as a possible introduction of bias favouring a specific operative technique. The retrospective nature of this study also potentially limits its significance. Prospective studies are needed to better compare outcomes between these two reconstructive methods.

## 5 | CONCLUSION

Gastric pull-up offers lower rates of stricture and fistula formation, as well as high rates of return to oral diet. Patients who underwent preoperative radiation suffered higher rates of stricture and fistula regardless of reconstructive method.

## CONFLICTS OF INTEREST

None of the authors have any relevant conflicts of interest to disclose.

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## REFERENCES

1. Mustard RA. The use of the Wookey operation for carcinoma of the hypopharynx and cervical esophagus. *Surg Gynecol Obstet.* 1960;111:577-592.
2. Nouraei SA, Dias A, Kanona H, et al. Impact of the method and success of pharyngeal reconstruction on the outcome of treating laryngeal and hypopharyngeal cancers with pharyngolaryngectomy: a national analysis. *J Plast Reconstr Aesthet Surg.* 2017;70(5):628-638.
3. Ong GB, Lee TC. Pharyngogastric anastomosis after oesophago-pharyngectomy for carcinoma of the hypopharynx and cervical esophagus. *Br J Surg.* 1960;48:193-200.
4. Butskiy O, Rahmanian R, White RA, et al. Revisiting the gastric pull up for pharyngoesophageal reconstruction: a systematic review and meta-analysis of mortality and morbidity. *J Surg Oncol.* 2016;114(8):907-914.
5. Butskiy O, Anderson DW, Prisman E. Management algorithm for failed gastric pull up reconstruction of laryngopharyngectomy defects: case report and review of the literature. *J Otolaryngol Head Neck Surg.* 2016;45(1):41.
6. Marion Y, Labreton G, Brevart C, et al. Gastric pull-up reconstruction after treatment for advanced hypopharyngeal and cervical esophageal cancer. *Eur Ann Otorhinolaryngol Head Neck Dis.* 2016;133(6):397-400.
7. Yang G, Chen B, Gao Y, et al. Forearm free skin flap transplantation. *Natl Med J China.* 1981;61:139.
8. Harii K, Ebihara S, Ono I, et al. Pharyngoesophageal reconstruction using a fabricated forearm free flap. *Plast Reconstr Surg.* 1985;75:463-476.
9. Kim Evans KF, Mardini S, Salgado CJ, Chen HC. Esophagus and hypopharyngeal reconstruction. *Semin Plast Surg.* 2010;24(2):219-226.
10. Schusterman MA, Shestak K, de Vries EJ, et al. Reconstruction of the cervical esophagus: free jejunal transfer versus gastric pull-up. *Plast Reconstr Surg.* 1990;85(1):16-21.

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