We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800
Open access books available

122,000
International authors and editors

135M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

CLARIVATE ANALYTICS BOOK CITATION INDEX INDEXED

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Chapter 10

Effects of Radiotherapy on Pharyngeal Reconstruction After Pharyngo-Laryngectomy

Jimmy Yu-Wai Chan and Gregory Ian Siu Kee Lau

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/56604

1. Introduction

After adequate extirpation of tumours in the hypopharynx, the defect created should be reconstructed appropriately to provide optimal function. Local cervical skin flaps were first described and employed 60 years ago for the reconstruction of defects after pharyngo-laryngectomy [1]. However, the procedures involved had to be carried out in stages, which typically required 4 – 6 months for completion. In addition, the subsequent ability to swallow was frequently limited by the stenosis at the anastomotic junction. Nowadays, with more advanced techniques, reconstruction of the circumferential hypopharyngeal defect is nearly always performed at the time of resection as a single stage procedure [2]. The most commonly employed reconstructive options include the use of myocutaneous flaps (pedicled pectoralis major flap or free anterolateral thigh flap) with the skin island sutured and fashioned as a tubular conduit, or the free visceral flap (free jejunal flap).

Radiation therapy has become an integral part of treatment for malignancies in the head and neck region. Apart from being the primary treatment for radiation sensitive cancers, or as part of the organ-preserving therapy for early cancer of the larynx and hypopharynx, it is more commonly used as adjuvant treatment after surgery for advanced stage cancers. Studies showed that the 5-year survival rate as well as the loco-regional tumour control was significantly improved after combined surgical resection and post-operative radiation therapy, compared with single modality treatment.

Ionizing radiation, however, is not without side effects. In this chapter, we will focus on the effect of radiation on the functional and oncological outcome on pharyngeal reconstruction after pharyngo-laryngectomy for carcinoma of the hypopharynx.

2. Problem statement

- To investigate the effect of radiotherapy on the functional outcome of pharyngeal reconstruction
- To investigate the effect of radiotherapy on the oncological outcome of pharyngeal reconstruction
- To formulate the choice of reconstructive options for pharyngeal defects

2.1. Application area

- Reconstruction of the defect created after circumferential pharyngectomy for malignancies in the region of the hypopharynx and cervical esophagus

2.2. Methods

We identified all consecutive patients undergoing reconstruction for circumferential pharyngeal defects after resection of tumours of the hypopharynx and the cervical esophagus over a 30-years interval from 1980 to 2009. All the operations were performed in a single, tertiary referral, university based hospital. The patients' data were prospectively collected in the head and neck cancer database of the Division of Head and Neck surgery, including patients' demographic data, types of cancer treated, the operations performed, outcomes of surgery, dose of radiation given and the subsequent follow up information.

During the study period, we had performed circumferential pharyngectomy for 202 patients suffering from tumours involving the pharyngeal region. Those with tumours requiring pharyngo-laryngo-esophagectomy and subsequent gastric pull-up were excluded from the study. All patients had pre-operative work-up for tumour staging, anaesthetic assessment and nutritional build-up if necessary. All of the patients received total laryngectomy and circumferential pharyngectomy. Cervical lymph node dissection was performed if there was evidence of lymphatic metastasis. Intra-operative frozen section examination of the resection margins was performed to ensure microscopic clearance of disease.

The resultant pharyngeal defect in the form of a conduit between the oropharynx above and the esophagus below was reconstructed with either the pectoralis major (PM) flap, free anterolateral thigh (ALT) flap or free jejunal flap as described below.

3. Myocutaneous flap

3.1. Pectoralis major myocutaneous flap

Following Ariyan's [3] publication in 1979, Withers at al [4] described the technique of folding the skin island of a PM flap into a tube for the reconstruction of circumferential pharyngectomy defects. In essence, a rectangular or trapezoid skin island was designed over the pectoralis major muscle, which was transferred together with its supplying blood vessels, namely the thoracoacromial and lateral thoracic artery, to the neck for reconstruction of the neopharynx (Figure 1). The length of the pharyngeal defect should be accurately measured

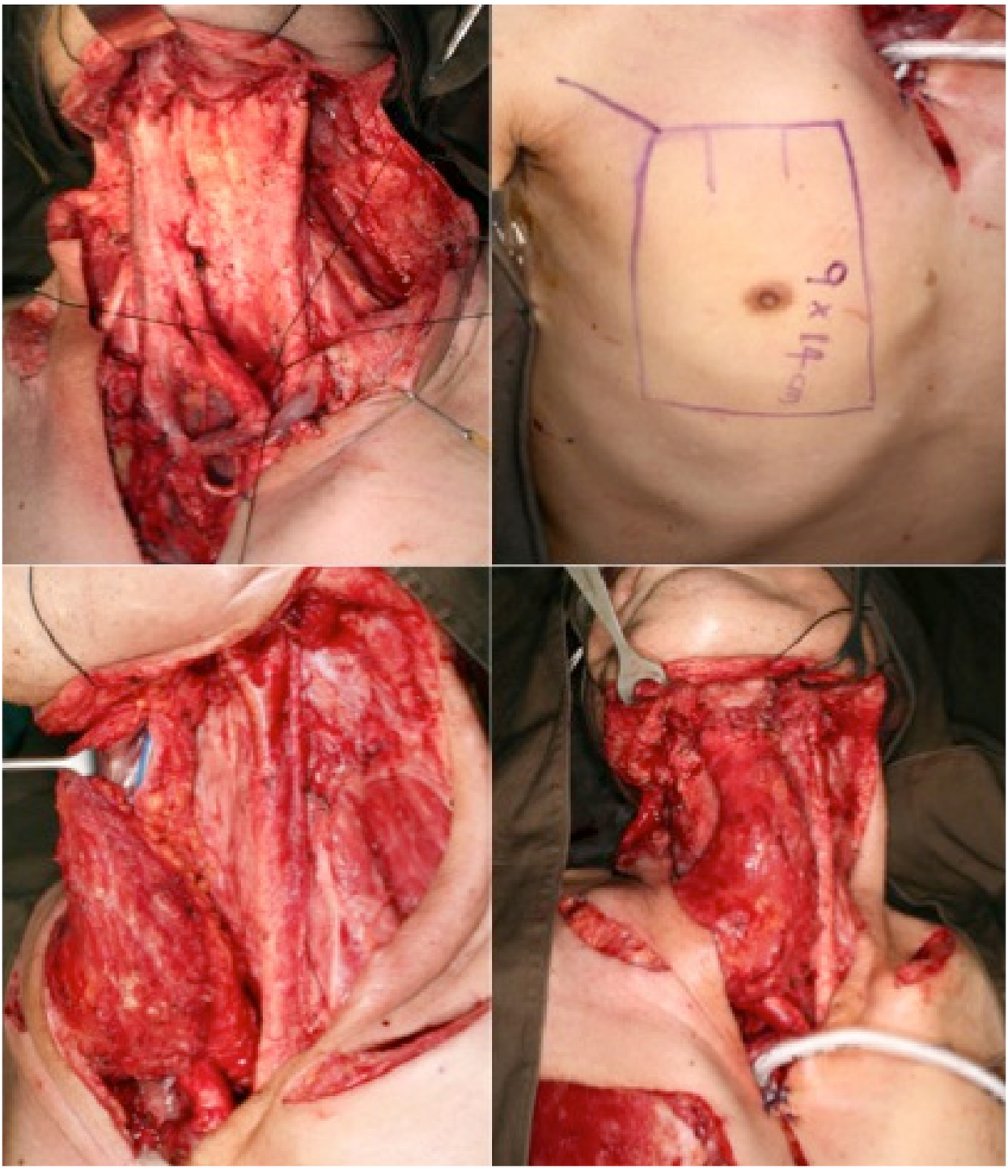

Figure 1. Circumferential pharyngeal defect reconstructed with tubed pectoralis major flap. (Above, left) circumferential defect after tumour extirpation. (Above, right) Pectoralis major myocutaneous flap with a trapezoid skin island. Slits are made at the upper edge of the skin island so that the anastomosis with the cervical esophagus can be performed in an interdigitating fashion. (Below, left) The flap is transferred to the neck through a subcutaneous tunnel. The skin island is folded into a tube and sutured to form a conduit. Nasogastric tube is inserted for feeding during early post-operative period (Below, right) Completion of inset, showing the pectoralis muscle facing outside. It was then resurfaced with autologous split thickness skin graft.

and the length of the skin island marked out accordingly. In addition to the expected 10% shrinkage in size after harvesting, the length of the skin island should be at least 2cm longer than the defect if the interdigitating suturing method is employed at the lower (esophageal) anastomosis. The width of the skin island should be at least 6cm in order to provide a reconstructed skin tube with a 2cm diameter. In order to include as many perforators as possible, the skin island should be placed entirely on the pectoralis major muscle, and the shape of the skin island should be in the form of a trapezium, with the shorter edge on its upper part. This upper edge of the skin island, when transposed to the neck, will be anastomosed to the cervical esophagus which is always smaller in caliber than that of the oropharynx.

After passing through the subcutaneous tunnel, the skin island of the pectoralis major flap is fashioned into a tube. It is then sutured to the oropharynx above and the cervical esophagus below. In order to prevent stricture formation of the circular mucocutaneous anastomosis with the esophagus, the anastomosis is carried out in an interdigitating fashion [5]. Three incisions are made at the stump of the cervical esophagus. Similar incisions are made over the skin island so that at anastomosis, skin island flaps can be sutured in an interdigitating fashion with the corresponding flaps from the cervical esophagus. The resultant anastomosis is in a wave-like form rather than circular. Upon healing, the scar stretches the anastomosis wider rather than causing it to stenose.

3.2. Free anterolateral thigh flaps

Free anterolateral thigh fasciocutaneous flap was popularized by Song *et al* in 1984 [6] and later modified by Koshima *et al* [7-8] for clinical application. As in the pectoralis major myocutaneous flap, the skin paddle of the anterolateral thigh flap can be fashioned into a tube for the reconstruction of the circumferential pharyngeal defects after tumour resection. It is supplied by the musculocuatneous or the septocutaneous perforators of the descending branch of the lateral circumflex artery and its venae commitantes. After transfer from the donor site, the blood supply of the flap is reconstituted by microvascular anastomosis of the vascular pedicle with appropriate vessels in the neck. The vascular anastomosis is performed under magnification with interrupted sutures. Any suitable branch from the external carotid artery can be used as the recipient artery, and either the external jugular vein or any branch of the internal jugular vein can be selected as the recipient vein.

4. Free visceral flap

4.1. Free jejunal flap

The free jejunal flap was first described by Seidenberg [9] in 1958. It represents one of the most popular methods for the reconstruction of circumferential pharyngeal defects nowadays (Figure 2). Through an upper midline laparotomy, the required length of the jejunum is harvested. Usually, the segment of the jejunum supplied by the second vascular arcade from the ligament of Treiz is used, as the vessels are relatively straight with a size comparable

with that of the recipient vessels in the neck. The size of the jejunal lumen is comparable with that of the cervical esophagus, and an end-to-end anastomosis can usually be accomplished easily. The discrepancy in size usually occurs at the anastomosis between the oropharynx and the jejunum. It can be handled by slitting the jejunal wall at the anti-mesenteric border so that a longer circumference is made available for anastomosis.

In order to minimize the ischaemic time of the jejunal flap, the recipient vessels in the neck should be prepared and ready for microvascular anastomosis before the flap is detached from its blood supply in the abdomen. The jejuno-esophageal anastomosis is performed for fixation of the bowel, followed by vascular anastomosis. Once the perfusion of the bowel is restored, upper anastomosis between the oropharynx and the jejunal flap can be performed leisurely without time constraint.

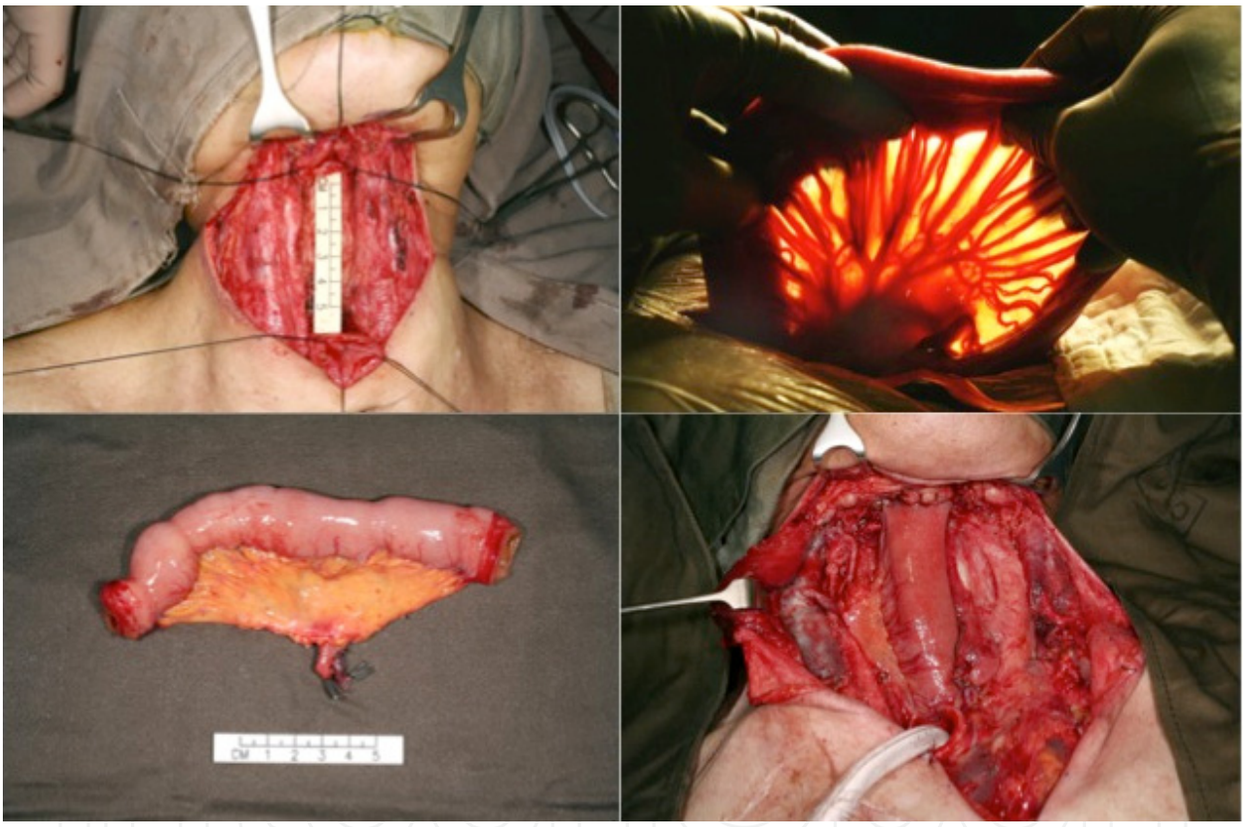

Figure 2. Circumferential pharyngeal defect reconstructed with the free jejunal flap. (Above, left) Circumferential pharyngeal defect created after resection of tumour at the hypopharynx. The length of the defect between the oropharynx above and the cervical esophagus below is accurately measured. (Above, right) Through a upper midline laparotomy, the segment of jejunum of appropriate length is harvested. The vascular anatomy is better appreciated with light shining from behind. The second arcade of blood vessels is commonly harvested because of the favorable configuration. (Below, left) The flap is delivered after division of the vascular pedicle. Effort should be made to shorten the ischaemic time as much as possible. The jejuno-esophageal anastomosis is performed first, followed by microvascular anastomosis under magnification. (Below, right) Upon completion of the upper oropharyngo-jejunal anastomosis. The anti-mesenteric border of the jejunal flap may be splitted to accommodate the larger size of the oropharynx.

Post-operative gastrograffin swallow study was performed 10 days after surgery to complete wound healing before oral feeding was resumed. For those patients who developed pharyngo-cutaneous fistula with significant leakage, a control pharyngostome was performed to allow the patient to recover from the inflammation before second stage repair was contemplated. Those minor leakages with no clinical evidence of inflammation were treated conservatively and monitored closely. Contrast swallow study was performed subsequently to confirm complete wound healing before allowing oral feeding. Those patients with significant delay of post-operative adjuvant chemoradiotherapy secondary to anastomotic leakage or necrotic flap requiring multiple surgeries were excluded. All patients were referred to clinical oncologists for post-operative adjuvant chemoradiotherapy.

External beam radiotherapy, when indicated, was commenced as soon as possible after all the surgical wounds were healed. Radiation was delivered by Cobalt 60, 4MV, or 6MV linear accelerator, which was given once per day with daily fraction size of 2Gy, 5 days per week. The spinal cord was shielded after 4500 cGy and the flap for the pharyngeal reconstruction was included in the high dose field of radiation.

All the patients were followed up regularly with clinical and endoscopic examination to detect tumour recurrence and complications such as anastomotic stricture and donor site morbidities. A stage-to-stage comparison of the loco-regional tumour control was performed between different methods of reconstruction.

5. Results

5.1. Functional results after reconstruction of circumferential pharyngeal defects

Pharyngo-cutaneous fistula leading to anastomotic leakage is a serious complication during the early post-operative period. If not detected and treated early, it will result in severe infection and carotid artery blowout. While surgical technique is important to prevent such complication, the choice of reconstructive options may also affect the incidence of early anastomotic leakage. According to our experience over the past two decades [10], the incidence of early post-operative pharyngo-cutaneous fistula was 23.9% when pectoralis major flap is used, 12.5% when the free anterolateral thigh flap is used, and 4.6% when the jejunal flap is used. Similar results are demonstrated in other series [11-12]. Majority (65.5%) of the patients with salivary leakage required exteriorization by creating a control pharyngostome pharyngostomy, followed by a second stage reconstruction after the inflammation subsided. The rest of the patients (34.5%) were managed successfully by conservative approach. There was no significant relationship between pre- or post-operative radiotherapy ($p=0.848$) and early post-operative fistula formation. However, among the patients who leaked, those with a history of irradiation were significantly more likely to required exteriorization to control the infection (88.2% required exteriorization vs. 11.8% managed conservatively).

One of the most important functional problems after circumferential pharyngectomy is swallowing. In addition to the restoration of the resected pharyngeal conduit for the passage of food, proper swallowing in these patients requires patent anastomosis without stenosis.

Late anastomotic stricture rate was 27.2% in the pectoralis major flap group, 12.5% in the anterolateral thigh flap group, and 2.3% in the jejunal flap group. The mean time to develop dysphagia secondary to the stricture was 18.4 months. The only factor that was found to have significant association with stricture formation was the history of pharyngo-cutaneous fistula during early post-operative period (p=0.023). The history of radiotherapy has not significantly increased the risk of anastomotic stricture.

In the group of patients who had no demonstrable anastomotic stricture, only some of them were able to resume the usual diet before operation, the proportion of which being 35.8% in the pectoralis major flap group, 38.2% in the anterolateral thigh group and 61.9% in the jejunal flap group. The rest of the patients tolerated fluid or soft diet only. The presence of mucus secretion as well as peristalsis in the jejunal flap may aid the passage of food bolus. Table 1 summarizes the functional outcome after different types of reconstruction techniques.

	Total number	Early fistula (%)	Late stricture (%)	Resume usual diet (%)	Donor site morbidity (%)
Pectoralis major flap	92	22 (23.9)	25 (27.2)	24 (35.8)	7 (7.6)
Anterolateral thigh flap	24	3 (12.5)	3 (12.5)	8 (38.1)	1 (4.2)
Jejunal flap	86	4 (4.6)	2 (2.3)	52 (61.9)	2 (2.3)

Table 1. Comparison of the functional outcome after different types of reconstruction of the circumferential pharyngeal defect.

Majority of the patients require a combined surgical resection followed by post-operative adjuvant radiotherapy for treatment of carcinoma hypopharynx. While free jejunal transfer appears to result in the lowest rate of early anastomotic leakage as well as late anastomotic stricture, the radiation tolerance of the visceral flap is always a concern. The jejunum is a radiosensitive organ in its native site in the abdomen. Radiation injury to the gastrointestinal tract is well recognized in patients with pelvic or colorectal malignancies who received external beam irradiation up to 60Gy [13]. Acute functional changes include diarrhea, bloating and abdominal pain, and reported late sequelae include chronic diarrhea, malabsorption with steatorrhoea, abdominal spasms, intestinal obstruction, bleeding and fistula formation [14]. It is observed that, apart from the total dose of radiation delivered, the volume of the small intestine exposed to the radiation is also important in determining the severity of the presenting symptoms of the patients [15]. When biopsies are taken from the mucosa of the jejunal flap before and after radiotherapy and compared under microscopy and scanning electron microscopy [16], it was found that there is generalized edema and loss of villi during early post-radiation period (Figure 3). The thinning of jejunal mucosa, the focal loss of glands and the blunting of the villi are found at 6 months after completion of irradiation and persisted throughout the following 2 years. However, none of the jejunal biopsies displayed any area of necrosis or ulceration secondary to radiation.

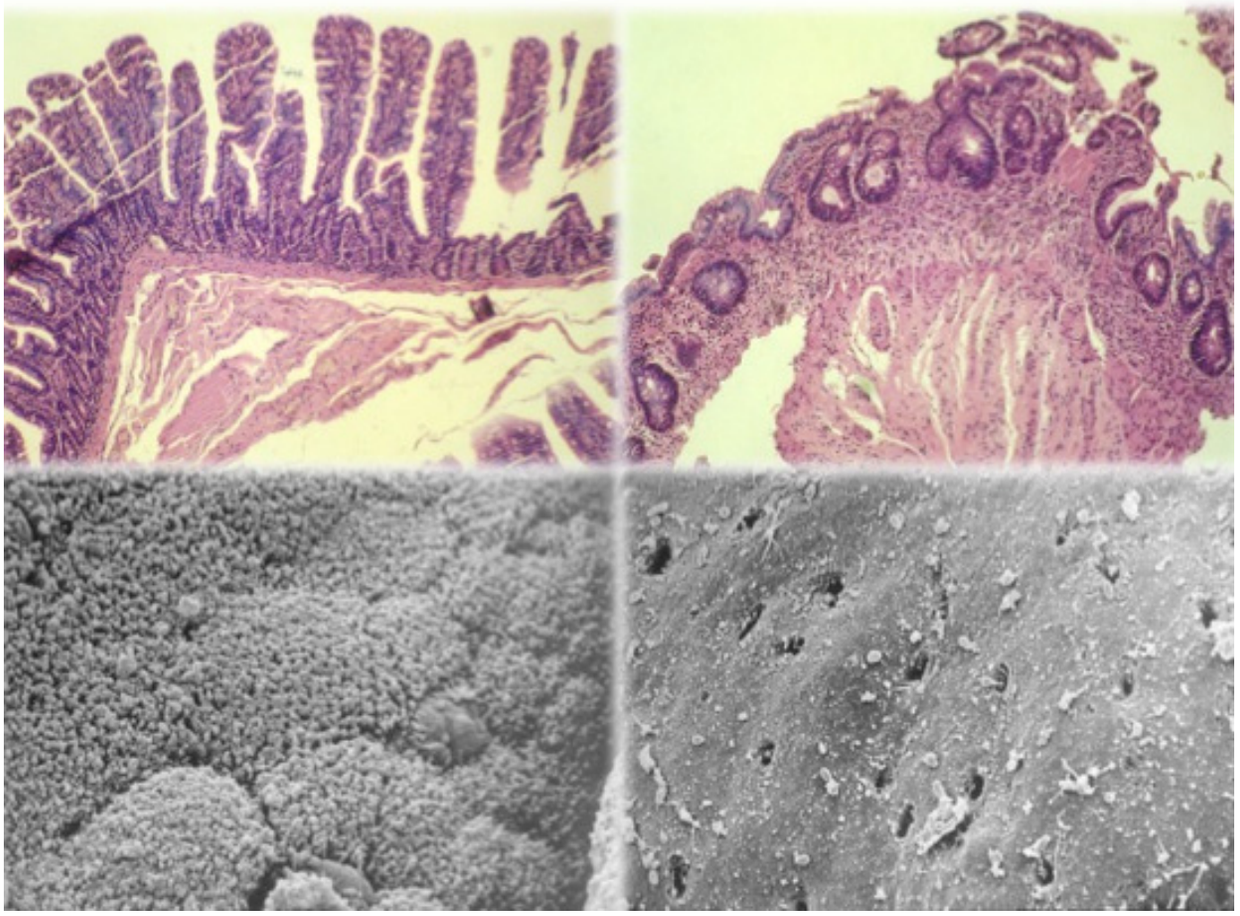

Figure 3. Effect of radiotherapy on the jejunal flap (Above, left) Haematoxylin and eosin stain, x 80. Before radiotherapy. The villi of the jejunal flap in normal configuration. (Above, right) Haematoxylin and eosin stain, x 80. 2 months after radiotherapy. Shortening and blunting of villi with increased fibrosis and retraction of the glands noted. (Below, left) Scanning electron micrograph. Before radiotherapy. Normal jejunal mucosa with healthy microvilli and cell boundaries well demonstrated. (Below, right) Scanning electron micrograph. 2 months after radiotherapy. There is generalized shortening of the microvilli. Pitted areas represent the loss of microvilli.

5.2. Oncological results after reconstruction of circumferential pharyngeal defects

Despite the increasing popularity of organ-preserving chemoradiation for early stage cancer of the hypopharynx, surgery remains the preferred therapeutic option for locally advanced disease, when post-operative radiotherapy is generally indicated. Evidence shows that adjuvant radiotherapy significantly improved locoregional control as well as survival after surgery for carcinoma at the hypopharyngeal region [17]. However, because of the potential risk of radiation damage to the jejunal flap which has been transferred to the neck as a free flap after tumour extirpation, it has been a common practice among the clinical oncologists to reduce the radiation dosage for patients who had received free jejunal flap reconstruction. Our experience showed that the mean radiation dosage given to patients after visceral flap transfer was much lower than those after cutaneous flap reconstruction (54.8Gy vs. 62.2Gy) [18].

At this level of radiation, there was no evidence of secondary ischaemia or necrosis of the flap upon completion of the adjuvant treatment. Despite the reduction of radiation dosage in the jejunal group, the difference in the 5-year actuarial loco-regional tumour control between the 2 groups of patients was not significant for TNM stage II (61% vs. 69%, p = 0.9) and III (36% vs. 46%, p = 0.2) disease. However, for stage IV disease, patients with jejunal flap reconstruction had significantly poorer loco-regional tumour control (32% vs. 14%, p = 0.04) (Table 2). This may be explained by the failure of the reduced dose of radiation to deal with the more widespread microscopic tumour deposits in the advanced stage of disease. Despite the apparently better functional outcome using the jejunal flap to reconstruct circumferential pharyngeal defects, the choice of reconstructive options should never compromise the oncological control. The surgeons should communicate with the oncologists, and if a reduced dose of radiation is to be given, then jejunal transfer should not be the first choice of reconstruction in advanced staged carcinoma of the hypopharyngeal region.

	Cutaneous flap reconstruction	Free jejunal flap reconstruction	p-value
Stage II	61%	69%	0.9
Stage III	36%	46%	0.2
Stage IV	32%	14%	0.04

Table 2. Comparison of 5-year actuarial loco-regional tumour control between patients using cutaneous flap and free jejunal flap for pharyngeal reconstruction.

6. Conclusion

Reconstruction of circumferential pharyngeal defects after tumour extirpation remains a therapeutic challenge. In order to achieve the best functional and oncological outcome, the choice of the reconstructive options should be individualized according to the patients' characteristics.

Author details

Jimmy Yu-Wai Chan* and Gregory Ian Siu Kee Lau
Division of Head and Neck Surgery, Department of Surgery
University of Hong Kong Li Ka Shing Faculty of Medicine, Queen Mary Hospital, Hong Kong SAR, China

* Corresponding Author

7. References

[1] Wookey H. The surgical treatment of carcinoma of the hypopharynx and the oesophagus. Br J Surg 1948; 35: 249 – 66.
[2] Surkin MI, Lawson W, Biller HF. Analysis of the methods of pharyngoesophageal reconstruction. Head Neck Surg 1984; 6: 953 – 70.
[3] Ariyan S. The pectoralis major myocutaneous flap. A versatile flap for reconstruction in the head and neck. Plast Reconstr Surg 1979; 63: 73-81.
[4] Withers EH, Franklin JD, Madden Jr JJ, et al. Pectoralis major musculocuatneous flap: a new flap in head and neck reconstruction. Am J Surg 1979; 138: 537-43.
[5] Lam KH, Wei WI, Lau WF. Avoiding stenosis in the tubed greater pectoral flap in pharyngeal repair. Arch Otolaryngol Head Neck Surg 1987; 113(4):428-31.
[6] Song YG, Chen GZ, Song YL, et al. The free thigh flap: a new free flap concept based on septocutaneous artery. Br J Plast Surg 1984; 37:149-59.
[7] Koshima I, Yamamoto H, Nagayama H, et al. Free combined composite flaps using the lateral circumflex femoral system for repair of massive defects of the head and neck regions: an introduction to the chimeric flap principle. Plast Reconstr Surg 1993; 92:411-20.
[8] Koshima I, Fukuda H, Ohta S, et al. Free anterolateral thigh flaps for reconstruction of head and neck defects. Plast Reconstr Surg 1993; 92:421-8.
[9] Seidenberg B, Rosenak SS, Hurwitt ES, et al. Immediate reconstruction of the cervical esophagus by a revascularized isolated jejunal segment. Ann Surg 1959; 149:162-71.
[10] Chan YW, Ng RW, Liu LH, Chung HP, Wei WI. Reconstruction of circumferential pharyngeal defects after tumour resection: reference or preference. J Plast Reconstr Aesthet Surg 2011; 64(8): 1022 - 8.
[11] Ho MW, Houghton L, Gillmartin E, et al. Outcomes following pharyngolaryngectomy reconstruction with the anterolateral thigh (ALT) free flap. Br J Oral Maxillofac Surg 2012; 50(1): 19 - 24.
[12] Yu P, Hanasono MM, Skoracki RJ, et al. Pharyngoesophageal reconstruction with the anterolateral thigh flap after total laryngopharyngectomy. Cancer. 2010; 116(7): 1718 - 24.
[13] Andreyev HJ. Gastrointestinal problems after pelvic radiotherapy: the past, the present and the future. Clin Oncol 2007; 19: 790-9.
[14] Coia LR, Myerson RJ, Tepper JE. Late effects of radiation therapy on the gastrointestinal tract. Int J Radiat Oncol Biol Phys 1995; 31: 1213-36.
[15] Fiorino C, Alongi F, Perna L, et al. Dose-volume relationship for acute bowel toxicity for patients treated with pelvic nodal irradiation for prostate cancer. Int J Radiat Oncol Biol Phys 2009; 75: 29-35.
[16] Wei WI, Lam LK, Yuen PW, Kwong D, Chan KW. Mucosal changes of the free jejunal graft in response to radiotherapy. Am J Surg 1998; 175: 44-6.
[17] Vandenbrouk C, Eschwege F, De La Rochefordière A. Squamous cell carcinoma of the pyriform sinus: retrospective study of 351 cases treated at the Institut Gustave-Roussy. Head Neck Surg 1987; 10: 4-13.
[18] Chan JY, Chow VL, Chan RC, Lau GI. Oncological outcome after free jejunal flap reconstruction for carcinoma of the hypopharynx. Eur Arch Otorhinolaryngol 2011 Nov 18 [Epub ahead of print].