

Infrahyoid flap in oropharyngeal reconstruction following carcinoma resection: A study of 6 patients and literature review

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Abstract. The present study aimed to describe the techniques used and the results obtained with the infrahyoid flap for the reconstruction of medium-sized oropharyngeal defects following resection for advanced squamous cell cancer. During a period of 1 year, six patients with oropharyngeal defects were reconstructed using the infrahyoid flap. The tumor characteristics, location and size of the defect, resective and reconstructive techniques employed and the complications and outcomes of the speech and swallowing functions, as identified in the follow-up visits every 3 months, were evaluated. All flaps were performed simultaneously in association with tumoral excision and ipsilateral supraomohyoid neck dissection. The mean size of the skin paddle was 7.0x3.5 cm. The donor site was primarily sutured. The postoperative course was uneventful and all flaps were viable. One case of marginal skin paddle loss occurred without affecting the survival of the flap. Five patients received postoperative radiotherapy and one patient received concurrent postoperative chemotherapy. During the follow-up period (mean, 63 months), all patients showed excellent oral swallowing. Speech was excellent in five patients and in one patient speech was classified as good. The aesthetic results of the cervical donor site were good. Based on the present case report and the literature review, the infrahyoid flap is a simple and safe procedure for the reconstruction of the oropharynx, with a high success rate, minimal donor site morbidity and good aesthetic and functional results. The infrahyoid flap is a valid surgical option that may be considered in selected oncological patients undergoing reconstruction of medium-size oropharyngeal defects.

Introduction

Oropharyngeal squamous cell cancer (OPSCC) develops from the epithelial lining of the anatomical structures comprising the oropharynx, including the base of tongue (posterior one-third), the soft palate, the tonsillar complex (tonsil, tonsillar fossa and pillars) and the posterior pharyngeal wall (1). Overall, OPSCC accounts for 15-25% of all head and neck cancers (2). Therapeutic strategies for OPSCC continue to evolve, and are usually based on the combination of surgical and nonsurgical treatments (3). In general terms, the choice of therapeutic modality is defined by the stage of disease and location of the lesion. In early-stage tumors (stages I and II), conventional ablative or minimally invasive surgery, or radiotherapy with anatomical and functional preservation of the oropharynx, achieve similar results (2,4). For the advanced stages of disease (stages III and IV), two oncological treatments are currently accepted: i) Surgical excision with or without postoperative radiation or chemoradiation and ii) nonsurgical organ preservation therapy, using combinations of chemotherapy and radiotherapy. The former treatment option emerged to minimize the postoperative morbidity of traditional open surgical approaches to the oropharynx (5). However, though current chemoradiation regimens were initially considered to have a positive impact on survival, long-term follow-up studies have failed to demonstrate superior survival rates and functional preservation (5). In addition, chemoradiotherapy is associated with an increased rate of acute, delayed and prolonged toxicity, and in the majority of patients results in significantly increased morbidity, in particular, due to late swallowing dysfunction (6,7). Despite progress in chemotherapy and chemoradiotherapy for treating advanced OPSCC, surgery remains a major therapeutic option (8). The surgical approach results in a reasonable long-term survival, while ensuring that the pathological staging of the disease may be used to determine the patient's prognosis (9). In addition, surgery may potentially prevent the requirement for additional chemoradiotherapy, which is expected to result in toxicity in patients (10).

Traditionally, the oropharynx is one of the most challenging regions of the body to reconstruct and rehabilitate following cancer surgery due to the implications for speech, swallowing

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and respiratory function, which may eventually negatively affect the quality of life of patients (11-13). Various types of loco-regional and free flaps are used for oropharyngeal reconstruction; but, at present, this issue remains the subject of debate since no 'ideal method' for all situations exists (11,14). The infrahyoid flap (IHF), introduced by Wang *et al* in 1986 (15), has been demonstrated to be a good alternative to for the reconstruction of small- or medium-sized defects in the oral cavity, oropharynx, hypopharynx and lower third of the face (15-33). In the present study, a prospective clinical study was performed on a series of consecutive patients with advanced OPSCC, with the aim of defining the principal characteristics and outcomes of oropharyngeal defect reconstruction with a simultaneously harvested IHF. The present study also reviews the knowledge that is available in the literature with regards to IHF. The advantages and inconvenience of IHFs are discussed and compared with other flaps that are universally used in oropharyngeal reconstruction.

Patients and methods

Patients. Between May 2009 and April 2010, six patients diagnosed with advanced OPSCC (stages III and IV) (34) underwent primary reconstruction with an IHF in Virgen del Rocío University Hospital (Seville, Spain). The primary sites included: The tonsillar complex; base of the tongue; soft palate; pharyngeal wall; or combined locations. The exclusion criteria were: Ipsilateral tonsillectomy or thyroidectomy prior to diagnosis; tumors of the oral cavity or oropharynx previously excised; tumoral recurrence after radiotherapy; or radiation to the neck. Reconstruction with the IHF was considered in the following situations: Defects located primarily in the oropharynx; estimated medium-sized defects (<5x10 cm) following excision; and cervical levels II and III (35) clinically free of ipsilateral lymph node involvement, based on palpation and computed tomography (LightSpeed 16; GE Healthcare Bio-Sciences, Pittsburgh, PA, USA). Prior to surgery, the management options for each case were discussed in the multidisciplinary Head and Neck Cancer Committee of the Virgen del Rocío University Hospital. In the cases where two options for reconstruction were raised, either an IHF or free flap, the decision of the reconstructive procedure was made ultimately by the patient subsequent to being informed of the advantages and disadvantages of each technique. Following the consensual decision between patient and surgeon, a written informed consent for each patient was obtained.

The anatomical access to the oropharynx was complete in all patients using a midline lip-split mandibulotomy approach and subsequent fixation with two osteosynthesis miniplates (Lorenz® Mandibular Plating System; Zimmer-Biomet, Jacksonville, FL, USA). The curative-intent resection of the tumors was performed under direct vision and palpation. The IHF was harvested as a myocutaneous flap following the completion of an ipsilateral supraomohyoid selective neck dissection. The IHF harvest technique was performed according to the standard technique suggested by Dolivet *et al* in 2005 (22). In none of the cases did the IHF surgery interfere with the neck dissection, as the flap was dissected in the cervical central compartment, medial to the carotid artery [cervical level VI (35)]. In all cases, a rectangular flap with a major

craniocaudal direction that would allow the direct closure of the donor site without cervical tension was designed.

Surgical technique (Fig. 1). A unilateral cervical 'T' incision with extension to the middle lip-split was performed. The flap included a paddle of skin that was measured according to the estimated size of the post-resective defect. The skin paddle was designed with a rectangular shape centered vertically on the infrahyoid muscles and cricothyroid region. The myofasciocutaneous flap was composed of platysma muscle and of all the infrahyoid muscles except the inferior belly of the omohyoid muscle and the thyrohyoid muscle. All flaps were taken from the ipsilateral side to the defect, and the limits were the hyoid bone (top), supra-sternal space (bottom), middle cervical line (medial) and 3-4 cm midline (lateral). The flap dissection technique began with the paddle design and cervical flap elevation. An incision of the superficial cervical fascia was then performed anteriorly to the sternocleidomastoid muscle between the sternum and the hyoid. The internal jugular vein and the omohyoid muscle tendon were identified and the latter was cut at that level. Sternal attachments of the sternohyoid and sternothyroid muscles were sectioned. Dissection of the thyroid capsule was performed subsequent to incising the medial border of the flap, which was dissected through the avascular plane constituted between the thyroid capsule and the middle cervical fascia. The skin paddle was sutured to the muscles to prevent the shearing of the skin perforator vessels. The vessels were ligated at the superior pole of the thyroid gland in order to release the flap and increase its arc of rotation (cricothyroid artery and vein, and posterior branches of the superior thyroid artery and vein). The sternothyroid muscle was disinserted from thyroid cartilage. The thyrohyoid muscle was not mobilized to avoid injury to the superior laryngeal nerve. The infrahyoid muscles were disinserted in a subperiosteal plane from the hyoid bone to improve the flap venous return. Finally, the connection between the superficial- and mid-cervical fascias was established through the vascular pedicle (superior thyroid artery and vein and the anterior vessels to the infrahyoid muscles). The ansa cervicalis of the hypoglossal nerve was included to prevent the flap muscular atrophy. To position the paddle into the oropharyngeal defect, the skin paddle lower edge was sutured anteriorly and the upper edge posteriorly.

Data analysis. A database regarding the oncological and functional aspects of each case was designed. Data were introduced prospectively and updated regularly to evaluate the type, size and location of tumors, the resective and reconstructive surgical techniques used in the management of cancer patients, follow-up, complications, and functional swallowing and phonatory outcomes. The degree of swallowing ability was categorized as excellent swallowing without difficulty, swallowing with some difficulty or swallowing not possible. The degree of speech ability was classified as: Excellent, perfectly understood by the family and another person; good, perfectly understood by the family and with a degree of difficulty by another person; fair, understood with a degree of difficulty by the family and another person; or poor, understood with great difficulty by the family and another person. Satisfaction with the cosmetic result in the donor site was evaluated by

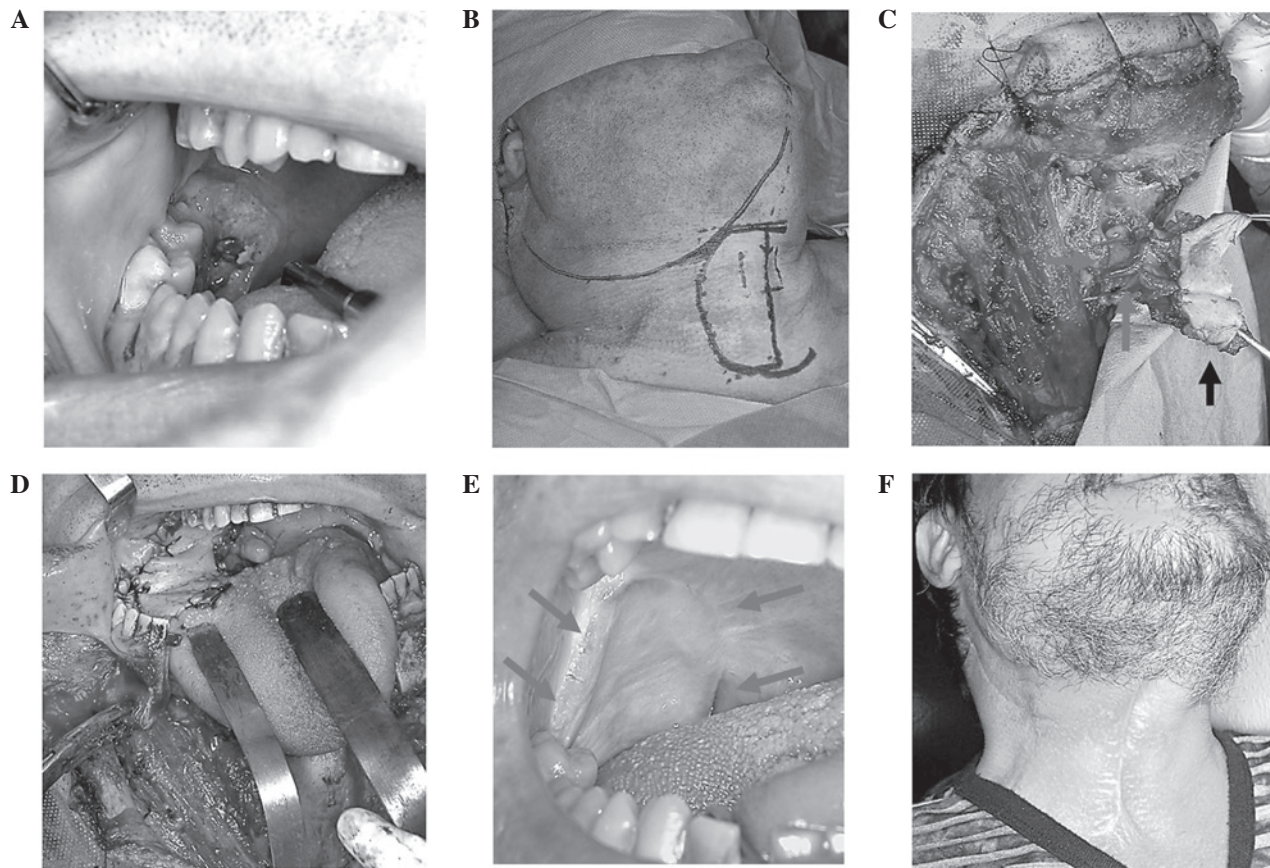


Figure 1. Case 2. (A) Ulcerative oropharyngeal squamous cell cancer in right tonsillar complex, base of tongue and 1/3 soft palate (arrows). (B) Neck flap design. (C) Intraoperative view of flap paddle and arterial and venous pedicle (arrows). (D) Skin paddle positioned and sutured into the oropharyngeal defect. (E) Postoperative appearance of the infrahyoid flap (arrows), and (F) donor site showing a satisfactory aesthetic outcome.

patients with an ordinal visual analog scale (VAS): 0, very good; 1-3, good; 4-6, average; 7-9, poor; 10, intolerable. The inclusion of patients in the study was conducted over 1 year, following the principles of the Declaration of Helsinki (36). Patients were followed up for at least 58 months (median follow up, 5.3 years). All treatments were performed according to therapeutic protocols established by the Hospital and following approval of each case by the Committee.

Results

The clinical data of the patients are shown in Table I. All patients in the present study were male, with a mean age of 59.85 years (range, 52.00-72.00 years). A total of six reconstructions with IHF were performed following cancer excision and supraomohyoid neck dissection, according to the aforementioned criteria. Histological diagnosis of squamous cell carcinoma was based on the conventional morphological examination of formalin-fixed, paraffin-embedded specimens with conventional hematoxylin and eosin stained sections. All patients had a history of smoking and drinking. While the lesion in all patients involved several anatomical sub-sites, the tumor primarily occurred in the tonsillar complex in four patients and in the base of tongue in two patients. All patients underwent combined tumor resection, including partial oropharyngectomy, palatectomy or glossectomy. Four patients were classified as T4a, one patient as T4b and another

as T3 (34). In all patients, clear surgical histological margins were obtained; although in the case 3, a 1-mm close margin was reported. The mean pathological size of the tumors was 4.92 cm (range 4.50-6.00 cm). Two patients were classified as pathological stage N1 and four patients as stage N0 (34). Four patients were classified in stage IVa disease, one in stage IVb and another in stage III (34).

The IHF was the only reconstruction technique used and no additional reconstructive procedures were performed. The size of the skin paddle ranged between 6-8 cm long and 3-4 cm wide; the mean size was 7.0x3.5 cm. All flaps were harvested from the ipsilateral neck and transferred to the surgical defects without tension. The postoperative course was uneventful in all patients and all flaps were viable. In one patient (case 1), marginal necrosis of the skin paddle occurred without any disturbance to the healing of the reconstruction or affect on the final functional result. All patients were discharged from hospital between 6-15 days (mean, 9.5 days) subsequent to surgery with a complete restoration of independent oral feeding. No patient required a tracheotomy.

Five patients received postoperative radiotherapy (66 Gy divided into 33-35 fractions over 6-7 weeks) and one patient received concurrent postoperative chemotherapy (cisplatin 100 mg/m² every 21 days). One patient (case 3) demonstrated a prevertebral metastasis in the follow-up and succumbed 18 months later. Another patient (case 5) developed a second laryngeal squamous cell cancer 36 months later

Table I. Demographic characteristics of patients (n=6).

Case	Age, years	Gender	Tumor location	Staging pTNM ^a	Paddle size, cm	Neck dissection	Postoperative follow-up, months	Complications at the donor or recipient site	Functional results
1	72	M	Tonsillar complex, base of tongue, 1/3 soft palate	T4a N0 M0 (IVa)	8x4	SND	FD, 68	Superficial marginal necrosis of the skin paddle	Speech, good; swallowing, without difficulty
2	52	M	Tonsillar complex, base of tongue, 1/3 soft palate	T4a N0 M0 (IVa)	7x4	SND	FD, 68	-	Speech, excellent; swallowing, without difficulty
3	62	M	Tonsillar complex, base of tongue, 1/3 soft palate	T4a N1 M0 (IVa)	7x3	SND	DD, 18	-	Speech, excellent; swallowing, without difficulty
4	55	M	Tonsillar complex, retromolar trigone, base of tongue, 1/3 soft palate	T4b N0 M0 (IVb)	6x3	SND	FD, 59	-	Speech, excellent; swallowing, without difficulty
5	65	M	Base of tongue, tonsillar complex	T3 N1 M0 (III)	7x4	SND	DS, 36	-	Speech, excellent; swallowing, without difficulty
6	53	M	Tonsillar complex, base of tongue, 1/3 soft palate, retromolar trigone	T4a N0 M0 (IVa)	7x3	SND	FD, 58	-	Speech, excellent; swallowing, without difficulty

^a(35). M, male; SND, supraomohyoid neck dissection; FD, free of disease; DD, died of disease; DS, died of second tumor.

and succumbed to it. The remaining four patients survived without tumor recurrence (mean follow-up, 63.25 months; range, 58.00-68.00 months). The aesthetic results of the oropharyngeal reconstructions were satisfactory, although one patient (case 3) had a small hairy area on an intraoral paddle margin, which disappeared subsequent to the postoperative radiotherapy. An assessment of functional outcome was performed at the follow-up visits, every 3 months. All patients demonstrated excellent oral swallowing, and reintegrated to their usual diet without difficulty. Five patients demonstrated excellent speech function, and in one patient (case 1) the speech was classified as good. The average patient satisfaction with the cosmetic outcome in cervical donor site was good (mean VAS score, 3).

Discussion

In the majority of cases, elimination of a primary advanced OPSCC with clear surgical margins requires a surgical reconstruction of the defect created. In the oropharyngeal reconstruction, the surgeon faces the problem of choosing the most appropriate reconstructive method for each patient. A comparison of various reconstructive procedures for a given primary tumor site has, to the best of our knowledge, never been performed in a randomized manner (37). The basic technique for providing soft tissue is by means of loco-regional flaps. Among the local flaps, the palate island flap, submental flap and myomucosal buccinator flap have indicated to be useful for closing small oropharyngeal defects (11). Larger defects, including a complete loss of the soft palate, half of the base of tongue, or composite defects involving the base of tongue, palate and pharyngeal wall, are recommended to be reconstructed with a pedicled regional myocutaneous flaps as the pectoralis major flap (38). The advantages include a relatively low surgical complexity, a short operative time and reduced morbidity rate and complications (38). Disadvantages include the excessive volume of the skin paddle and the lack of sensitivity with regards to the subsequent challenges for speech and swallowing (31). In more complex defects, the first choice are microvascular free flaps. Free flaps have a high success rate with few complications, and allow a flexible flap design that may be adapted to almost every defect (8,9). Currently, the most commonly used method worldwide for oropharyngeal reconstruction is the radial forearm free flap followed by the anterolateral thigh flap (31). However, this microsurgical procedure is often slow and technique-sensitive (13). In addition, not all patients are suitable for a free flap reconstruction, particularly patients that are elderly and show poor general condition (29).

The IHF is a lesser-known reconstructive procedure that was perfected at the same time that free flaps have been developed (31). The IHF is a pedicled myocutaneous flap that nourishes from the superior thyroid vessels through the perforating vessels of the infrahyoid muscles, with preservation of the superior thyroid vein and the caudal stump of the internal jugular vein, and is sensitively innervated by the ansa cervicalis (33). Previously, various technical modifications have been described by Dolivet *et al* (22), Ricard *et al* (39) and Mirghani *et al* (28) to increase venous drainage, reduce complications and improve the aesthetic results in the donor

region. The procedure is usually indicated as a primary reconstruction with direct closure of the donor site.

The advantages of IHF may be summarized as: Excellent reliability, and low complication rate; the donor site is near the defect, thus allowing the paddle to be easily transferred without torsion or tension of the pedicle; minimal donor site morbidity as the cervical donor site is usually closed primarily; does not interfere with the movement of the tongue; by including the ansa cervicalis, the flap may become sensitive, which prevents atrophy of the paddle; the paddle is thin and flexible, very suitable for the reconstruction of the oral cavity and oropharynx, with an appropriate thickness and texture; allows good coverage without excessive volume; may be harvested during the neck dissection by the same surgical team, which lengthens the surgery time by <1 h; and a prolonged immobilization of the patient is not required subsequent to surgery, which is better tolerated by elderly and debilitated patients (27,28,31,33). The flap dissection does not require microsurgical expertise and vigilant monitoring, as free flaps do.

Table II lists the articles published on the IHF in the English literature (16-32). The versatility of the IHF in the reconstruction of defects of the head and neck region is well known and widely accepted. The IHF has been used to reconstruct small to medium defects located mainly in the oral cavity in 69.8% of reported cases, but the flap may be extended to locations where the arc of rotation reaches, including the oropharynx (21.1%), hypopharynx (4.9%) or larynx (2.2%). In the majority of cases, the mean size of the flap was 7x4 cm (33). Traditionally, the frequency of complications has been reported as 0-47% (17,27). The majority of authors identify the major problems in association with the unreliability of the skin paddle due to insufficient venous drainage (31,32). In the literature analysis, total flap necrosis and total skin paddle necrosis was indicated in 1.7 and 3.7% of cases, respectively. A total of 5.6% of cases suffered from partial skin paddle necrosis; however, the majority of such cases were resolved without any of the flaps showing signs of necrosis. However, since the modifications to increase venous drainage were recently devised (22), the rate of complications and flap loss has been significantly reduced.

The present study analyzed the reconstructions performed by a single surgeon to avoid interoperator differences. The prospective nature of the present study and the time span of 1 year may be considered an important advantage. The present study was based on a homogeneous sample with strict inclusion criteria of patients. Only the defects in which a communication with neck spaces was established were selected in order to share a similar level of complexity. In a search of the English literature, 125 cases of oropharyngeal reconstruction were identified (Table II). A major limitation was the relatively small number of patients included in the majority of studies. The results of six flaps support other previous studies. Only one IHF suffered a small necrosis of the skin paddle in a marginal area, which resolved spontaneously without treatment. In the case that demonstrated skin paddle necrosis, the infrahyoid muscles remain alive and allow a secondary epithelialization. This represents a success rate of 100% in the present study, which is comparable to the published results of other series. Generally speaking, the aesthetic and functional results of the present study were very good. In one patient, the presence of

Table II. Studies of patients that have been reconstructed with an infrahyoid flap, published in the English literature (n=592).

Study	Authors	Year	Number of flaps	Sub-site				Other (parotid, lip, submental)	Overall complications			(Ref.)
				Oral cavity	Oropharynx	Hypopharynx	Larynx		Total flap necrosis	Total skin paddle necrosis	Partial of necrosis skin paddle	
1	Wang <i>et al</i>	1986	112	105	0	0	0	7	0	0	11	(15)
2	Rojananin <i>et al</i>	1991	22	18	0	0	0	4	0	2	3	(16)
3	Magrin <i>et al</i>	1993	15	9	2	4	0	0	3	4	0	(17)
4	Remmert <i>et al</i>	1997	11	0	11	0	0	0	0	0	1	(18)
5	Hell <i>et al</i>	1997	23	19	4	0	0	0	1	0	0	(19)
6	Lockhart <i>et al</i>	1998	21	21	0	0	0	0	0	4	4	(20)
7	Zhao <i>et al</i>	2001	53	53	0	0	0	0	1	1	2	(21)
8	Dolivet <i>et al</i>	2005	152	78	47	14	13	0	2	8	0	(22)
9	Gangloff <i>et al</i>	2006	23	0	23	0	0	0	0	0	2	(23)
10	Tincani <i>et al</i>	2006	14	11	3	0	0	0	0	0	4	(24)
11	Deganello <i>et al</i>	2007	13	7	2	3	0	1	0	0	0	(25)
12	Seidl <i>et al</i>	2007	6	0	0	6	0	0	0	0	0	(26)
13	Minni <i>et al</i>	2010	32	32	0	0	0	0	0	0	0	(27)
14	Mirghani <i>et al</i>	2011	32	21	11	0	0	0	0	2	2	(28)
15	Deganello <i>et al</i>	2012	18	12	6	0	0	0	0	0	1	(29)
16	Ouyang <i>et al</i>	2013	11	11	0	0	0	0	2	0	0	(30)
17	Peng <i>et al</i>	2013	20	16	2	2	0	0	1	1	2	(31)
18	Perrenot <i>et al</i>	2014	8	0	8	0	0	0	0	0	0	(32)
19	Present study	2014	6	0	6	0	0	0	0	0	1	
Total no., (%)			592 (100.0)	413 (69.8)	125 (21.1)	29 (4.9)	13 (2.2)	12 (2.0)	10 (1.7)	22 (3.7)	33 (5.6)	

intraoral hair was detected, which disappeared with postoperative radiotherapy. The aesthetic effect on the donor site was minor, and the phonation, swallowing and chewing functions were satisfactorily preserved.

According to numerous authors, the IHF may compete with fascio-cutaneous free flaps in the management of medium-sized defects of the oropharynx (30-33). In the experience of the current authors, the results of IHFs are of a particularly high quality as the rectangular shape fits almost perfectly to usual oropharyngeal resections. Therefore, the flexible and thin skin paddle may be positioned and sutured around the defect mucosa, and the infrahyoid muscles may fill the loss of deep tissue from *en bloc* resections with the neck dissection. In a study consisting of 32 consecutive reconstructions of the oral cavity and oropharynx, Deganello *et al* (25) indicated that the functional outcomes in patients with poor performance status that received a reconstruction with IHF were as fair as the functional outcomes in patients with good performance status that received a transference of a radial forearm free flap. In addition, the medical cost the IHF reconstruction produced a cost saving in comparison (40).

The major disadvantage of IHF in oropharyngeal reconstruction lies in the limited size and volume of the skin paddle, which prevents its use in large and complex defects. According to a previous study (33), the IHF in medium defect reconstruction was used. The maximum length of the flap is generally ~10 cm, depending on the length of the patient's neck. If the width is >5 cm, an additional flap may be required to close the donor site (31). When a neck dissection is performed concurrently, a functional or supraomohyoid neck dissection should be used to preserve the internal jugular vein and superior thyroid vein (33). The vascular pedicle of IHF is located in the vicinity of the lymph nodes where primary tumors of the oropharynx drain. However, the technique meticulously skeletonizes the vascular pedicle flap, allowing a complete dissection of the ipsilateral lymph nodes in levels II and III (31,35). Therefore, the risk of compromising oncological control in the neck is minimized. Consequently, the IHF was not performed in patients with clinically positive nodes in ipsilateral levels II or III (35) in the present study. Other classical contraindications of the IHF include: Previous thyroid surgery or neck dissection; N3 neck metastasis; and positive lymph nodes in levels III-IV (27-29,35). For these reasons, the IHF is recommended to always be planned in advance and not be performed as a backup solution in case of another flap failure, as an IHF may not be used in a previously-operated neck. The likely damage to the artery or vein thyroid or the possible elevation of the skin overlying the muscles prevent the option of performing this flap.

In conclusion, IHF has been mainly used to repair various oral cavity defects, but it appears to be a particularly valuable method for the simultaneously reconstruction of medium-sized oropharyngeal defects following the elimination of advanced squamous cell carcinoma. The IHF is easy to perform and is associated with a high success rate, minimal donor site morbidity and good aesthetic and functional results. By respecting the indications and contraindications of the method and using the knowledge of its clinical utility and limitations, a well-planned IHF constitutes an elegant surgical option that may be taken into account in patient counseling, and used

to better inform the patient on surgical practice prior to an oropharyngeal reconstruction.

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