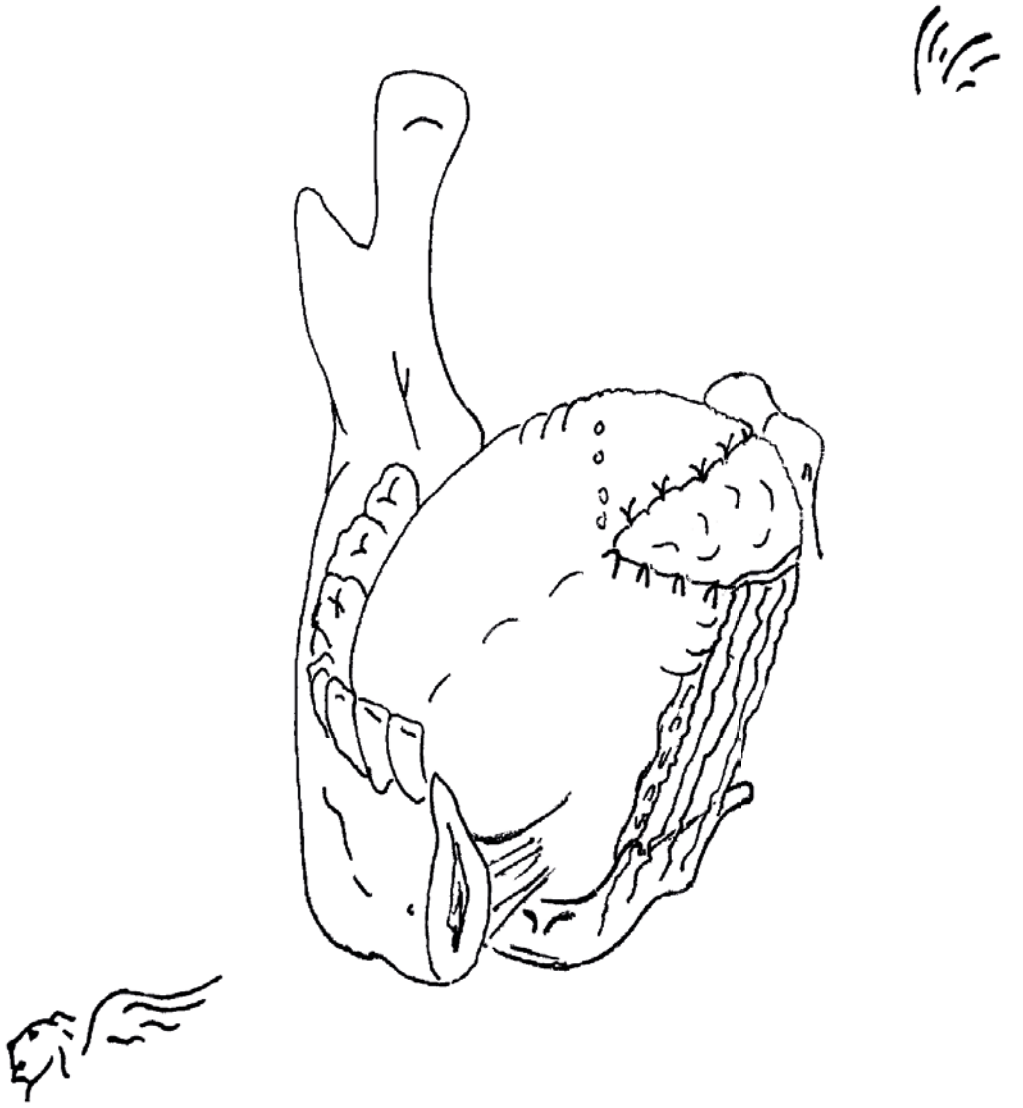
Head and neck reconstruction with the infrahyoid flap in era of free flaps



Alberto Deganello

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Head and neck reconstruction with the infrahyoid flap in the era of free flaps

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door

Alberto Deganello

geboren te Conselve, Italië

promotor: prof.dr. C.R. Leemans

copromotor: prof.dr. R. de Bree

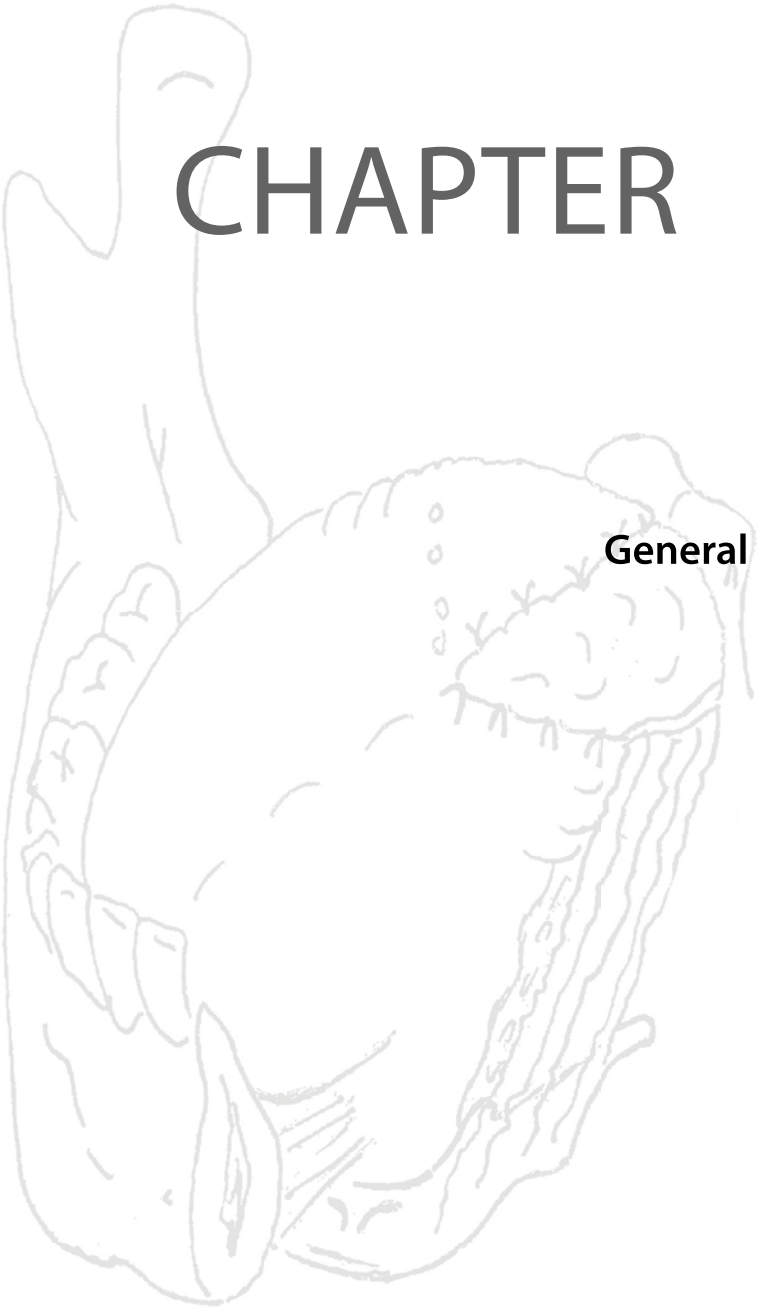
Chiara

ti dedico questo piccolo traguardo, senza di te non sarebbe mai stato raggiunto.
Grazie per come mi sei sempre stata vicino, per come mi sostieni, incoraggi,
consigli, sopporti, e soprattutto perché continui ad amarmi.
Tu sei il punto di riferimento, il fulcro della nostra meravigliosa famiglia.

Tuo,
Alberto

Contents

CHAPTER 1



General introduction

Every year, worldwide, cancer of the head and neck region is diagnosed in more than 550.000 people [1] accounting for approximately 3% of all malignancies; more than 90% of head and neck malignancies are squamous cell carcinomas arising from the mucosa of the upper aero-digestive tract: oral cavity, pharynx and larynx [2]. The remaining histologic entities include adenocarcinomas, sarcomas, melanomas and rare tumors [3].

Cigarette use is the most-cited risk factor for the development of head and neck squamous cell carcinomas (HNSCC), rising the risk from 3- to 7- fold; concomitant alcohol consumption, acting synergistically, further increases the risk 10- to 15- fold [4,5]. Besides these well established risk factors, epidemiologic trends starting from the 1980s indicate that today the incidence of laryngeal, hypopharyngeal and oral cancers has declined [6,7], and that this decline is related to declining tobacco use; on the other hand the incidence of oropharyngeal cancers has increased during the same period [6,8]. It is now proven that high-risk human papilloma virus (HPV) infection causes many of these cancers in absence of conventional risk factors, therefore HPV-related HNSCC is a different disease as compared to non HPV cancers, and efforts to tailor its treatment in this light is now under investigation with ongoing clinical trials. Another virus playing a crucial role in the pathogenesis of head and neck malignancies is the Epstein-Barr virus (EBV), latent EBV infection is significantly associated with the onset of nasopharyngeal carcinoma; this disease is characterized by a unique set of geographic, etiologic and biologic features distinct from other head and neck cancers [9].

In general, HNSCC are more prone to metastasize to regional lymph nodes in the neck rather than spread hematogeneously [10], several studies report an incidence of nodal metastasis varying between 20% and 50% [11,12]; moreover, neck lymph node status proved to be the single most important prognostic factor for HNSCC in terms of overall survival, disease-specific survival, and relapse-free survival [13-15]; in fact, the presence of nodal metastases reduces survival by 50% [5]. Independent of nodal metastasis, extracapsular spread (ECS) portends worse regional and distant metastatic failure rates relative to nodal metastasis without ECS (regional recurrence, 28.9% *v* 19.2, and distant metastasis, 24.4% *v* 8.1%, respectively). This directly correlates with worse 5-year disease-specific survival and overall survival, comparing the presence of nodal metastasis with ECS relative to nodal metastasis without ECS (DSS, 48% *v* 66%, and OS, 29% *v* 51%, respectively). Although the extent of ECS is not correlated with survival, involvement of more than two lymph nodes with ECS is significantly associated with worse outcomes [5,16,17].

The distribution of lymphatic metastases is related to the anatomic lymphatic pathways, the risk of developing nodal metastases varies by primary tumor site, size, tumor thickness and lymphatic invasion [10]; when positive lymph nodes are present at diagnosis, a therapeutic neck dissection is considered the surgical standard of care, and usually a comprehensive neck dissection encompassing neck levels from I to V is then indicated. When no evidences of neck metastasis are found an elective neck dissection is indicated if the probability of occult

metastases exceeds 15–20% [18-21]; usually an elective neck dissection is not comprehensive but instead is selective, which means limited to the neck levels at highest risk for occult neck disease.

The management of patients with head and neck cancers is complex, therefore a multidisciplinary team is needed in order to achieve optimal treatment; early stage disease is mostly cured with a single modality treatment, usually surgery or radiotherapy, while more advanced cancers require a combination of surgery-radiotherapy-chemotherapy. Several host and tumor factors must be taken into consideration in treatment planning: patient's general conditions (performance status) and specific comorbidities that might prevent withstanding of the treatment, the chances of obtaining a free margin resection in case of surgical intervention, the possibility of delivering curative doses of radiation without damaging vital structures, the locoregional volumetric extension of the disease and the presence or absence of distant metastases. Unresectable cancer is mainly treated by radiotherapy with or without concomitant chemotherapy, the setting of which is designed for a curative or a palliative intent based on the realistic chances of tumor control [22].

A thoughtful analysis regarding the impact of treatment on quality of life must be taken in consideration since HNSCC proves to be associated with serious deterioration in quality of life; not only tumor-related factors, but also the combined multimodality treatment, including surgery, chemotherapy and radiotherapy, proves to have a profound effect on function and quality of life. Even though these treatments contribute to increased disease control for locally-advanced head and neck cancers, they come at the expense of increased acute and late effects [23,24]. The three major advancements in the management of HNSCC during the last 30 years are represented by the introduction and the development of non-surgical organ preservation protocols; by the refinements of endoscopic and, more recently, robotic-assisted minimally invasive surgical techniques; and by the application of microvascular free flaps in head and neck reconstructions.

Head and neck cancer resection results in local defects with loss of functioning tissue, which can lead to a broad range of functional impairments and in some cases even to disfigurement; as a matter of fact, the head and neck area provides to the human being the self representation when looking at the mirror and is a particularly complex region providing very important functions: respiration, voice production, articulation, and swallowing functions. The choice regarding the type of reconstruction depends on the characteristics of the anticipated defect and on patient 's related factors: age, performance status, general comorbidities, and previous treatments (especially within the head and neck area).

The aim of this thesis is to define the role of head and neck reconstruction with the infrahyoid flap (IHF) in the era of free flaps.

Chapter 1 of this thesis contains a brief introduction on the general aspects of head and neck squamous cell carcinoma.

Chapter 2 of this thesis gives a general overview on the options for oral cavity reconstruction using microvascular free flaps or alternative pedicled flaps. Usually, free flaps carry enormous advantages over pedicled flaps in head and neck reconstruction, tissue dimensions and thickness can be tailored to the size of the defect and vascularized bone can be used to reconstruct complex defects, all together leading to superior aesthetic and functional results [25,26]; nevertheless, in selected cases, pedicled flaps seem preferable to free flaps, and in some cases they can provide an excellent solution even competing with free flaps [27].

Chapter 3 of this thesis contains a comprehensive review on the IHF, the more appropriate adjectives that define the IHF are convenient and unpopular; this pedicled flap was born and has been developed in a free flap era, hence it is important to assess its usefulness in this modern scenario. When dealing with a surgical reconstructive method that is not widely accepted yet, it is important to start from the origins, focusing on the developments, technical modifications and improvements, with a critical eye to appropriate indications and specific contraindications.

The blood supply to the cervical skin was a matter of investigation in the seventies and early eighties of the past century [28-30]: the reports aimed to guide the surgeon in choosing the correct neck incision in order to minimize postoperative cervical wound breakdown following head and neck surgery, especially in pre-irradiated patients; furthermore, these studies helped in understanding the blood supply for the harvest of the platysma flap which was gaining popularity. In these reports, the inferior cervical skin approaching the midline was considered to be poorly vascularized; this is exactly the skin paddle area for a myocutaneous infrahyoid flap [30]. In 1985 Rabson et al. indicated how this region receives blood supply from perforator vessels coming from the superior thyroid artery piercing the infrahyoid muscles [31], therefore this cervical skin region is not reliable if a platysma flap is planned, but it is suitable when the infrahyoid muscles are harvested. In 1986 Wang et al. [32] first reported in the English literature the surgical technique and the results of 112 head and neck reconstructions in 108 patients, describing the infrahyoid myocutaneous flap as we know it today.

This chapter highlights the many advantages that the IHF can offer to the head and neck surgeon even in a free flap era, with the aim of promoting the use of something that is convenient and therefore should not remain unpopular; the small bulk of the existing literature, overwhelmed by reports on microvascular free flaps, probably explains why this flap remains unknown and overlooked by most head and neck surgeons.

In **Chapters 4**, **5** and **6** of this thesis, the results of 3 different clinical series using the IHF are reported, highlighting the clinical utility of this flap, with a critical eye on the advantages and limitations of this reconstructive procedure over the use of fascio-cutaneous free flaps. Furthermore, **Chapter 4** contains a new personal modification of the flap's harvesting technique and **Chapter 5** also describes a new personal technique for tongue base reconstruction using the IHF.

The concept that regional flaps remain a fundamental tool in the management of head and neck cancer is addressed in **Chapter 7** of this thesis, where the costs related to oral cavity and oropharyngeal reconstructions with microvascular free flaps and pedicled flaps were analyzed and compared. The analysis of economic and financial issues revealed that, in Italy, head and neck reconstruction with pedicled flaps produces a savings, especially when the IHF is used.

In **Chapter 8** of this thesis a discussion on several aspects influencing the decision making process of reconstructive head and neck surgery is undertaken, also a brief discussion on future perspectives is reported. This chapter highlights how a pedicled flap reconstruction should be taken into fair account in every decisional algorithm, especially in consideration of patient related aspects, with the aim of achieving optimal functional and oncologic results in the appropriate cases.

In **Chapter 9** of this thesis a summary of the thesis English, Italian and Dutch is reported.

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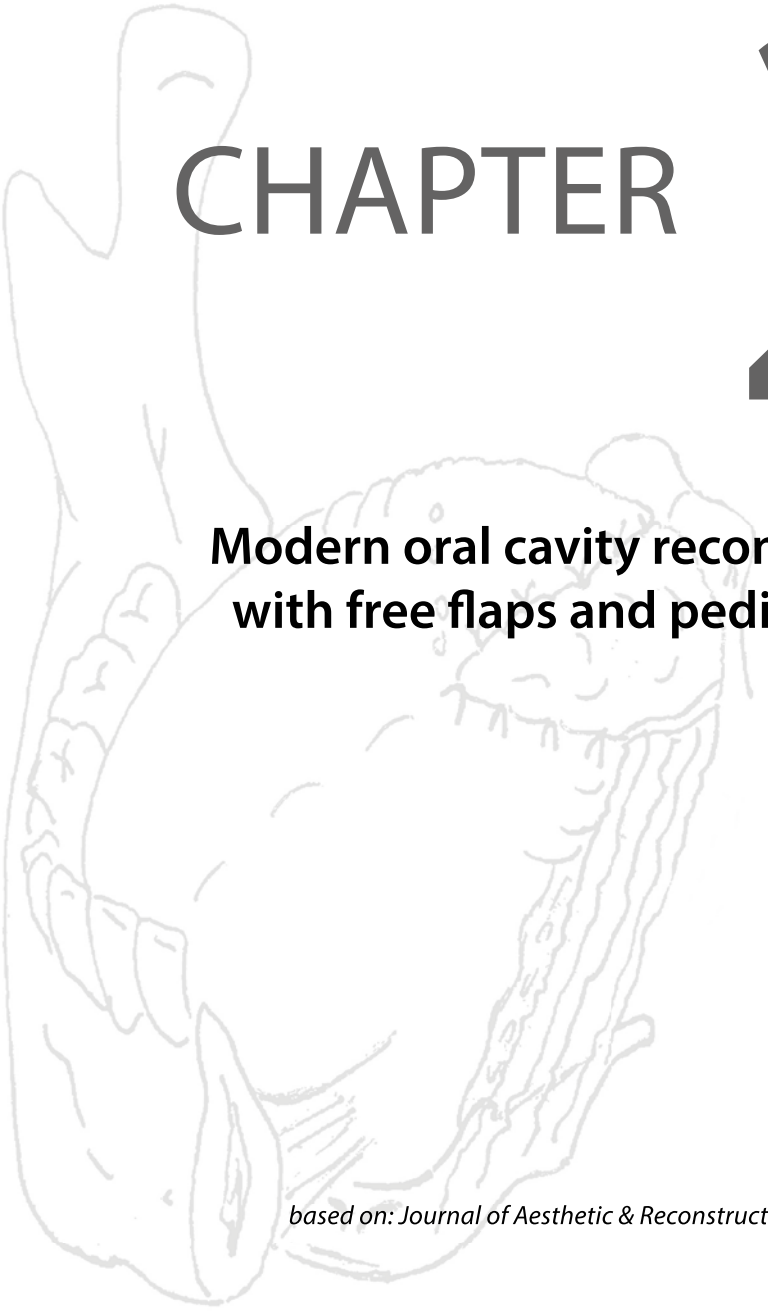

CHAPTER 2

Modern oral cavity reconstruction with free flaps and pedicled flaps

Deganello A

based on: Journal of Aesthetic & Reconstructive Surgery. 2015;1:4

Head and neck reconstructive surgery is a challenging discipline since it deals with a region throughout which the patient breaths, speaks, swallows and has the self-representation when looking at the mirror.

Small defects resulting from tumor ablation can be successfully managed with primary closure (i.e. limited excisions within the oral cavity), sometimes can be left to heal for secondary intention (transoral oropharyngeal/laryngeal/hypopharyngeal resections) or can be resurfaced using skin grafts or small local flaps, but in the majority of the cases the resulting defect requires a flap transposition in order to attempt a restoration of form and function and to ensure rapid and adequate wound healing. Therefore, the anticipation of the resulting defect prior to surgery is crucial in order to propose the most pertinent reconstructive solution, in this light every head and neck defect should be evaluated in terms of lack of support, cover and lining, and the chosen flap should ideally approximate the resected tissues in terms of type, thickness, texture, mobility, sensation and function. Another important aspect to consider is the need to restore a separation between different compartments; in fact, the surgical approach for tumor resection can often create an iatrogenic communication between the upper aerodigestive tract and neck contents, or between oral cavity and nasal/sinonasal cavities, orbital and cranial contents.

The introduction of microvascular reconstructions has provided the head and neck surgeon with the possibility of choosing among a broad variety of free flaps [1-5]. This reconstructive method represents a major evolution in the management of head and neck cancer with a consequent limitation of pedicled flap reconstructions. Unfortunately, not every patient is an ideal candidate for a microvascular reconstructive procedure and it is true that not every defect strictly requires a free flap transfer to achieve good functional results [6]. Nowadays the head and neck surgeon is more and more dealing with elderly patients suffering from severe comorbidities [7], with pre-treated patients presenting with a persistent/recurrent disease requiring salvage surgery, or with patients developing second primary tumors [8,9].

In these circumstances free flap surgery, with its prolonged anesthesia times and with the need of finding adequate recipient vessels in previously operated and radiated necks may rise serious concerns [6,10]. The surgeon, therefore, must not be extravagant in the application of advanced reconstructive techniques and must always carefully evaluate the general status and regional anatomy of each patient, in order to adopt and propose the most pertinent solution among multiple techniques. In this scenario, at our institution, pedicled regional flaps still represent a valid alternative to free flaps for patients considered suboptimal for microvascular reconstruction [11-15].

For oral and oropharyngeal soft tissue defects that require adequate lining without the need for a bulky cover, fascio-cutaneous free flaps provide excellent results enabling optimal resurface, ensuring a good motility of the preserved structures around the resected area

(preserved portions of the tongue, tongue base, floor of mouth, soft palate), giving a tight separation between oral/oropharyngeal cavity and neck contents. The microvascular workhorses for this purpose are represented by the free radial forearm flap [1] and the by anterolateral thigh flap [2], other less popular fascio-cutaneous free flaps are the ulnar forearm [16], the lateral arm [17], the (para)scapular [19], and lateral thigh flap [19].

The infrahyoid myocutaneous flap [20] (Figure 1), the submental island flap [21] and the supraclavicular artery island flap [22] represent reliable alternative pedicled flaps in patients with poor general conditions, while the pectoralis major flap [6] and the temporal myofascial flap [10,23] can be successfully employed when the quality of recipient vessels in the neck is compromised by previous treatments.

Figure 1 | Infrahyoid myocutaneous flap reconstruction following pull through resection of an anterior floor of mouth squamous cell carcinoma, the resection encompassed a marginal mandibular resection and was carried en block with bilateral selective neck dissection.

In case of total glossectomy, musculo-cutaneous free flaps, such as the rectus abdominis [24-26] and the latissimus dorsi [27] or thick fascio-cutaneous free flaps such as the anterolateral thigh flap [26], provide enough bulk to accomplish a restoration of form, furthermore, by creating a neo-tongue/palate competence, these flaps are even able to restore some sort of initial oral propulsion of the bolus towards the pharynx. Free flaps do not suffer from pedicle-related traction and are certainly superior to pedicled flaps, however in patients with vessel depleted necks (Figure 2) or when a total glossectomy is associated with total laryngectomy (Figure 3), the reconstruction with a pectoralis major myocutaneous flap or with a latissimus dorsi myocutaneous flap (transposed as a pedicled flap) is an excellent alternative. To minimize the pedicle-related traction, it is convenient to harvest a long skin paddle, which will be than tailored to the defects requirement after transposition. To increase the neo-tongue/palate competence we recommend to avoid to suture the anterior mucosa of the oral cavity with the skin paddle but instead with the underlying muscle.

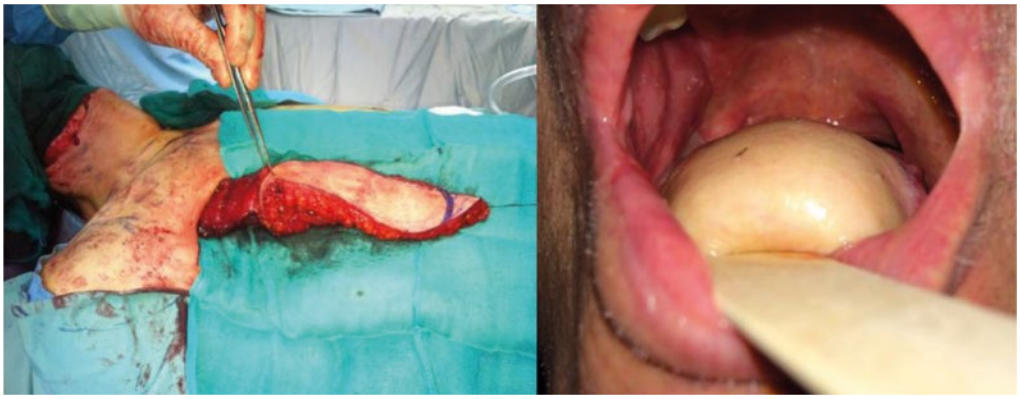

Figure 2 | Recurrent oral tongue carcinoma after previous transoral resection and neck dissection at the right hand side with adjuvant radiotherapy. Pull through resection of the oral tongue with marginal mandibular resection preserving the tongue base and left side neck dissection. The long skin paddle of the pectoralis major myocutaneous flap was tailored to the defects requirement after transposition, to increase the neo-tongue/palate competence the muscle underlying the skin paddle was sutured to the anterior mucosa of the oral cavity.

Figure 3 | This patient underwent previous total laryngectomy with subtotal pharyngectomy with bilateral neck dissection and bilateral pectoralis major flap reconstruction (for pharyngeal reconstruction and for subsequent closure of salivary fistula) for a pT4aN2c piriform sinus squamous cell carcinoma, surgery was followed by adjuvant radiotherapy. Two years later he presented with a second primary requiring a transmandibular total glossectomy. The latissimus dorsi provided an excellent solution in this case.

For segmental mandibular resections a reconstruction with bone carrying free flaps (fibula, scapula, iliac crest etc.) is considered nowadays the standard of care, and it is almost mandatory for anterior mandibular defects in order to avoid the so called Andy Gump deformity; for lateral segmental mandibular defects a bony free flap reconstruction is always preferable but in selected cases a soft tissue reconstruction with alternative pedicled flaps such as the pectoralis major or the latissimus dorsi can be considered as an acceptable alternative.

A recent major advancement in palatomaxillary reconstruction is represented by the angular branch-based osteomuscular scapular free flap [28]. The versatility of this flap, its long pedicle with large caliber donor vessels, the morphologic similarity with maxillary bony structures, and the limited donor-site morbidity compare favorably with those of other osteomuscular and osteomusculo-cutaneous free flaps described for such challenging reconstructive purposes.

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CHAPTER 3

The infrahyoid flap: a comprehensive review of an often overlooked reconstructive method

Deganello A
Leemans CR

Oral Oncology. 2014;50:704-10

ABSTRACT

The infrahyoid flap is a myocutaneous pedicled flap mainly nourished by the superior thyroid vessels through the perforators of the infrahyoid muscles. This thin and pliable flap provides a skin island of about 7 by 4 cm from the central part of the anterior neck. The flap can be transferred on its pedicle of superior thyroid artery and vein to reconstruct medium sized head and neck defects created after cancer ablation. We have successfully used this flap in a series of 40 cases with no total flap loss and with 1 case of superficial skin necrosis. The aim of this review is to highlight the clinical usefulness of this pedicled flap even in the microvascular free flap era. A comprehensive review of the available literature reporting on the infrahyoid flap has been carried out using a web search. The history of the infrahyoid flap, the surgical technique with technical innovations, the clinical utility and limitations of this flap, are reported and discussed. Among the 7 larger series (cohort larger than 50 cases) a total of 956 flaps were performed, and the global success rate was 91.7%, with failures being mainly related to partial skin necrosis, as the rate of total (skin and muscle) flap necrosis was only 1%.

This flap is reliable, easy to harvest during neck dissection, oncologically safe, it does carry a negligible donor site morbidity. This paper highlights how the infrahyoid flap can represent an excellent reconstructive solution in selected patients and head and neck sites.

INTRODUCTION

The introduction of microvascular reconstructions has provided the head and neck surgeon with the possibility of choosing among a broad variety of free flaps. This reconstructive method represents a major evolution in the management of head and neck cancer with a consequent reduction of pedicled flap reconstructions. The IHF is a thin and pliable pedicled flap that has been developed in a free flap era, hence it is important to assess its usefulness in this modern scenario.

History

The first report of using the infrahyoid system of muscles as a pedicled flap with reconstructive intents came from Clairmont and Conley in 1977 [1]. In their report they described the transposition of the infrahyoid muscles to repair anterior floor of mouth defects arising from pull through composite resections with en block neck dissection. In the report it was clearly specified that only the infrahyoid muscles were transposed upwards, and the Authors recommended to make any effort to preserve the superior thyroid artery and the innervation by the ansa hypoglossi in order to ensure the viability of this newly designed flap.

In 1984 Eliachar et al. included the overlying skin to a transposition of the infrahyoid muscles for the reconstruction of laryngotracheal defects. In their technique this myocutaneous flap was used as a rotary-door flap with a double blood supply from the superior and inferior thyroid arteries [2,3]. Having thus substantial limitation on the arch of rotation (coming from the need of maintaining both cranial and caudal pedicles), this rotary-door flap was therefore recommended only for laryngotracheal defects.

In 1985 Rabson et al. pointed out how the inferior cervical skin approaching the midline receives blood supply from perforator vessels coming from the superior thyroid artery piercing the infra- hyoid muscles [4].

The most important and decisive step was taken by Wang et al. when in 1986 they first reported in the English literature the surgical technique and the results of 112 head and neck reconstructions in 108 patients, describing the infrahyoid myocutaneous flap as we know it today [5]. The flap was mainly transposed to replace intraoral defects; the blood supply being clearly identified in the superior thyroid vessels. It is important to remark that since this first report Wang noticed how this easy and quick reconstructive method was particularly convenient and useful in weak elderly patients. This series starts from May 1979, so, even if undoubtedly Wang is the father of this flap, credit for the original idea (the grandfathers) must be given to Clairmont and Conley [1].

METHODS

A comprehensive review of the available literature reporting on the IHF has been carried out using a web search in Pubmed/Med line, Google Scholar, Isi Web of Knowledge and Scopus. Nowadays, this method is reported in 61 published papers, including less than 1400 patients. Only 24 full text papers in the English language were published in 28 years since 1986, with only 10 papers appearing in US Journals [5-14], the remaining 37 papers were published in other languages (Chinese, French, German, Polish and Japanese). This review is intended to highlight the many advantages that this flap can offer to the head and neck surgeon even in a free flap era.

Surgical technique

In its original description by Wang et al. the IHF is harvested as a myocutaneous flap [5] after ipsilateral modified radical or selective neck dissection is completed. Technically, the harvest of the IHF does not interfere with the extent of the neck dissection, since this flap lies in the central compartment of the neck, medial to the carotid artery at neck level VI. When a therapeutic modified radical neck dissection is indicated, this is performed according to the standard technique, with the only mandatory requirement being the preservation of the superior thyroid vein and the caudal stump of the internal jugular vein.

The infrahyoid muscles included in this flap are the sternohyoid muscle, the superior belly of the omohyoid muscle [6] and the sternothyroid muscle. Usually the flap is unilateral and the side is determined by the location of the defect, therefore the skin paddle and cervical incision for neck dissection are outlined in the same neck side of the tumor resection. The shape of the flap is rectangular or oval in a vertical position, and the skin paddle must be fitted and included in the incision for unilateral or bilateral neck dissection. In 2005 Dolivet et al. [15] introduced a modification for the neck incision proposing an S instead of the original T shaped incision, and this modification was acquired in further reports (Figure 1) [8,11,16-20].

The medial edge of the IHF lies at the midline, the upper edge at the level of the hyoid bone and the lower edge at the suprasternal notch, the lateral edge lies three to five cm from the midline. When a tracheotomy is required this is usually performed first and it is important to prevent tracheotomy site contamination to the wound bed. We recommend to place the caudal edge of the skin paddle at list 1 cm above the incision for the tracheotomy, and to open the trachea under the thyroid isthmus; the harvest of the flap will eventually create a communication with the tracheotomy at the side where the infrahyoid muscles are harvested, later on, to ensure a tight separation, the thyroid isthmus and the sternal edge of the sternocleidomastoid muscle are sutured to the subcutaneous tissue above the tracheotomy opening.

Figure 1 | Neck incision: vertically oriented infrahyoid flap at the left side: neck incision for unilateral and bilateral neck dissection.

The skin and platysma all around the skin paddle are incised to allow prompt choke perforator vessels opening [8]; the skin flaps are elevated and, before starting with the intended modified radical or selective neck dissection, the superficial cervical fascia along the anterior border of the sternocleidomastoid muscle, from the sternal insertion to the level of the hyoid bone, is incised and the dissection of the fascia proceeds until the omohyoid muscle is identified at its intersection with the internal jugular vein. The intermediate tendon is divided and the fascia, together with the anterior belly of the omohyoid muscle is elevated towards the lateral edge of the skin paddle and sutured to it Figure 2.

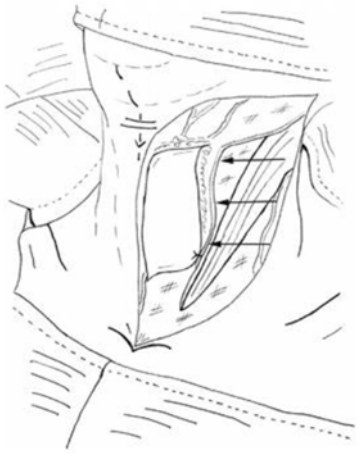

Figure 2 | Step 1 harvesting technique: the skin and platysma all around the skin paddle are incised, the fascia along the anterior border of the sternocleidomastoid muscle (arrows) is incised and sutured to the lateral edge of the skin paddle.

Neck dissection and primary tumor resection are now completed. The elevation of the flap starts by dividing the anterior jugular vein and sectioning the sternohyoid and sternothyroid muscles distally at the level of the suprasternal notch. The skin paddle is stitched to the underlying muscles and then the IHF is raised over the avascular plane of the proper capsule of the thyroid gland, Figure 3.

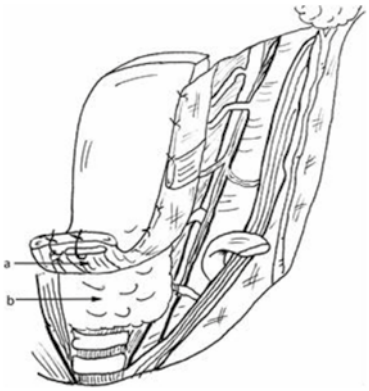

Figure 3 | Step 2 harvesting technique: the sternohyoid and sternothyroid muscles are transected at the suprasternal notch and sutured to the skin paddle (**a**) and the flap is elevated over the proper capsule of the thyroid lobe (**b**).

When the dissection reaches the upper pole of the thyroid gland, the crico-thyroid artery (at the midline of the neck) and the posterior branch of the superior thyroid artery (at its entrance in the upper pole of the gland) are cut, ligated and kept with the flap. The sternothyroid muscle is detached from the thyroid cartilage, Figure 4.

Figure 4 | Step 3 harvesting technique: the cricothyroid artery and vein (**a**), the posterior branch of the superior thyroid artery and vein (**b**), are cut, ligated and kept with the flap. The laryngeal insertion of the sternothyroid muscle is severed (**c**), the hyoid insertions of the sternohyoid and omohyoid muscles are severed.

Fascial connections between the superficial and median cervical fascia are maintained in proximity of the neurovascular pedicle; these fascial connections are important to directly provide microvascular venous return towards the median cervical fascia and to protect the superior thyroid vein from twisting or kneeing [8,11].

Special care must be taken in preserving the external branch of the superior laryngeal nerve, and therefore the thyrohyoid muscle is usually spared and left in place. Finally, the hyoid insertions of the sternohyoid and omohyoid muscles are severed, the entire flap remains attached only by the neurovascular pedicle formed by the superior thyroid artery and vein, and nerves from the ansa cervicalis, and is then ready to be transferred to reconstruct the defect, Figure 5.

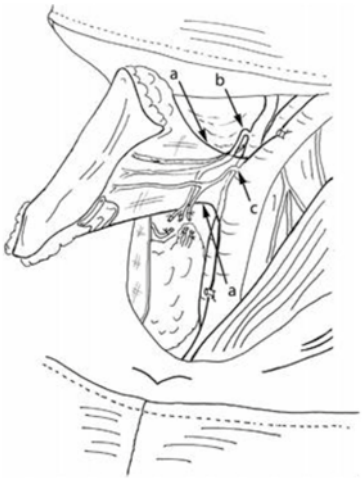

Figure 5 | Step 3 harvesting technique: fascial connections between superficial and median cervical fascia (**a**) are maintained to protect the pedicle: superior thyroid artery (**b**) and vein (**c**).

The arc of rotation of the IHF depends on the location of the carotid bifurcation and of the superior thyroid vessels: the more cranial the more convenient to reach upper sites. The zygomatic arch sets the superior limit for the IHF, usually for soft palate or lateral pharyngeal wall reconstructions the lower edge of the skin paddle is rotated to the most cranial portion of the defect. For oral cavity reconstructions the lower edge of the skin paddle is usually placed anteriorly and the upper edge posteriorly. After the flap is transposed to the donor site, the tacking sutures connecting the skin paddle with underlying fascia and muscles are removed, increasing the arc of rotation for the inset. If the width of the skin paddle is not greater than 5 cm the donor site can be primary closed with excellent aesthetic results and no scar-related impairment in neck movements, otherwise the transposition of a deltopectoral flap is usually necessary.

Technical modifications

The venous drainage is anatomically ensured by both the external and internal jugular systems, and the preservation of one systems is crucial: the superior thyroid vein provides drainage to the internal jugular vein, Figure 6; the cranial portion of the anterior jugular vein drains, with retrograde flow, into the external jugular vein, Figure 7.

Some put particular emphasis on the preservation of the cranial portion of the anterior jugular vein [12,13,21,22], which is perfectly feasible and reliable, nevertheless preservation of the external jugular system makes ipsilateral neck dissection technically more demanding.

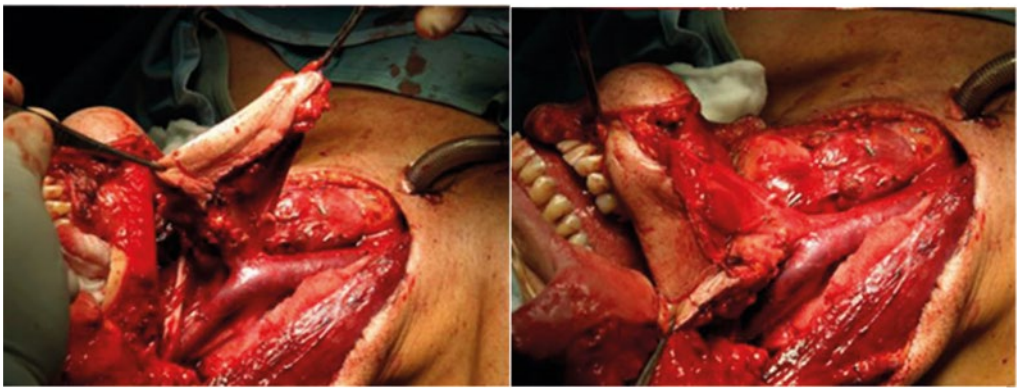

Figure 6 | Superior thyroid vein: infrahyoid flap with venous drainage ensured by the superior thyroid vein. The picture shows how the flap easily reaches the oral cavity; after the flap is transposed (medial to the mandible) to the donor site, the tacking sutures connecting the skin paddle with underlying fascia and muscles are removed to increase the arc of rotation.

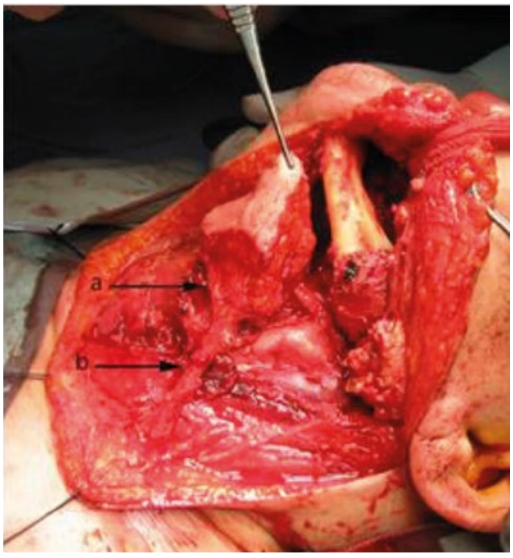

Figure 7 | Anterior jugular vein: infrahyoid flap with venous drainage ensured by the anterior jugular vein (**a**) and draining with retrograde flow to the external jugular vein (**b**). The flap is ready to reconstruct a lateral floor of mouth and alveolar ridge defect resulting from lateral pull through resection with marginal mandibulectomy and en block selective neck dissection I–III.

We described a new technique for tongue base reconstruction [11]: the neurovascular IHF is transposed without detaching it from the hyoid bone that acts as rotational pivot. During deglutition, the hyoid bone elevates and pushes the flap backwards, thus helping with bolus propulsion. For defects limited to the tongue base, IHF is perfectly suited to the resected area having the desired thickness Figure 8.

Figure 8 | Tongue base reconstruction: schematic representation of tongue base reconstruction maintaining the muscular insertions at the hyoid bone.

As originally suggested by Wang et al. [5], it is wise to preserve the motor innervations of the infrahyoid muscles (provided by the ansa cervicalis) in all cases of tongue reconstruction, to prevent subsequent atrophy. Conversely, for other sites, we recommended to resect all motor innervations since denervation atrophy of the underlying muscles will increase flap's pliability with better functional results Figure 9 [11].

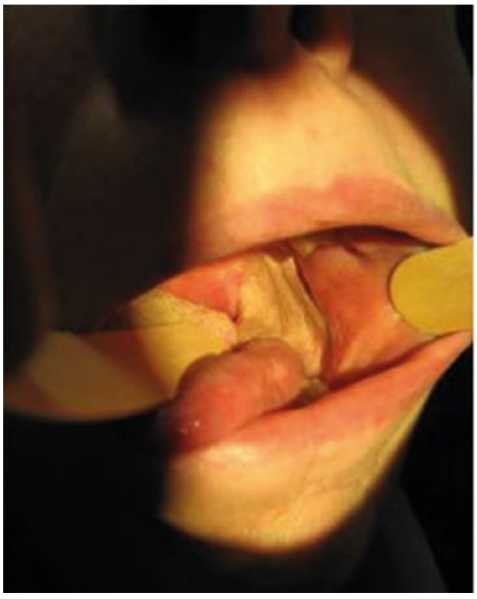

Figure 9 | Oral cavity reconstruction: Postoperative result after reconstruction of the whole retromolar trigone, the flap ensures good pliability (informed consent for publication was obtained).

Majoufre-Lefebvre et al. [23] introduced the horizontal infrahyoid flap claiming less cosmetic sequelae at the donor site; this technique was then implemented in a large series of 276 cases from the same group [24], and the authors also stated that no additional scars in the

neck were required. This is certainly true when a selective neck dissection I-III is planned (as it happened for the 275 squamous cell carcinoma patients in this series), nevertheless only the neck incision for a vertically oriented flap allows a comprehensive neck dissection without further incisions. Furthermore, a vertically oriented flap has a superior arc of rotation as compared to a horizontal flap, allowing for upper reconstructions that reach the soft palate [19].

CLINICAL SERIES AND RESULTS

The web search identified 7 series with a study cohort larger than 50 flaps (Table 1) [5,13,15,24–27], and 16 series with 10 to 50 cases [6-8,10-12,18-22,28-32]. Among the 7 larger series a total of 956 IHF were performed, and the global success rate was 91.7%, with failures being mainly related to partial skin necrosis, as the rate of total (skin and muscle) flap necrosis was only 1%.

Table 1 | Overview of the 7 largest series

Author	N. of flaps	Site	Previous neck RT	Skin necrosis	Flap necrosis	Patients requiring further surgery
Wang 1986	112	OC:101 Parotid:7	NR	11	0	0
Wang 1991	148	/	/	5		
Faucher 1997	62	OC:19 OP:32 PL:9 Skin:2	1	Partial:2	2	NR
Zao 2001	53	OC:53	NR	Partial:2 Total:2	1	0
Verhulst 2004	153	OC:54 OP:99	1	Partial:17	4	4
Dolivet 2005	152	OC:78 OP:47 PL:27	19	8	2	NR
Ricard 2009	276	OC: 264 OP:12	none	Partial:22 Total:2	0	none

OC: oral cavity, NR: not reported, OP: oropharynx, PL: pharyngo-larynx

In 1991 Wang reported his global experience with the IHF analyzing 260 cases [25]; this series came from the 112 flaps described in 1986 with further 148 flaps in the following 3 years. In the first report, Wang stated how the rate of failure was 38% (7 of 18 cases), versus 4% (4 of 94 cases) when the internal and external jugular veins were both removed or not both removed respectively. The success rate reported by Wang in the further 148 flaps was 97% [25]. Wang indicated several technical points to increase the success rate, but the attention to venous drainage is the crucial step. Another aspect to be highlighted is that no total flap necrosis was reported in this large series and the necrosis of the skin paddle never lead to further surgery.

In a series of 276 cases, the horizontal IHF was used for oral cavity reconstructions in 95.6% of the cases, insufficient venous return was recorded in 22 cases (8%), leading to partial skin

paddle necrosis in 20 patients, and total sin paddle necrosis in the remaining 2 patients [24]. Also in this series no total flap loss was recorded and no further surgery was required for the management of the superficial skin paddle necrosis. All these patients received a selective neck dissection of levels I–III; data on clinical and pathological neck involvement were not reported.

Among the 16 series with 10–50 IHFs a total of 328 flaps were reported, and the overall success rate was 85.5%, with a large range from 54% [7] to 100% [8,28,31]; also in these series the rate of total (skin and muscle) flap necrosis was low (2.7%). Among the 80 flaps used as myofascial transposition [10,28,29,32] 2 partial muscular necrosis and 3 total were recorded (92.7% success rate).

Unfortunately, data regarding the oncologic appropriateness of harvesting the IHF in N+ necks are lacking.

Wang demonstrated how this flap was oncologically sound in N1 necks [25], but in the majority of other large series patients were submitted to selective neck dissections I–III, and this would indicate a preponderance of cN0 cases. Only other 7 series in literature report IHF in N + necks [8,11,19–21,28,29]; among the 153 IHF harvested in these series, 88 flaps were harvested in N + necks: 35 N1 out of 88 N+(39.7%), 51 N2 (58%), 2N3 (2.27%).

Therapeutic neck dissection is not a contraindication for IHF as long as the oncologic radicality doesn't require the resection of the internal jugular vein, jeopardizing venous drainage.

CLINICAL UTILITY

In head and neck reconstructions, especially for oral cavity and oropharyngeal defects, the pliability of the flap should allow for a good motility of the preserved structures all around the resected area. The majority of pedicled myocutaneous flaps for head and neck reconstruction (e.g., pectoralis major, trapezius, latissimus dorsi) are quite bulky, and this intrinsic characteristic carries a disadvantage in terms of functional results; conversely the IHF is thin and pliable competing with fascio-cutaneous free flaps in the management of medium sized defects of the floor of mouth, alveolar ridge, and base of tongue. In our experience, for these sites, the results are particularly high-quality, because the pliable skin paddle is placed and sutured all around the mucosal defect and the infrahyoid muscles fill the deep tissue loss coming from resections carried en block with neck dissection. In case of marginal mandibulectomy, the flap's muscles cover the denuded mandibular bony surface, moreover the oval/rectangular shape of the IHF perfectly matches the usual shape of the resections in these cases, Figure 7 (informed consent for publication was obtained). Excellent

functional results are also obtained for base of tongue reconstructions [10,28], especially if the flap is not detached from the hyoid bone [11].

In a series of 34 consecutive oral cavity and oropharyngeal reconstructions from our group, functional results of 18 patients in poor general conditions unfit for a microvascular procedure and therefore receiving IHF reconstruction, were as good as those of the 16 patients in good general conditions receiving microvascular free radial forearm flap transposition [11], furthermore, comparing the medical costs, IHF reconstruction produced a savings in this fragile cohort of patients [33]. We also used the IHF for intraoral reconstruction together with free fibula osseous mandibular reconstruction, whenever skin perforators for a fibular osteo-cutaneous harvest were not found or reliable [8].

In literature this flap has been successfully used for defects of the oral cavity and oropharynx [5,8,11,19,25,27,30,31], the parotid region [5], the pharyngolaryngeal tract [8,15,26,27] and the cervical trachea [9]. As a myofascial transposition, it has been used to close iatrogenic pharyngeal [34] and esophageal [35] fistulas following anterior cervical spine surgery, or to prevent fistula formation after total laryngectomy [36].

LIMITATIONS

This flap does carry dimensional limitations, which make it unsuitable for large sized and complex defects. The maximal length of the flap is usually around an average of 10 cm, depending on the length of the patient's neck. If the width of the flap exceeds 5 cm, a further flap (usually a deltopectoral flap) is required to close the donor site, and this would decrease all the intrinsic convenience of the IHF; in most series the average dimensions of the flap is 7 x 4 cm. It could be consequently argued that small or medium sized defects within the oral cavity and oropharynx can also be primarily closed or reconstructed using local flaps and skin grafts, without requiring a pedicled flap or a free flap transposition. This can be true when the defect comes from a transoral resection, but if the resection put in communication the oral cavity/oropharynx with neck spaces, as a result of tumor resection with en block neck dissection, then primary closure usually leads to fixation of mobile structures; furthermore, in this situation local flaps or skin grafts are less able to ensure a tight separation between different compartments to prevent the occurrence of a salivary fistula with all its negative impacts.

Whenever the defect is large or encompasses more subsites, then a reconstruction with a more pliable fascio-cutaneous free flap ensures better results as compared to IHF transposition, because microvascular flaps can better follow the contour of the original anatomy, and can also be double folded in complex reconstructions.

Previous (chemo)radiotherapy is not an absolute contraindication for IHF [5,11,15], but pre-operative careful evaluation of the intended skin paddle is recommended: if lack of pliability, radiation induced fibrosis or teleangiectasias are encountered in the cervical skin, then a decrease in blood supply to the skin through the perforator vessels is probably occurring and the flap is contra-indicated. However, if none of these features is present and the appearance of the skin is normal, then the flap can be considered [11,15].

CONTRAINDICATIONS

Disadvantages of IHF mainly coincide with its contraindications: previous thyroid surgery or neck dissection, N3 neck metastasis, and positive lymphnodes at level III–IV. All these contraindications pose consistent limitations to the use of this reconstructive option. The IHF must always be planned in advance and cannot represent a back-up solution in case of other flap failure, since it cannot be used in a previously operated neck. In fact, probable damages to the superior thyroid artery and/or vein and/or possible elevation of the skin overlying the strap muscles pre- vent the possibility to rely on this myocutaneous flap.

CONCLUSIONS

The infrahyoid flap is a quick, easy, and reliable reconstructive method, when specific contra-indications are respected and when used with knowledge of its clinical utility and limitations, the functional results are excellent with great patient's satisfaction.

CONFLICT OF INTEREST STATEMENT

This work had no founding, furthermore there are no financial disclosures from the authors.

ACKNOWLEDGMENT

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CHAPTER 4

Infrahyoid fascio-myocutaneous flap as an alternative to free radial forearm flap in head and neck reconstruction

Deganello A
Manciocco V
Dolivet G
Leemans CR
Spriano G

Head & Neck. 2007;29:285-91

ABSTRACT

The use of microvascular free flaps is currently the favored method for the reconstruction of defects after resection of head and neck cancer. The flap most commonly used for head and neck reconstruction is the free radial forearm flap, but the less popular infrahyoid flap represents a good alternative in selected cases. This flap has proven to be helpful in the reconstruction of a wide range of moderate-sized head and neck defects.

Methods: We reviewed a series of 13 patients with defects resulting from cancer of the head and neck, who underwent infrahyoid flap reconstruction as an alternative to free radial forearm flap. The series includes 12 squamous cell carcinomas arising from the oral cavity and oropharynx, and 1 Merkel cell carcinoma of the submental skin. In the harvesting of the flap, the technical modifications recently suggested by Dolivet et al were used in all cases. Furthermore, another technical change has been introduced so creating a new infrahyoid facio-myocutaneous flap (IHFMCF). The surgical technique is described in detail.

Results: No total or partial flap necrosis was experienced. All reconstructions healed quickly without wound complications and with good functional results. The healing process in the donor site was excellent in every case with good aesthetic results.

Conclusions: The IHFMCF is a versatile, reliable, and convenient flap suitable for repairing small and medium-sized defects of the oral cavity and oropharynx and obviates the need for a microvascular reconstruction.

INTRODUCTION

The main goals of modern head and neck reconstructive surgery are adequate wound healing, restoration of function, and appearance. In the preoperative planning, it is crucial to determine which reconstructive procedure will be most suitable for the patient to optimize functional outcome after cancer ablation. As a general rule, an optimal reconstruction should enhance the residual function allowing good motility of the preserved structures around the resected area, guarantee a quick and safe healing process, and provide a restoration of form with acceptable aesthetic results. The application of microvascular free flaps is the most widespread method currently employed for the reconstruction of extensive defects after resection of head and neck cancer because of their versatility and reliability. The flap most commonly used for head and neck reconstruction is the free radial forearm flap (FRFF) [1].

The realization that not all patients are suitable for a free flap reconstruction and that not every defect strictly requires a free flap transfer to achieve a good functional result raises the necessity to find alternatives. The pectoralis major flap and temporalis flap are the most used pedicled flaps in head and neck reconstruction, but the less popular infrahyoid myocutaneous flap (IHMCF) represents an interesting alternative in selected cases.

In 1980, Wang and Shen [2] first described the IHMCF for head and neck reconstruction. In spite of its limited rotation arch, this flap has proven to be helpful in the reconstruction of a wide range of moderate-sized head and neck defects (intraoral, pharyngeal, and parotid region) [3-8]. The major blood supply of the IHMCF is derived from the superior thyroid artery, which is the first branch of the external carotid artery. The higher the bifurcation of the common carotid artery, the more convenient it is to transfer the IHMCF upward. All the branches of the superior thyroid artery, except its posterior branch to the thyroid gland, have tiny tributaries entering the infrahyoid muscles and the overlying cervical skin. To increase success rate, Wang in 1991 recommended including the sternal edge of the sternocleidomastoid (SCM) muscle to protect the platysma and the SCM branches of the superior thyroid artery [9].

The complication rate reported in the literature is extremely variable, ranging from 3% to 47% [3-7]; the main problems are related to the reliability of the skin paddle for insufficient venous drainage. Recently, Dolivet et al. [10] described a modification of the original surgical technique to improve drainage [2-5]: the detachment of the infrahyoid muscles from the hyoid bone is carried out in a subperiosteal plane to preserve microvenous drainage toward digastric triangle network. They also changed the cervical incision from an inverted T to an inverted Z, with better aesthetic results. In this article, a series of 13 infrahyoid flap reconstructions for selected tumors of the oral cavity, pharynx, and cervical skin is presented as an alternative to FRFF reconstruction. All patients underwent reconstruction using the improvements of Dolivet et al. [10] with the addition of a personal surgical modification.

MATERIALS AND METHODS

From October 2003 to April 2005, 13 patients, 11 men and 2 women, underwent infrahyoid flap reconstruction after cancer ablation and neck dissection, in a single-stage procedure. The ages of the patients ranged from 29 to 81 years, with median age of 60 years. The series included 12 squamous cell carcinomas (SCC) arising from the mucosa of the oral cavity and oropharynx, and 1 Merkel cell carcinoma (MCC) of the submental skin. Disease was staged according to the 6th edition of the TNM classification established by the UICC/AJCC [11]. All the reconstructions were performed by the first author.

In this series, infrahyoid flap reconstruction was chosen as an alternative to FRFF reconstruction. Selection criteria were a defect estimated as small or medium size or the presence of relative general contraindications to a microvascular free flap reconstruction. In the harvest of the flap, the technical modifications suggested by Dolivet et al. [10] were used in all cases with an extra technical change. In this series, to increase venous drainage toward the median cervical fascia, a portion of the superficial cervical fascia is included in the flap creating actually a new infrahyoid fascio-myocutaneous flap (IHFMCF).

The dimensions of the skin paddle ranged from a minimum of 5 cm in length and 3 cm in width for a pharyngolaryngeal reconstruction to a maximum of 9 cm in length and 5 cm in width used for oropharyngeal reconstruction; the average size was 7.15 cm long and 3.73 cm wide. An overview of the clinical series is described in Table 1.

Seven patients had an oral cavity carcinoma. Three were T2 lesions of the floor of the mouth, 1 was a T4a of the left mobile tongue, 1 was a T1 retromolar trigone carcinoma, 1 was a second primary T1 buccal mucosa carcinoma (in the field treated 7 years before with brachytherapy), and 1 was an alveolar process T4a carcinoma with bony invasion that required a segmental mandibular resection. In this patient, an intraoral soft tissue reconstruction using the IHFMCF was combined with osseous fibula free flap reconstruction. Five patients had oropharyngeal carcinoma: 1 was a T2 unilateral soft palate carcinoma, 1 was a T4a base of tongue (this patient required the widest skin paddle of the series, 9 x 3 x 5 cm, so that a deltopectoral flap was used to close the donor site), while the remaining 3 patients presented with a unilateral T4a vallecula carcinoma (the tumor extended inferiorly to the epiglottis and homolateral aryepiglottic fold and superiorly to the base of tongue). A partial pharyngolaryngectomy with a controlateral pharyngotomy approach was combined with IHFMCF reconstruction of the resected pharyngolaryngeal unit. One patient had a Merkel cell carcinoma of the submental skin region and was treated with wide local excision and bilateral selective neck dissection [8].

All the flaps were harvested from the same neck side as the primary tumor during homolateral neck dissection; 11 patients had bilateral neck dissection. In 1 case, the internal jugular vein and external carotid artery were ligated above the branching of the superior thyroid pedicle

to allow for a safe removal of a lymph node metastasis at level IIa without compromising the vitality of the flap. The reliability of the IHFMCF reconstruction was evaluated in terms of possibility to reach the recipient site, shape matching between the defect and the skin paddle, vitality after transposition, and definitive integration. Postoperative vitality of the flap was checked by clinical observation only. In the series, 9 patients underwent postoperative therapy; 2 patients received concomitant chemoradiation, and the remaining 7 patients received radiation therapy alone. Twelve patients, excluding the patient with Merkel cell carcinoma, required a temporary tracheotomy that was closed within 2 weeks. The nasogastric feeding tube was removed within a week in 10 patients and within 20 days in the 3 patients that underwent partial pharyngolaryngeal resection.

Table 1 | Overview of the clinical series.

Subsite	pTNM	Tumor Surgery	Nodal Surgery	IHFMCF	Other flap	Adjuvant therapy	Results
ORAL CAVITY							
Floor of mouth	pT2N0	Marginal mandibulectomy	Bil. SND I-III	6 x 3,5 cm	No	No	NED at 5 months.
Floor of mouth	pT2N0	Marginal mandibulectomy	Bil. SND I-III	9 x 4 cm	No	No	NED at 22 months.
Floor of mouth	pT2N1	Marginal mandibulectomy	MRND	7 x 3,5 cm	No	No	NED at 20 months.
Mobile tongue	pT4aN0	Hemiglossectoly	Bil. MRND	8 x 4 cm	No	RT	M1pul at 21 months.
Retromolar trigone	pT1N0	Marginal mandibulectomy	Bil. SND I-IV	8 x 4 cm	No	No	NED at 20 months.
Buccal mucosa	pT1N0	Marginal mandibulectomy	SND I-IV	6 x 3,5 cm	No	RT	NED at 20 months.
Alveolar ridge	pT4aN2b	Segmental mandibulectomy	Bil. MRND	8 x 4 cm	Fibula free flap	CT-RT	NED at 21 months.
OROPHARYNX							
Tonsil soft palate	pT4aN2b	Tonsil + soft palate resection	RND ligature IJV, ECA	7 x 3 cm	No	CT-RT	NED at 21 months.
Base of tongue	pT4aN2c	Tongue base resection	Bil. MRND	9 x 5 cm	Delto-pectoral	RT	No follow-up
Vallecula	T4aN2b	Partial pharyngo-laryngectomy	Bil. MRND	8 x 4 cm	No	RT	NED at 22 months.
Vallecula	T4aN2c	Partial pharyngo-laryngectomy	Bil. MRND	6 x 3,5 cm	No	RT	NED at 22 months.
Vallecula	T4aN1	Partial pharyngo-laryngectomy	Bil. SND I-IV	5 x 3 cm	No	RT	NED at 20 months.
SKIN							
Sub-mental	R0N1	Wide local Bi excision	Bil. SND I-III	6 x 3,5 cm	No	RT	DOD at 18 months.

IHFMCF: infrahyoidfasciomyocutaneous flap, Bil.: bilateral, SND: selective neck dissection, NED: no evidence of disease, MRND: modified radical neck dissection, RT: Radiotherapy, CT: Chemotherapy, RND: radical neck dissection, IJV: internal jugular vein, ECA: external carotid artery, DOD: dead of disease.

Surgical Technique

The cervical incision is outlined as shown in Figure 1, the skin paddle always being located at the same neck side of the tumor resection. The medial limit of the IHFMCF lies at the midline, the upper limit at the level of the hyoid bone, and the lower limit at the suprasternal notch, the lateral limit lies 3 to 5 cm from the midline. The shape of the flap is rectangular in a vertical position.

While performing the incision, we suggest immediately incising the skin and platysma all around the skin paddle to allow prompt choke perforator vessels opening.

Figure 1 | Neck incision: vertically oriented infrahyoid flap at the left side: neck incision for unilateral and bilateral neck dissection.

The cervical skin flap are elevated as during a standard neck dissection, the superficial cervical fascia along the anterior border of the sternocleidomastoid muscle, from the sternal insertion up to the level of the hyoid bone, is incised, and the dissection of the fascia proceeds until the intermediate tendon of the omohyoid muscle is identified at its intersection with the internal jugular vein. The tendon is divided and subfascial dissection is carried on toward the flap, suturing this portion of the fascia and the stump of the omohyoid muscle to the lateral edge of the skin paddle, Figure 2.

After modified radical or selective neck dissection is completed (the preservation of the superior thyroid and internal jugular veins is mandatory), the dissection of the flap starts by dividing the anterior jugular vein and sectioning the sternohyoid and sternothyroid muscles distally at the level of the suprasternal notch, Figure 3.

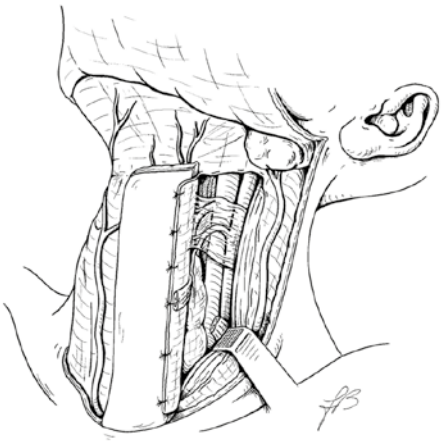

Figure 2 | The tendon of the omohyoid muscle is divided and subfascial dissection is carried on toward the flap.

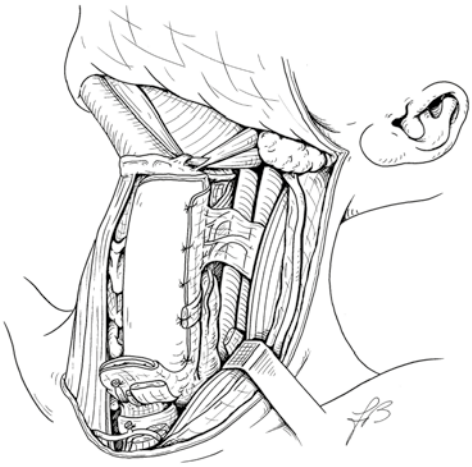

Figure 3 | The dissection of the flap starts by dividing the anterior jugular vein and sectioning the sternohyoid and sternothyroid muscles distally at the level of the suprasternal notch.

The skin paddle is stitched to the underlying muscles and then the IHFMCF is raised over the avascular plane of the proper capsule of the thyroid gland; when the dissection reaches the upper pole, the cricothyroid artery and vein, all the distal branches of the superior thyroid artery and vein that supply the thyroid gland and the posterior branch of the superior thyroid artery and vein at their entrance in the upper pole of the gland are legated, divided, and kept with the flap (Figure 4).

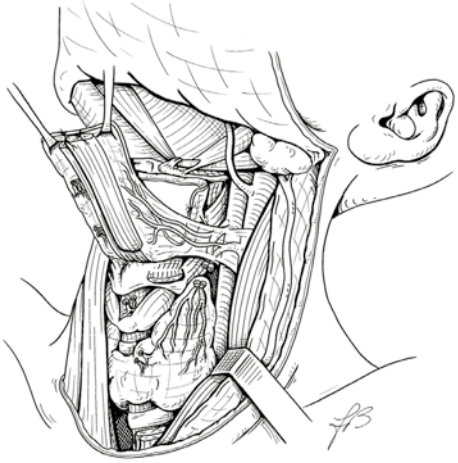

Figure 4 | When the dissection reaches the upper pole of the thyroid gland, all the distal branches of the superior thyroid artery and vein that supply the thyroid gland are individually legated, divided, and kept with the flap.

The sternothyroid muscle is detached from the thyroid cartilage.

Special care must be taken in preserving the external branch of the superior laryngeal nerve; therefore, the thyrohyoid muscle is usually spared and left in place. Finally, the hyoid insertion of the sternohyoid and omohyoid muscles are sectioned inside out in a subperiostial plane. The pedicle of the flap is formed by the neurovascular pedicle (superior thyroid artery and vein and ansa cervicalis), by fascial connections between the superficial and median cervical fascia, and by periosteal connections to the digastric muscle, Figure 5.

Those facial connections are important to directly provide microvascular venous return toward the median cervical fascia and to protect the superior thyroid vein from twisting or kneeing, so creating the new infrahyoid fascio-myocutaneous flap.

The flap is ready to be transferred to reconstruct the defect.

The donor site can be usually primarily closed, if the width of the skin paddle is greater than 5 cm a deltopectoral flap could be needed.

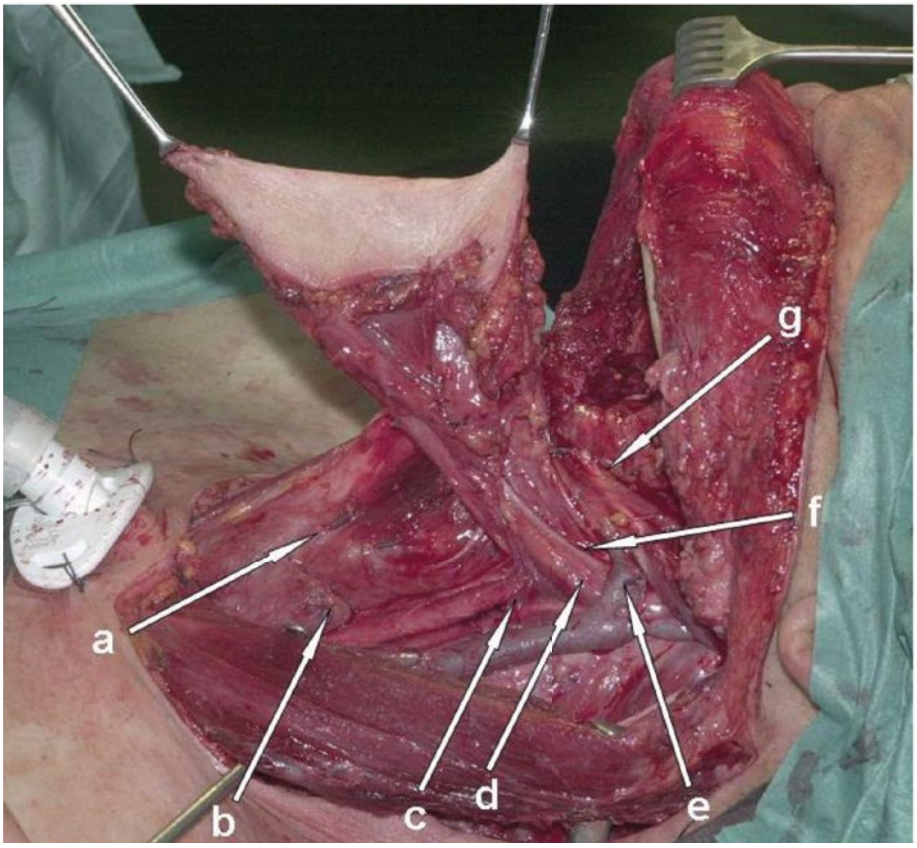

Figure 5 | (**a**) cricothyroid artery; (**b**) posterior branch of the superior thyroid artery at the entrance in the upper pole of the thyroid gland; (**c**) fascial connections between superficial and median cervical fascia; (**d**) superior thyroid artery; (**e**) superior thyroid vein; (**f**) ansa cervicalis; (**g**) periosteal connections to the digastric muscle.

RESULTS

In this series, all the flaps reached the recipient area without extensive vascular pedicle stretching, even in case of soft palate reconstruction. The rectangular shape of the skin paddle matched perfectly with the shape of the resections that resulted mostly oval or rectangular, Figure 6. No total or partial flap necrosis was experienced. All reconstructions healed timely and without wound complications. Also, the healing process at the donor site was excellent in every case, with good aesthetic results, including the patient who needed a deltopectoral flap to achieve donor site closure.

In this series, good functional results were achieved; all patients were decannulated and the nasogastric feeding tube was removed with restoration of oral intake in all cases. In every

case, the flap withstood adjuvant treatments without any local complication, and the long-term results as to reconstruction appearance were excellent. We experienced no flap fibrosis, and only 1 patient experienced hair growth in the skin paddle.

Figure 6 | Postoperative result after 6 months. The flap covers the marginal mandibulectomy and reconstructs the floor of mouth allowing good tongue mobility. The rectangular shape of the skin paddle matched perfectly with the shape of the resection.

DISCUSSION

In this series, 7 patients of 13 presented with a relative contraindication for a FRFF reconstruction: 2 patients had systemic vascular insufficiency, 1 patient was HIV positive with poor general condition, 1 patient was a professional piano player, and 3 patients were elderly and in poor general condition.

The advantages of the IHFMCF include its easy and relatively quick preparation, and a flap that is harvested during neck dissection so there is no need for a second surgical team. The skin paddle is hairless in most cases, and in almost every case the donor area can be primarily closed avoiding skin grafting or scars beyond the head and neck area, with absence of significant cosmetic and functional squeals. On the other hand, FRFF reconstruction mostly requires 2 surgical teams, an expert microsurgeon, and vigilant monitoring of the free flap during the first postoperative days.

The majority of myocutaneous flaps for head and neck reconstruction (e.g., pectoralis major, trapezius, latissimus dorsi) are quite bulky, and for this reason, we found that the IHFMCF represents an excellent alternative to FRFF reconstruction for medium-sized defects of the oral cavity and oropharynx, which can also easily reach sites such as retromolar trigone and soft palate.

The IHFMCF is thin and pliable, and even if it is not as thin and pliable as the FRFF, it appears to be extremely suitable in case of floor of mouth reconstruction, especially in case of

marginal mandibulectomy and en bloc resections, because it is able to provide thigh closure preventing salivary fistulas in the neck and it allows good motility of the tongue.

In 1 case, where a segmental mandibulectomy was performed, we combined the IHFMCF with a free fibula reconstruction. If the mucosal loss is not very large, the IHFMCF suits the defect perfectly and the osseous microvascular transfer is well covered by vascularized infrahyoid muscles.

In case of tongue reconstruction, it is useful to preserve the motor innervation of the infrahyoid muscles provided by the ansa cervicalis. The main advantage of this voluntary innervated flap is that the innervation prevents scarring and atrophy of the reconstructed tongue [6]. For intermediate oropharyngeal defects, we found that the IHFMCF suits the defect perfectly if the defect does not extend into the oral cavity. On the other hand, if a pharyngeal defect does extend to the oral cavity, a complex reconstruction in terms of dimensions and shape is needed, and the FRFF appears to be preferable. For soft palate reconstruction, if the resection is strictly unilateral and does not include the uvula, the IHFMCF can be used with good functional results preventing open rhinolalia and providing soft palate competence without nasal regurgitation. If a larger soft palate defect exists, a double-folded FRFF is functionally superior. In case of partial pharyngolaryngectomy for vallecula carcinoma, the IHFMCF provided an excellent restoration of form and function, being small and pliable.

CONCLUSIONS

A critical recodification of the role of the infrahyoid flap in modern days could be of great help for the microvascular surgeon looking for alternatives, because in management of head and neck tumors the toolbox of a wide range of reconstructive options is of a great advantage. In our series, the IHFMCF has shown to be a reliable flap even in elderly patients and in patients in general poor condition or with peripheral vessel insufficiency who are not optimal candidates for free flap reconstruction. The use of the described technical modifications together with the inclusion of part of the superficial cervical fascia in the harvest has led to a complete success rate without venous problems in this series.

This flap is thin and pliable, so that it is particularly useful in oral cavity reconstructions. In this preliminary experience, our impression is that for small and medium-sized defects the functional results are comparable to those with the FRFF reconstruction. FRFF appears to be preferable for the reconstruction of extensive oropharyngeal defects where a large amount of skin is needed, but for the closure of small and medium- sized defects and after partial pharyngolaryngectomy, IHFMCF has proved to be an excellent alternative.

Contraindications such as previous neck dissection, previous thyroid surgery, and presence of N3 neck disease must be respected. A relative contraindication is previous radiotherapy. If it is possible to preserve the superior thyroid pedicle dividing the internal jugular vein and external carotid artery just above its branching, the infrahyoid flap can be harvested also if metastatic lymph nodes are present at level II. In our series, 8 patients presented a pN+ neck at the side of the flap, and it was always possible to use the planned IHFMCF despite the proximity to a metastatic node.

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CHAPTER 5

Infrahyoid flap reconstruction of oral cavity and oropharyngeal defects in elderly patients with severe general comorbidities

Deganello A
Gitti G
Parrinello G
Larotonda G
Meccariello G
Leemans CR
Gallo O

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ABSTRACT

Background: In current practice, surgeons frequently deal with elderly patients who have severe medical comorbidities.

Methods: We present our series of 18 consecutive patients with severe general comorbidities that received infrahyoid flap reconstruction. The results were compared with those of 16 consecutive patients in good general medical state receiving free radial forearm flap reconstruction during the same study period. We also describe an original method for tongue base reconstruction using the infrahyoid flap.

Results: No total flap necrosis was experienced; successful separation between oral cavity/oropharyngeal contents and neck spaces was obtained in all patients with a low rate of general complications. No significant differences were found with regard to verbal intelligibility and diet scores between groups.

Conclusions: Infrahyoid flap in high-risk cases represents a valid alternative to free radial forearm flap. We introduced a novel technical innovation for tongue base reconstruction using the infrahyoid flap with very encouraging results.

INTRODUCTION

The application of microvascular free flaps is the most widespread method currently used for the reconstruction of extensive defects after resection of head and neck cancer because of their versatility and reliability. The success rate of free tissue transfers has risen to >95%, and the free radial forearm flap (FRFF) [1] together with the free anterolateral thigh flap [2] are currently considered the gold standard for soft tissue reconstruction of oral cavity and oropharyngeal defects.

In current practice, surgeons frequently deal with elderly patients who have severe medical comorbidities and pretreated patients with recurrent disease or second primary malignancies. There are no agreed-upon universally validated contraindications for microvascular reconstruction in head and neck surgery; the trend in recently published reports is to extend indications for free flaps even in generally compromised patients and in the vessel depleted neck [3,4].

Furthermore, free flap reconstruction also seems to be reliable in elderly patients [5,6], despite the risk that general comorbidities, especially diabetes mellitus, pose to the success of microvascular transfers [7].

However, not all patients are ideal candidates for free flap reconstruction, and not every defect strictly requires a free flap transfer to achieve good functional results. Thus there is a need for comparable alternatives. The infrahyoid flap (IHF) in head and neck reconstruction was first described by Wang et al. [8,9]. The major blood supply of this pedicled flap is derived from the superior thyroid artery; all its branches, except the posterior branch to the thyroid gland, have tiny tributaries entering the infrahyoid muscles and the overlying skin. Therefore, the flap can be harvested as a fascio-myocutaneous [10,11] or a myofascial flap. It has proven its reliability and good functional results in various sites of head and neck reconstruction, especially for oral tongue and base of tongue reconstruction [8-14].

At our institution, FRFF remains the first choice for soft tissue reconstruction of oral cavity and oropharyngeal defects that present a communication with neck spaces. However, instead of performing free flap reconstructions in cases that are considered to be unsuitable or suboptimal for microvascular procedures, alternative pedicled flaps are considered. Although the temporal flap and pectoralis major flap represent the alternatives in case of unfavorable anatomic conditions (vessel depleted neck and previous chemoradiation), the IHF represents our first alternative to FRFF in high-risk patients because of severe general comorbidities. We present our results in 18 consecutive patients with severe general comorbidities that received IHF reconstruction as alternative to FRFF reconstruction. We also describe an original method for tongue base reconstruction using the infrahyoid fascio-myocutaneous flap. We critically compared healing and functional results between this series of 18 high-risk patients with a population of 16 subjects in good general medical condition who received FRFF reconstruction during the same study period.

MATERIALS AND METHODS

Data Collection

We reviewed the medical records of 88 consecutive patients who had free flap or pedicled flap reconstruction, performed by the first author (A.D.), at the department of Otolaryngology-Head and Neck Surgery of the University of Florence, Italy, between July 2006 to May 2010.

Follow-up data were obtained in all patients using clinical chart notes. Disease was staged in accord with the 6th edition of the TNM classification established by the Union Internationale Contre le Cancer/American Joint Committee on Cancer (UICC/AJCC) [15] using all the information available, including physical findings, imaging studies, and pathology reports.

The preoperative medical status of each patient was assessed by the anesthesiologists using the American Society of Anesthesiologists (ASA) classification of physical status.

Follow-up data including status of the flap and complications were collected. Postoperative functional results regarding diet and speech were assessed by a physician at outpatient follow-up consultation with use of a score system from 1 to 4 (Table 1).

Table 1 | Functional analysis.

Score	Diet	Speech
1	regular diet without restrictions	always understandable
2	moist or soft diet	usually understandable, but with frequent repetition or face to face contact required
3	liquid diet	difficult to understand even with face to face contact
4	tube-dependent intake	never understandable, with written communication required

Patients

From the 88 consecutive head and neck reconstructions, we identified 68 cases in which the defect of the oral cavity or oropharynx was in communication with neck spaces as a result of transmandibular or pull-through approaches. The reconstruction was accomplished with free radial flap in 16 patients, infrahyoid flap in 18 patients, pectoralis major flap in 10 patients, temporal myofascial flap in 10 patients, fibula osteocutaneous flap in 5 patients, rectus abdominis flap in 2 patients, and latissimus dorsi in 1 patient.

We compared results between 18 patients who had IHF reconstruction (group 1, G1) and 16 patients in good general conditions that received FRFF reconstruction (group 2, G2).

G1 accounted for 12 men and 6 women, 12 receiving IHF for oral cavity and 6 for oropharyngeal reconstruction. All flaps were harvested from the same neck side of the primary tumor during

homolateral neck dissection; 10 patients had bilateral neck dissection. For flap harvesting technique we refer to our previous report [10]. The mean age in G1 was 69.6 years (range, 55–83 years; median, 72 years); 3 patients were classified ASA II, the remaining ASA III. The mean dimensions of the skin paddle of the IHF were 6.5 cm 3.5 cm (mean surface area, 22.7 cm^2). Contraindications for FRFF reconstruction in G2 were: severe comorbidities (diffuse atherosclerosis, diabetes mellitus, heart failure) in 15 cases, and age exceeding 80 years with moderate comorbidities in 3 cases.

G2 accounted for 12 men and 4 women; 9 patients received a FRFF to reconstruct a defect of the oral cavity, whereas 7 patients had a reconstruction of the oropharynx. The mean age in G2 was 58.2 years (range, 45–70 years; median, 58 years) and all patients were classified ASA I–II. The mean dimensions of the skin paddle of the FRFF were 7.1 cm x 6.3 cm (mean surface area, 44.7 cm^2). In all cases end-to-end arterial anastomoses were performed between the facial and radial arteries. In 11 cases a single venous anastomosis was performed, whereas in 5 cases a double venous drainage was provided. In all cases the main recipient vessel was the internal jugular vein. In 2 cases anastomoses were performed on the contralateral side of the primary tumor.

Between groups we recorded and compared flap viability, operative time, blood loss and blood transfusion, postoperative intensive care unit (ICU) recovery, postoperative complications, postoperative reinterventions, duration of hospitalization, hospital readmissions related to head and neck surgery within 6 months, oral intake restoration time, time of tracheotomy closure, diet, and speech assessment.

Statistical Analysis

Statistical analysis was performed with an IBM computer (International Business Machines Corp., Armonk, NY) using STATA (Stata Corp., College Station, TX). Differences in mean values between groups were tested with Wilcoxon-Mann-Whitney test; for categorical variables the Pearson chi-square test was used: probability values <0.05 were considered statistically significant.

RESULTS

Patient characteristics and results are displayed and summarized in Table 2.

The mean operative time in G1 was 6 hours 40 minutes (range, 5 hours 20 minutes to 8 hours), whereas in G2 it was 9 hours (range, 7 hours to 12 hours 40 minutes).

Postoperative intensive care recovery was used in 4 patients in G1 with a mean stay of 3 days and in 4 G2 patients with a mean stay of 3.7 days.

Flap Survival

No total flap necrosis was experienced in the series; successful separation between oral cavity/oropharyngeal contents and neck spaces was obtained in all patients. In G1, 1 patient developed a venous congestion revealed by the color of the skin paddle. Superficial cuts were made on the flap and heparin solution was injected twice a day; after 1 week the necrotic skin was removed, revealing underlying healthy muscles. Complete reepithelization occurred within 3 weeks (Figure 1).

Figure 1 | An 83-year-old woman with T4aN0 oral tongue squamous cell carcinoma treated with pull-through resection encompassing three fourths of the mobile tongue, "en bloc" modified radical neck dissection, infrahyoid flap reconstruction. Complete reepithelization after superficial skin necrosis.

In G2, 1 patient required postoperative revision of the venous anastomosis 8 hours after the end of surgery; intraluminal thrombus was found and removed at the end-to-side confluence between the cephalic vein and the preserved caudal stump of the internal jugular vein. The flap reconstructed the lateral oropharyngeal wall and was double folded to restore half the soft palate. After microvascular revision the flap slowly developed marginal necrosis on its upper distal third. Further reconstruction of the soft palate using the remaining uvula under local anesthesia was required to prevent open rhinolalia and nasal regurgitation. No patient was readmitted within 6 months.

Complications

The overall rate of complications was 14.7% (5/34), including partial necrosis (2/34, 1 in G1 and 1 in G2) and postoperative pneumonia (3/34, 1 in G1 and 2 in G2). The rate of complications that required surgical revision was 2.9% (1/34). Indication for surgical revision was venous congestion and subsequent marginal necrosis in 1 G2 case. The remaining complications were successfully treated with conservative management.

Functional Results

All patients were discharged with complete restoration of oral intake (mean time, 14 days; range, 7–18 days) and tracheotomy closure (mean time, 6 days; range, 3–10 days). Mean

discharge time after surgery was 22 days (range, 12–37 days) with no differences between groups (21.8 days G1 and 23.2 days G2). No significant differences were found with regard to verbal intelligibility and diet score between groups.

Table 2 | Patients overview and statistical analysis.

	G1 (18 patients)	G2 (16 patients)	p*
Age, mean (SD); range	69.6, (9.41); 55–83	58.2, (6.32); 45–70	p=0.06
Gender, No. of patients (%)			
Male	12 (66%)	12 (75%)	p=0.86
Female	6 (34%)	4 (25%)	
Tumor Site	12 OC 6 OP	9 OC 7 OP	p=0.64
Primary Tumor	15	12	
Recurrent Tumor	2	2	p=0.79
Second Primary	1	2	
pT classification			
1	—	—	
2	5	7	p=0.20
3	9	8	
4a	4	1	
pN classification			
0	8	4	
1	2	2	
2a	—	1	p=0.14
2b	6	5	
2c	2	4	
3	—	—	
Adjuvant RT, No. of patients (%)			
Yes	6 (33%)	4 (25%)	p=0.42
No	12 (66%)	12 (75%)	
Adjuvant ChT-RT, No. of patients (%)			
Yes	3 (17%)	6 (37%)	p=0.08
No	15 (83%)	10 (63%)	
Previous RT, No. of patients (%)			
Yes	1 (5%)	2 (12%)	p=0.10
No	17 (95%)	14 (88%)	
Skin Paddle Surface in cm^2, mean (SD); range	22.7 (4.5); 18–40.5	44.7 (15.5); 20–63	p<0.01
Operative time in hours, mean (SD); range	6.6 (0.8); 5.2–8	9.5 (1.6); 7–12.4	p<0.01
Reconstructive time in hours, mean (SD); range	1.05 (0.6); 0.8–1.2	2.3 (1.2); 2–2.8	p=0.04
Blood loss (Hb g/dL), mean (SD); range	2.6 (1); 0.4–3.5	3.25 (1.4); 1.1–6.2	p=0.76

Table 2 | Patients overview and statistical analysis *(Continued)*.

	G1 (18 patients)	G2 (16 patients)	p*
No. of blood-transfused patients and (%)			
Yes	3 (17%)	3 (19%)	p=0.96
No	15 (83%)	13 (81%)	
Tracheotomy closure (days), mean (SD); range	7.4 (2.7); 4–11	6 (4.2); 3–9	p=0.09
Oral intake restoration (days), mean (SD); range	11.5 (5.9); 6–25	14.8 (10); 8–40	p=0.24
Discharge (days), mean (SD); range	21.8 (12); 12–61	23.2 (7.5); 16–39	p=0.21
Diet score, mean value (SD); range	1.28 (0.4); 1–2	1.33 (0.4); 1–2	p=0.78
Speech score, mean value (SD); range	1.07 (0.2); 1–2	1 (0); 1–1	p=0.31

DISCUSSION

Reconstruction of the oral cavity and oropharyngeal defects requires a thoughtful approach to guarantee a safe healing process and to enhance residual functionality. In the present study, we analyzed reconstructions performed by a single surgeon (A.D.) to avoid interoperator differences and we focused on soft tissue reconstructions to test different options. We selected only defects in communication with neck spaces to represent a similar level of complexity in these reconstructions. In fact, transoral resections are mostly performed for small tumors, where the reconstruction in these cases is less difficult, using primary closure, local flaps, or skin grafts only.

Because voluntary dynamic reconstruction is not currently achievable, optimal reconstructive outcome would be aimed at enhancing residual function and allowing good mobility of the preserved structures around the resected area. The replacement of dynamic structures with static ones has obvious limitations so that a thoughtful analysis of the anticipated defect and impairment is mandatory.

In our series FRFF appeared to be an excellent reconstructive method, confirming all advantages that make it the most popular and widespread microvascular flap in head and neck reconstruction.

The long pedicle allowed anastomoses to be performed in the contralateral neck side in 2 cases. We experienced a single case of venous congestion that was solved with microvascular revision. The problem was caused by a displacement of the caudal remaining stump of the internal jugular vein that had been superiorly fixed to prevent collapse and to facilitate venous drainage from the flap and from the middle thyroid vein. Refixation of the venous stump together with the removal of the intraluminal thrombus solved the problem. In this situation, however, extravenous anastomosis between one comitant vein and the external jugular system might have overcome venous congestion.

Although age itself is not a major risk factor, the mortality and morbidity rates for major surgical procedures are definitely higher in the elderly population compared with younger adults [16]. The death rate resulting from surgery increases 3-fold each year after the age of 60 [17]. This risk is more significant after age 70 and patients aged 80 years or older are more prone to operative mortality and morbidity [18]. In a study of 78 patients aged 70 years or older that underwent free flap transfer for head and neck reconstruction, Coskunfirat et al. [19] reported an overall success rate of 96%; however, postoperative medical complications arose in 44.1% of ASA III patients and in 50% of ASA IV.

IHF represented an excellent alternative solution to FRFF in high-risk populations in terms of healing and functional results. Average age in G1 was 11 years higher than that in G2; patients presented severe comorbidities with 83.3% (15/18) assessed as being ASA III. Despite this, all patients had a successful reconstruction, with excellent functional results and a low rate of general complications. In one elderly patient (83 years old) with diabetes mellitus, we experienced superficial skin necrosis but healthy muscles provided complete reepithelization without scar fixation of the residual tongue (see Figure 1). In microvascular reconstructions the hemorheologic status of the patient must be carefully controlled during the early postoperative period to achieve good results; the maintenance of optimal parameters is particularly difficult in weak patients suffering from severe general comorbidities [20-22]. It is also recognized that the risk for thrombosis is highest during the first 2 post-operative days [23,24]. For prevention, several agents have been used such as heparin, acetylsalicylic acid, dextran, and prostaglandin E1. Side effects, other than bleeding risk of anticoagulation, should not be underestimated. Aspirin can cause gastric ulceration and nephrotoxicity. Heparin can cause heparin-induced thrombocytopenia. Dextran is known for anaphylaxis, pulmonary and cerebral edema, and platelet dysfunction [25]. Conversely, in pedicled flap reconstruction this aspect is not as crucial as it is for microvascular procedures.

The majority of myocutaneous flaps for head and neck reconstruction (eg, pectoralis major, trapezius, latissimus dorsi) are quite bulky; conversely, the IHF is thin and pliable. Although the latter is not as thin and pliable as FRFF, it appears to be extremely suitable for all sites within the oral cavity and oropharynx, preventing salivary fistulas in the neck and allowing good motility of the tongue (Figures 2 and 3).

In cases of tongue reconstruction our practice is to always preserve the motor innervations of the infrahyoid muscles (provided by the ansa cervicalis) to prevent subsequent atrophy, as originally suggested by Wang et al. [9]. Conversely, for other sites, denervation atrophy of the underlying muscles will increase the flap's plasticity and pliability.

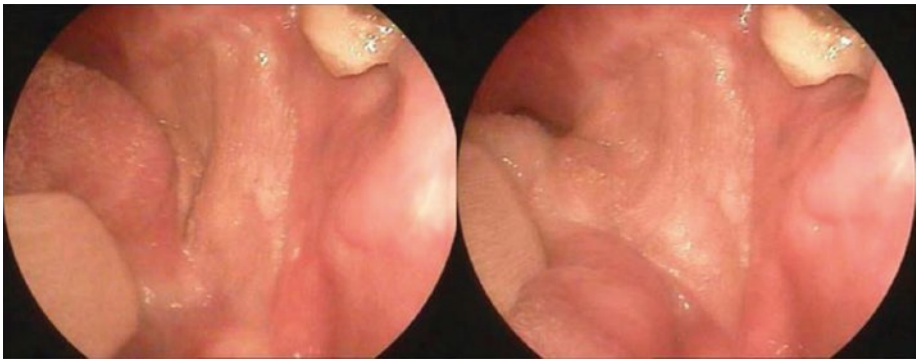

Figure 2 | Infrahyoid flap reconstruction of the left retromolar trigone, anterior pharyngeal pillar, and posterior third of the tongue.

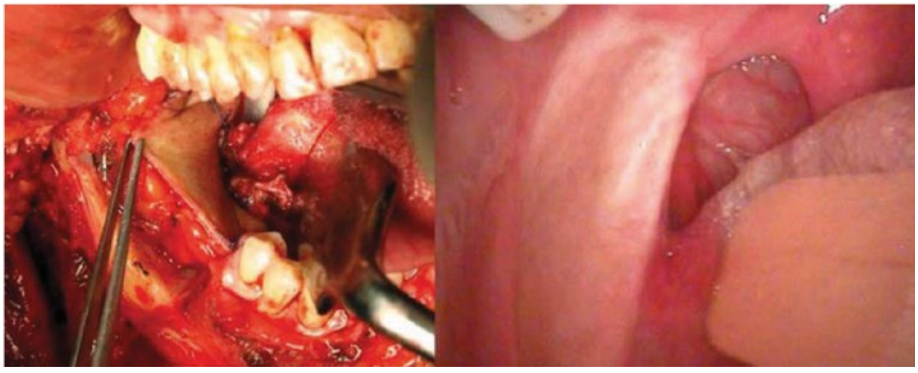

Figure 3 | Infrahyoid flap reconstruction of the right tonsillar region, soft palate, and retromolar trigone.

Furthermore, we are pleased to highlight a new personal modification of the surgical technique for base of tongue reconstruction that was used in this series. We noted that, in cases of tongue base reconstruction, the transposition of the flap without detaching it from the hyoid bone (that acts as rotational pivot), improves swallowing efficacy. In fact, during deglutition, the hyoid bone elevates and pushes the flap backward, thus helping with bolus propulsion (as shown by dynamic fibroscopic investigations). For defects limited to the tongue base, IHF is perfectly suited to the resected area having the desired thickness. For all the above-mentioned reasons IHF is becoming our preferred method for base of tongue reconstructions (see Figure 4).

In this series we used this technique in 4 patients with very promising results; however, our purpose was to further validate the technique in the future with more cases and videofluoroscopic studies. The reconstruction of oral tongue and base of tongue with infrahyoid flap has also been developed by a German group that has used a myofascial transposition of the flap. Whenever the resection encompassed more than half of the oral

tongue and/or base of tongue, the infrahyoid myofascial flap was lined with a microvascular FRFF [12,13]. However, in the description of surgical technique contained in their reports, the flap is being systematically transected from the hyoid bone; furthermore, the authors do not harvest the skin attached to the infrahyoid muscle group with the aim of reducing operative time for the surgical procedure and postoperative donor site morbidity.

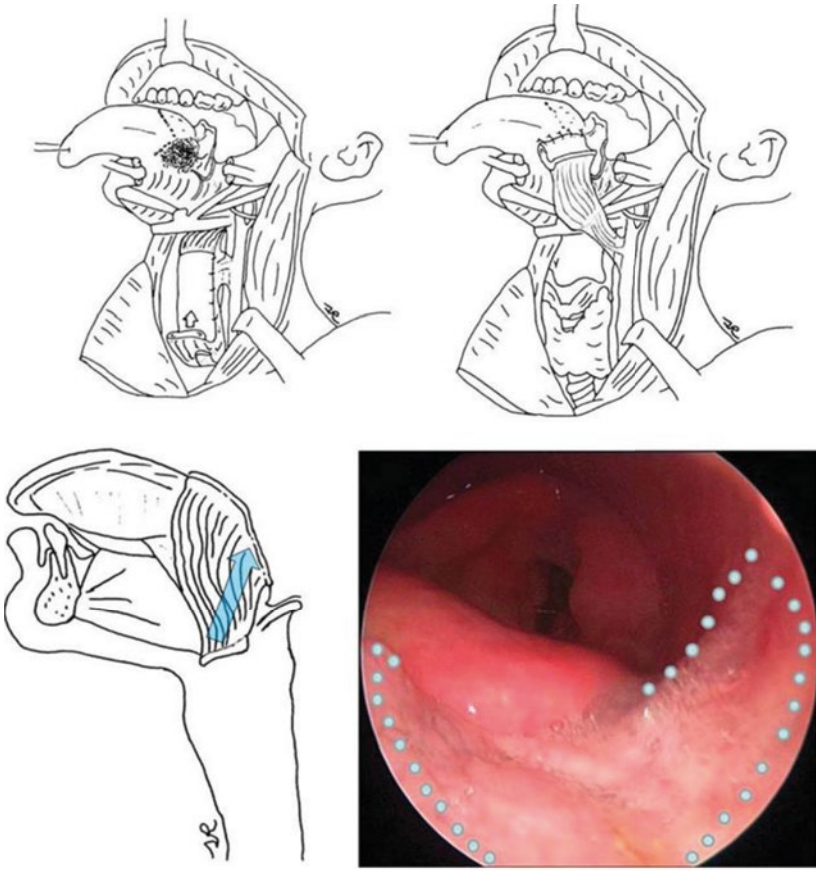

Figure 4 | Base of tongue reconstruction after transmandibular resection of pT3N1 SCC at the left hand side. Infrahyoid flap (dotted line) has been transposed maintaining the muscular insertions at the hyoid bone. During deglutition, the hyoid bone elevates and pushes the flap backward, so helping with bolus propulsion.

In our series IHF reconstruction proved to be quick and convenient: the average operative reconstructive time in G1 was 1 hour and 25 minutes less than it was in G2; furthermore, in G1 only 1 surgical team was needed. The flap was harvested after neck dissection without interfering with oncologic radicality and all donor sites were primary closed with good aesthetic results (see Figure 5). The mean reconstructed surface area was 22.7 cm^2, making this flap particularly suitable for medium-sized defects; the almost double surface of the skin

paddle for the FRFF is mainly explained by its higher pliability. In fact, this thin fasciocutaneous flap offers a much more tailored reconstruction, providing an effective lining for all recesses of the resected area, and occasionally it can also be double folded (2 cases in this series). Conversely, the IHF is mainly used to connect the mucosal edges of the resection, whereas all recesses will be covered by the infrahyoid muscles. Nevertheless, for larger defects, IHFs with skin paddles measuring 9 x 4.5 cm (40.5 cm^2) and 7.5 x 4 cm (30 cm^2) have been easily transposed in this series.

Figure 5 | Donor site result following primary closure.

Disadvantages of IHF mainly coincide with its contraindications: previous thyroid surgery or neck dissection, N3 neck metastasis, and positive lymph nodes at level III–IV. This flap is also better not harvested in previously irradiated necks. All these contraindications pose consistent limitations to the use of this reconstructive option. The IHF must always be planned in advance and cannot represent a back-up solution in case of other flap failure, since it cannot be used in a previously operated neck. In fact, probable damages to the superior thyroid artery and/or vein and/or possible elevation of the skin overlying the strap muscles prevent the possibility of relying on this myocutaneous flap. Previous radiotherapy is not an absolute contraindication, but preoperative careful evaluation of the intended skin paddle is recommended: if lack of pliability, radiation-induced fibrosis, and/or telangectasias are encountered, then a decrease in blood supply to the skin through the perforator vessels is probably occurring and the flap is better not harvested. However, if these features are lacking and the appearance of the skin is normal, then the flap can be considered. In this series we used it in 1 post-radiation neck without facing postoperative complications.

CONCLUSIONS

In our recent experience, FRFF still remains the first-choice flap for many oral cavity and oropharyngeal soft tissue reconstructions. IHF in high-risk cases represents a valid alternative with excellent functional results. IHF does not require a second surgical team, change of the patient's position during surgery, or sophisticated harvesting procedures. Furthermore, we introduced a novel technical innovation for tongue base reconstruction using the IHF so that it has become our preferred method for this specific area and we are now using it as first choice rather than FRFF.

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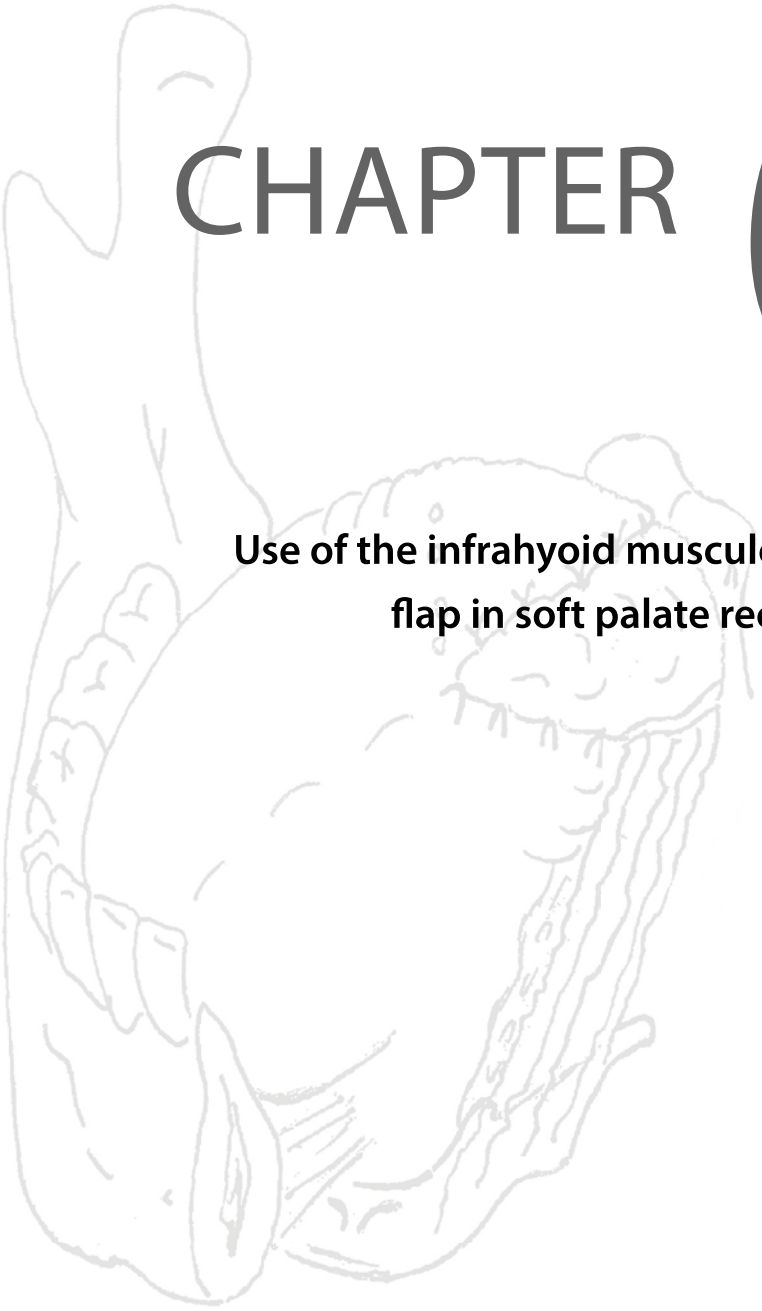

CHAPTER 6

Use of the infrahyoid musculo-cutaneous flap in soft palate reconstruction

Gangloff P
Deganello A
Lacave ML
Verhaeghe JL
Lapeyre M
Maire F
Phulpin B
Guillemin F
Dolivet G

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ABSTRACT

Aims: To review a series of 23 consecutive patients with squamous cell carcinomas arising from oropharynx who underwent infra hyoid musculo-cutaneous flap reconstruction including soft palate in alternative to free radial forearm flap or maxillofacial prosthesis. Postoperative radiotherapy was performed for all patients.

Results: Every reconstruction healed quickly without major wound complications. The functional results evaluated by speech and swallowing capacities, were good for 17 patients, fair for 4 patients and bad for 2.

Conclusions: The infrahyoid musculo-cutaneous flap is a versatile, reliable and convenient flap suitable for repairing small and medium sized defects; it can be used in combination with other flaps, and in selected cases obviates the need for a microvascular free radial forearm flap or maxillofacial prosthesis.

INTRODUCTION

Velopharyngeal function is often compromised by the resection and reconstruction of oropharyngeal and palatal tumors. While free tissue transfer has improved the outcomes of head and neck reconstruction, in general, palatal reconstruction remains a challenge [1].

The use of microvascular free flaps is the most widespread method currently employed for the reconstruction of extensive defects after resection of head and neck cancer, so that they represent today the golden standard in many cases because of their versatility and reliability. The flap most commonly used for head and neck reconstruction is the free radial forearm flap (FRFF) [2]. This FRFF can be used alone or combined with other local flaps. The study of Brown et al. [3] shows that the addition of the superiorly based pharyngeal flap to the FRFF in soft palate reconstruction results in improved speech and swallowing. Brown et al. [3] recommend the use of the additional flap in resections in which more than one quarter of the soft palate is included.

The evidence that not all the patients are suitable for a free flap reconstruction, and also that not every defect strictly requires a free flap transfer to achieve a good functional result, rises the necessity to find good alternatives.

Pectoralis major flap and temporalis flap are the most used pedicled flaps in head and neck reconstruction, but the infrahyoid musculo-cutaneous flap (IHMCF) is one of the alternatives to be considered for the reconstruction of moderate defects following resection of the oral cavity, oropharynx or hypopharynx cancers in selected cases. It obviates the need for a microvascular free flap or other local flaps in many cases [4].

Here we report our experience of a series of 23 reconstructions for selected tumors of the soft palate by using the IHMCF, as a valid alternative to FRFF reconstruction or maxillofacial prosthesis.

PATIENTS AND METHODS

The infrahyoid muscles including sternohyoid (SH), thyrohyoid (TH), sternothyroid (ST) and omohyoid (OH) constitute the anatomical substratum of the flap, completed by the platysma and the overlying skin.

Design of flap

The IHMCF is designed as an oval vertically shape in a paramedian situation and can measure up to 10 cm in its greatest length and up to 5 cm widthways, Figures 1and 2 [5-7].

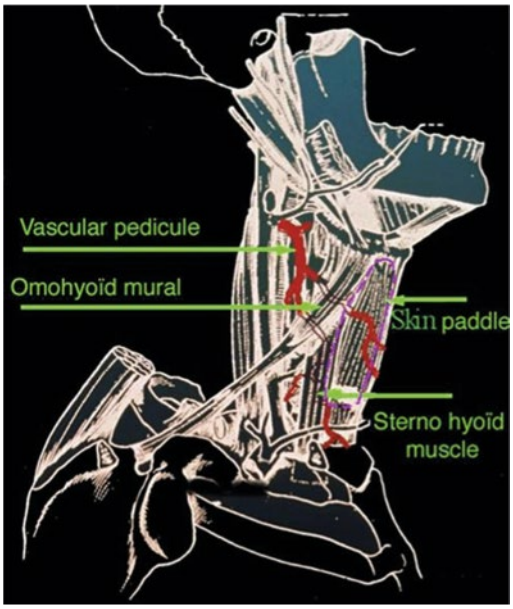

Figure 1 | Infrahyoid musculo-cutaneous flap and its vascular network.

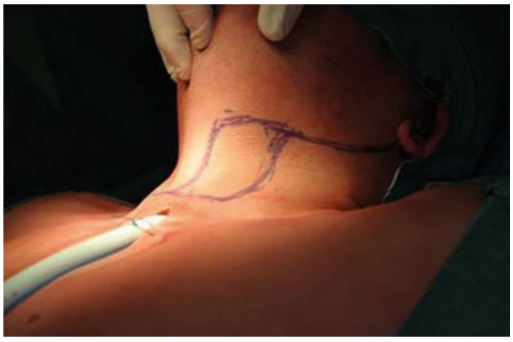

Figure 2 | Pre operative skin design.

The extent of the resection goes from 1 to ½ of the soft palate. Patients for whom the resection reaches more than the half of soft palate were excluded from this series. The flap is dissected in order to separate it from the median cervical fascia. The inferior muscular part of the flap is defined by sectioning the muscles downwards (SH and ST) and outwards (intermediate tendon of OH). The venous drainage has two systems through the anterior jugular vein and the superior thyroid vein. Then the strap muscles are separated from the thyroid plane in order to muscles are separated from the thyroid plane in order to identify the superior thyroid artery and vein pedicle, Figure 3 [8,9].

Collateral veins and superior laryngeal artery (carefully separated from the superior laryngeal nerve) can be ligated, allowing securing the flap to the external carotid artery and the facial vein, or perhaps the internal jugular vein. The SH is usually upwardly sectioned at the insertion

to the hyoid bone. The flap is then placed to repair the defect site, Figure 4. Cutaneous closure of the donor site is performed without important difficulties, Figure 5.

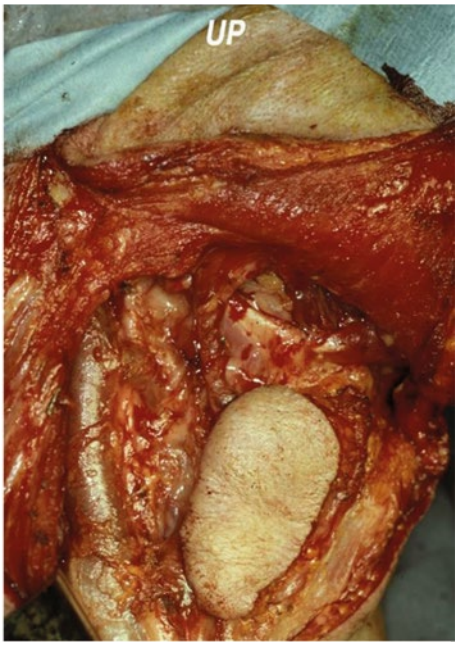

Figure 3 | Infrahyoid musculo-cutaneous flap. Surgical aspect, front view.

Figure 4 | Post operative view. Right soft palate reconstruction with infrahyoid musculo-cutaneous flap.

Figure 5 | Post operative view. Donor site cicatrisation.

PATIENTS AND TREATMENTS

From 1996 to 2005, 23 consecutive patients, 19 men and 4 women, underwent IHMCF recon-struction after oropharynx cancer ablation e including a part of soft palate e and neck dissection, in one stage procedure. The extension limits of the tumor had not to go beyond the midline of the soft palate. The ages of the patients ranged from 39 to 71 years, with median age of 58 years. The series accounts 23 squamous cell carcinomas (100%) arising from the mucosa of the oral cavity and oropharynx. The localization was velotonsil area for 20 patients and retro molar trigon for 3 patients. Twenty-one patients (91%) admitted to tobacco consumption and alcohol abuse. The disease was staged according to the VIth edition of the TNM classification established by the UICC/AJCC [10]. Four tumors were noted T1, 9 T2, 7 T3 and 3 T4. Nodes were staged as 5 N0, 5 N1, 3 N2a, 6 N2b, 3 N2c and 1 N3. Postoperative radiotherapy was performed for 23 patients. All patients underwent speech and swallowing evaluation and reeducation after surgery and radiotherapy.

In this series IHMCF reconstruction has been chosen instead of FRFF reconstruction or maxillofacial prosthesis.

RESULTS

Nineteen patients had cicatrisation without complications for the flap or the donor site. Local complications occurred in 4 patients. In 2 cases we observed a partial skin paddle necrosis. In the other 2 cases the patients demonstrated a minor cervical dehiscence of the skin requiring only local care.

17/23 patients were able to eat normally (good deglutition) with good speech evaluation (good intelligibility). The remaining 6 patients had to adapt their eating habits by mincing (2/6) (fair deglutition) or by mixing (2/6) (bad deglutition) their food. The last 2 patients had fair speech evaluation (fair intelligibility) (Table 1).

These six patients, for whom function was classified fair or bad, had T4 (2/6) or T3 (4/6) tumors. The two bad results were noted for patients who had presented in the past laryngeal or pharyngeal tumors. The 1st was a second localization and the 2nd was a third localization. For fair results, the delay of surveillance after surgery was too short for three patients (less than 12 months), one presented a second localization and the last obtained only fair results after reeducation. The extent of soft palate resection was varied: from the quarter to the half with no clear relation between the extent of the resection and the function quality (Table 2).

Table 1 | Series description.

Classification T	N	Localization	Postoperative treatment	Local complications	Function evaluation
4 T1	5N0	20 velotonsil	23 radiotherapy	2 partial skin paddle necrosis	17 good
9T2	5N1	3 retromolar trigone	23 speech and swallowing reeducation	2 minor cervical dehiscence	4 fair
7T3	3N2a				2 bad
3T4	6N2b				
	3N2c				
	1N3				

Table 2 | Fair or bad function description.

	TNM classification	Extent of soft palate resection	Function impairment	Main reason of function impairment	Follow-up
Fair#1	T3N1M0	one fourth	fair intelligibility	short rehabilitation time	8 months
Fair#2	T3N1M0	one fourth	fair deglutition	fair rehabilitation results	16 months
Fair#3	T3N2aM0	one third	fair deglutition	short rehabilitation time	6 months
Fair#4	T3N2cM0	one fourth	fair intelligibility	second localization and short rehabilitation time	10 months
Bad#1	T4N1M0	one half	bad deglutition	third localization	23 months
Bad#2	T4N2aM0	one third	bad deglutition	second localization	47 months

The delay of surveillance after surgery ranged from 6 months to 9 years, with median delay of 2 years and 9 months.

DISCUSSION

Since 1979, Wang et al. [11] performed a long series of IHMCF. Earliest studies were published from 1986 to 1994 [4,11-13]. Wang et al. [11] reported 112 flaps which were successful in 90% of the cases (101 of 112 cases). The same success rate of IHMCF is noted by Zhao et al. [14] who have concluded that cervical pedicle flaps have clinical value in selected patients needing reconstruction of small e and medium e sized defects after intraoral cancer surgery. IHMCF is a versatile, reliable, and convenient flap suitable for repairing the defects in and around the oral cavity, particularly in the oropharynx, even in aged and weak patients [11]. Since 1994, we performed routinely IHMCF to reconstruct mucous defects in the head and neck region with this technique, which we subsequently modified for head and neck surgery and immediate reconstruction [15].

At best, the flap extremity can reach a distance of 15 cm (theoretical) around its rotation axis. The effective region includes the cervical trachea up to the velotonsil, including the inferior facial cutaneous covering (under the labial e tragus commissura). For soft palate, the maximum size of defect that could be safely reconstructed with the IHMCF is the half. Functionally, flap resection does not induce phonatory, respiratory or swallowing complications. The size of the cutaneous flap sampled was always compatible with a direct suture of the donor site without cicatrisation complication.

In our experience, the results were comparable with those published in the literature [4,11-13]. The lack of ability to reconstruct the dynamic function of the soft palate continues to be disappointing. Limited studies have shown promise in soft palate reconstruction without the complications of velopharyngeal insufficiency. The lack of a uniform classification for palate defects has limited prospective comparison of reconstructive methods [16]. The usual respect of contraindications helped avoiding the complications encountered by other authors [11]. Contraindications of IHMCF such as previous thyroid surgery or radical neck dissection must be respected; relative contra indication is represented by previous cervical radiotherapy. It is acceptable to use material from a metastatic neck for defect cover in the cases where the vascular pedicle of the flap and the IHMCF itself are not in the tumor and are at least at 30 mm of cancerous tissue.

In case of soft palate reconstruction, it is useful to preserve the motor innervation of the infrahyoid muscles provided by the descending branch of the hypoglossal nerve (the ansa cervicalis), that is kept with the flap during its new positioning. The main advantage of this voluntary innervated flap is the prevention of atrophies and the improvement of scarring qualities of the reconstructed soft palate [17]. The function qualities are also improved by this innervation conservation which allows synchronous contraction of the two sides of soft palate during swallowing. As Wang et al. published [11], a minor motricity reappears within 12 months after intervention.

The IHMCF is a versatile, reliable and convenient flap, with interesting plastic qualities, suitable for repairing small and medium sized defects [15]; this is an additional tool in the therapeutic possibilities for cervicofacial reconstruction. It can be used in combination with other flaps, and in selected cases, as soft palate reconstruction, obviates the need for a microvascular FRFF or maxillofacial prosthesis. This flap is thin, pliable, so that is particularly useful in oral cavity reconstructions and, in our experience, the functional results are comparable to those of the FRFF reconstruction for small and medium sized defects. The IHMCF has the particularity to remain the anatomy after reconstruction, which is less possible with FRFF or maxillofacial prosthesis.

The realization of a maxillofacial prosthesis is another solution for these patients. Prosthetic treatment of soft palate defects varies based on the extent and site of the defect. The goal

of treatment is to attain velopharyngeal closure during function, which allows normal speaking and swallowing and keeps the patient relatively comfortable. While maxillofacial prosthetic treatment is not a substitute for plastic and reconstructive surgery, in certain circumstances it may be an alternative. Certain patients may simply not be good candidates for plastic surgery because of their advanced age, poor health, very large deformity, or poor blood supply to irradiated tissue. Moreover, maxillofacial prosthetic treatment is indicated when anatomical parts of the head and neck are not replaceable by living tissue or when recurrence of malignancy is likely.

Nevertheless, in patients with soft palate defects, it is difficult to obtain sufficient retention, support, and stability of the obturator prosthesis. In addition, its mobility during various functions is considered to be large.

Although the system of speech evaluation was subjective in our series, but standardized by the same speech therapist, the results obtained seemed equivalent to those obtained by Wang et al. [11] and Zuydam et al. [18]. Four fair results and two bad results were observed. On the one hand, these results seemed to be related to the tumor stage (T3 or T4) and not to the extent of soft palate resection (for some cases, good results have been obtained after resection of the half of soft palate) and on the other hand, three out of four fair results had a delay of surveillance after surgery less than 12 months, which can also explain these functional results. The two bad results were noted for T4 tumors.

The indications of this flap remain numerous for the upper aerodigestive tract allowing the repair of large mucous or cutaneous defects with acceptable functional or aesthetic sequelae.

Our surgical technical research has led us to the laryngeal and pharyngolaryngeal reconstruction (i.e. after near total resection) with the IHMCF and in some specific case, partial reconstruction of cervical esophagus. Our primary results seem to confirm the elective choice of this flap for these indications.

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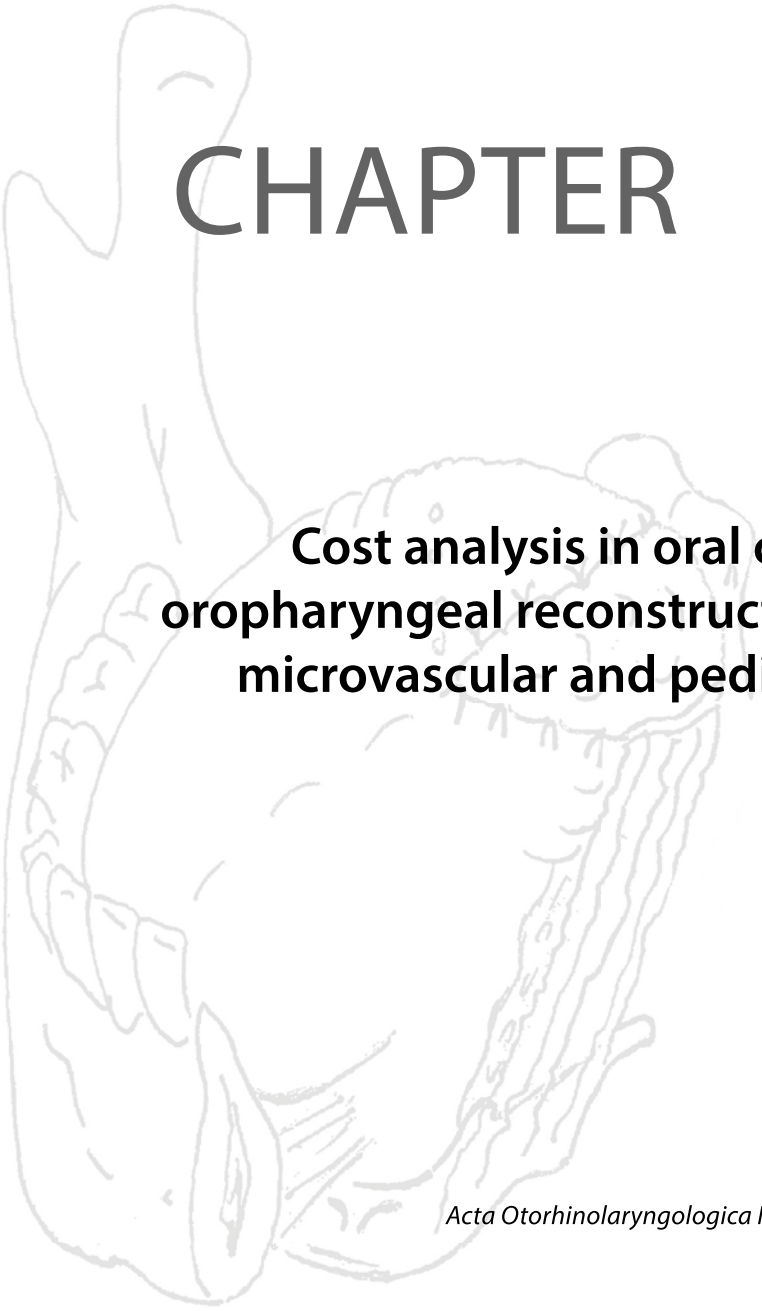

CHAPTER 7

Cost analysis in oral cavity and oropharyngeal reconstructions with microvascular and pedicled flaps

Deganello A
Gitti G
Parrinello G
Muratori E
Larotonda G
Gallo O

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ABSTRACT

Reconstructive surgery of the head and neck patient has undergone tremendous advancement over the past three decades, and the success rate of free tissue transfers has risen to greater than 95%. It must always be considered that not all patients are ideal candidates for free flap reconstruction, furthermore it is also true that not every defect strictly requires a free flap transfer to achieve good functional results. At our Institution, free flap reconstruction is first choice, however we use pedicled alternative flaps for most of weak patients suffering from severe comorbidities, and for pretreated patients presenting a second primary or a recurrent cancer. From July 2006 to May 2010, 54 consecutive patients underwent soft tissue reconstruction of oral cavity and oropharyngeal defects. We divided the cohort in three different groups: Group 1 (G1): 16 patients in good general conditions that received free radial forearm flap reconstruction; Group 2 (G2): 18 high-risk patients that received a reconstruction with infrahyoid flap; Group 3 (G3): 20 patients that received temporal flap (10 cases) or pectoral flap (10 cases) reconstruction. We must highlight that pedicled alternative flaps were used in elderly, unfavorable, and weak patients, where usually the medical costs tend to rise rather than decrease.

We compared the health care costs of the three groups, calculating real costs in each group from review of medical records, and operating room registers, and calculating the corresponding DRG system reimbursement. For what concerns the real costs, we found a statistically significant difference among groups: in G1 the average total cost per patient was €22.924, in G2 it was €18.037, and €19.872 in G3 ($p=0.043$). The amount of the refund, based on the DRG system, has been €7.650 per patient, despite the type of surgery. Our analysis shows that the use of alternative not-microvascular techniques, in high-risk patients, is functionally and oncologically sound, and can even produce a saving. In particular, the infrahyoid flap (G2) ensures excellent functional results, accompanied by the best economic results in the worst group of patients. Our data reflect a huge disconnection between the DRG system and the actual treatment costs.

INTRODUCTION

The application of microvascular free flaps is the most widespread method currently employed for the reconstruction of extensive defects after resection of head and neck cancer, because of their versatility and reliability. The success rate of free tissue transfers has risen to greater than 95%, and fascio-cutaneous free flaps (i.e. free radial forearm flap, free antero-lateral thigh flap) are currently considered the gold standard for soft tissue reconstruction of oral cavity and oropharyngeal defects [1,2,3]. A recent report showed that in the United States free flap reconstruction of the head and neck is even profitable, and generates substantial revenue for the hospital [3]. Is this scenario valid also in Italy? In fact, the complexity of modern head and neck reconstruction is paralleled by consumption of large amounts of resources, provided by both treating physicians as well as the institution. In times of increasing economic constraints, analysis of the financial value of providing these services seems beneficial. Free flap reconstruction requires special knowledge and surgical skills, dedicated personnel and tools, careful postoperative monitoring [5,6], and therefore it has been hypothesized that adopting microvascular reconstructive techniques could increase healthcare costs [7,8]. Our interest on this subject arises from our institutional policy of treating with alternative pedicled flaps, most of weak patients suffering from severe comorbidities [9,10], pretreated patients presenting a second primary or a recurrent cancer, and patients with major vessels exposure [11,12]. In fact, not all patients are ideal candidates for free flap reconstruction [13], and not every defect strictly requires a free flap transfer to achieve good functional results [14,15], minimizing medical complications and mortality [16].

Reimbursement system

DRG is the acronym of "Diagnosis-Related Group", and indicates the remuneration system to the hospital based on health care activities. The system was created in the early eighties by Professor Fetter of Yale University [17], and it has been embraced in Italy since 1995. In Fetter's prototype, the hospital is defined as a company that provides numerous products. The first step is to classify each hospital case in one of the 467 groups. Then, starting from inputs represented by the resources available, the hospital develops a defined number of outputs for each patient, that are fitted on the starting health status. All these outputs are directed to obtain a final product: diagnosis and/or treatment (defined as the evaluation and/or any change in the state of health of the patient). Fetter developed a classification system for discharged patients, identifying subgroups of patients receiving a similar pattern of outputs, and assuming that similar diseases, treated in similar institutions, need the same consumption of human and material resources. With this system, the hospital is remunerated using predetermined rates. Each resigned patient is attributed to a specific DRG, calculated using Software Grouper that, through a process of hierarchical combination of information contained in the hospital discharge card (in Italy called Scheda di Dimissione Ospedaliera, SDO), automatically assigns each group. The SDO contains: the main discharge diagnosis (encoded with ICD9-CM, a classification system in which diseases and traumas are ordered

with an epidemiological aim), any received treatment or procedure, and general patient's information.
The DRG code assignment is based on three steps:
– Assignment to one of 25 "Major Diagnostic Categories" (MDCS), based on the ICD9-CM encoded main discharge diagnosis;
– Assignment to a subgroup "Medical" or "Surgical".

Then consider:
– type of intervention (for surgical DRG);
– age;
– further disorders and/or complications related to the main discharge diagnosis;
– discharge status (alive, deceased, resigned against the advice of physicians, transferred to another Department).

Once codified, each DRG will have its weight, and the software will provide the fraction of DRG's value compared to a full DRG. Each DRG will be corresponding to a tariff.

To calculate the total reimbursement of a DRG is therefore necessary to apply the formula:
– Cost = [fraction of DRG's value] x DRG's point.

It must be specified that DRG's point value, in Italy, varies from region to region, and that for each DRG there's a threshold value, expressed in days, which is the length of hospitalization considered outside the threshold. Outside this limit, the applied additional remuneration per day is much less consistent than within the threshold. In this study we compared the real costs of microvascular versus alternative pedicled flap reconstructions, and we calculated the reimbursement based upon the DRG system.

METHODS

From July 2006 to May 2010, 86 consecutive patients with oral cavity or oropharyngeal squamous cell carcinomas underwent head and neck reconstruction by a single operator (AD), using microvascular free flaps or alternative pedicled flaps. We have selected cases where the surgical defect (resulting from pull-through or trans-mandibular approaches) put the oral cavity and/or the oropharynx in communication with neck spaces, and we excluded reconstructions after segmental bony resections (mandibular resections/maxillectomy), resulting in a study population of 54 patients. After the analysis of medical records and surgical registers we recorded for each patient: all examinations and visits carried out in pre-operative evaluation; tumor site, clinical and pathological staging (in accordance with the 7th edition of TNM classification system) [18]; type of reconstructive procedure, surgical and reconstructive time, materials and drugs used during surgery; days of hospitalization in

intensive care; global hospitalization time, consultations, medications, blood transfusions, and examinations performed in post-surgery or in protected resignation; time of tracheotomy closure, time of oral feeding restoration. The pre-operative risk of each patient has been evaluated using the Classification of the American Society of Anesthesiology (ASA) [19]. Postoperative functional results were assessed by the physician at outpatient follow-up consultation, 6 months after surgery, using a score system; the type of diet was assessed in all cases. Options were numerically weighted from 1 to 4 as shown in Table 1.

Table 1 | Functional analysis.

Score	Diet	Speech
1	regular diet without restrictions	always understandable
2	moist or soft diet	usually understandable, but with frequent repetition or face to face contact required
3	liquid diet	difficult to understand even with face to face contact
4	tube-dependent intake	never understandable, with written communication required

Patients

We divided the patients into three different groups. In Group 1 (G1) 16 patients in good general conditions receiving free radial forearm flap reconstruction; in Group 2 (G2) 18 high risk patients that received a reconstruction with infrahyoid flap; in Group 3 (G3) 20 patients that received temporal flap (10 cases) or pectoral flap (10 cases) reconstruction.

G1 accounted for 12 male and 4 female patients; 9 patients received a free radial forearm flap to reconstruct a defect of the oral cavity, while 7 patients had a reconstruction of the oropharynx. The mean age in G1 was 58.2 years (median 58, range 45–70 years) and all patients were classified ASA I-II.

G2 accounted for 12 male and 6 female patients, 12 receiving infrahyoid flap for oral cavity and 6 for oropharyngeal reconstruction. All flaps were harvested from the same neck side of the primary tumor, during homolateral neck dissection; 10 patients had bilateral neck dissection. The mean age in G2 was 69.6 years (median 72, range 55–83 years), 3 patients were classified ASA II, the remaining ASA III. Contraindications for free flap reconstruction in G2 were: severe comorbidities (diffuse atherosclerosis, diabetes mellitus, heart failure) in 15 cases, and age exceeding 80 years with moderate comorbidities in 3 cases.

G3 accounted for 16 male and 4 female patients, 11 reconstructions of the oral cavity (7 pectoralis major flaps and 4 temporal flaps) and 9 reconstructions of the oropharynx (3 pectoralis major flaps and 6 temporal flaps). The mean age in G3 was 69.6 years (median 70, range 64–81 years); 3 patients were classified ASA I, 14 patients ASA II, 2 patients ASA III, 1 ASA IV. The contraindications for free flap and infrahyoid flap in G3 were: age exceeding

80 years with severe comorbidities and contraindications for infrahyoid flap reconstruction in 3 cases; post surgical vessel-depleted neck and previous radiation in 10 cases, and previous chemoradiation in 7 cases. Ten patients with vessel-depleted neck had no neck dissection, however even in these cases, tumor resection created a communication between the oral cavity or the oropharynx and neck spaces.

Costs

We compared the health care costs of the three groups in two different ways:

- Calculating the reimbursement following the DRG system;
- Calculating real costs in each group from review of medical records, and from operating room registers.

In order to assess actual costs for each patient we looked at:

- The cost of main materials and drugs actually consumed during diagnostic and therapeutic procedures, provided by the regional administrative institution for human and financial medical resources of Tuscany, Italy, (ESTAV-Centro);
- The standard cost per hour of the physician and the nurse (obtained by dividing the average salary per contractual hours, €55 and €23 respectively);
- The cost of each diagnostic procedure, retrieved from the regional tariff list (including personnel expenditure);
- The average of hospital stay, according to the Institutional Business Accounting (€420 per day, all inclusive);
- The average cost of hospital intensive care unit stay, according to Institutional Business Accounting (€1.300 per day, all inclusive);
- The cost of operating theatre, estimated according to the Institutional Business Accounting (€200 per hour including all fees except those of the medical/paramedical staff).

Costs were divided into three categories: preoperative, operative and postoperative. Preoperative costs include only those required by the anesthesiologist for undertaking the surgical procedure. All diagnostic procedures requested by the surgeon to determine the specific characteristics of the disease (CT, MRI) have been excluded, since these belong and are charged within the outpatient path. Postoperative costs were calculated until the discharge.

Statistical analysis

Differences among groups were tested with the ANOVA; for categorical variables we used a chi-square test of Pearson: probability with values less than 0.05 were considered statistically significant.

RESULTS

Medical results

Patient characteristics and results are displayed and summarized in Table 2.

All reconstructions were successful. In all cases a separation between oral cavity or oropharynx and neck spaces was obtained and none of the patients was re-admitted within 6 months from surgery. The mean operative time in G1 was 9 hours (range 7h – 12h 40min), in G2 6 hours 40 minutes (range 5h 20min – 8h), and in G3 7 hours (range 5h 10min – 8h 30min).

Postoperative intensive care recovery was used in 4 patients in G1 with a mean stay of 3.7 days, in 4 G2 patients with a mean stay of 3 days and in 3 G3 patients with a mean stay of one day.

All patients were discharged with complete restoration of oral intake (mean time 15 days, range 7–18) and tracheotomy closure (mean time 7 days, range 3–11). Mean discharge time after surgery was 23 days (range 12–39) with no differences among groups (23,2 days G1; 21,8 days G2; 26,5 days G3). No significant differences were found as regard to verbal intelligibility and diet score among groups. Nevertheless, patients in G3 receiving TMF had minimal diet restrictions while all patients with PM flap reconstruction required soft or liquid diets.

Economic results

The DRG system has assigned all 54 patients to the main diagnostic category (MDC) n.3 "Diseases and disorders of the ear, nose, mouth and throat", and class number 482: "Surgical tracheotomy for diagnosis concerning the face, the mouth and the neck". Since our Hospital is a tertiary referral center, it gathers a 3% increase on 1st tariff level for DRG high specialty (weight >2.5). The amount of the refund, based on the DRG system, has been €7.650 per every patient. In fact, none of the patients had a hospital stay beyond the threshold of 72 days.

Looking at the real costs we found a statistically significant difference among groups: in G1 the average total cost per patient was €22.924, in G2 it was €18.037, and €19.872 in G3, (p=0.043; Table 1). Operative expenses for G1 patients were statistically higher than those for G2 and G3 patients: €9.673, €5.751, and €6.172 respectively (p=0.034; Table 3). No statistically significant differences were found for preoperative and postoperative costs among the 3 groups: €333 and €12.919, €458 and €11.828, €393 and €13.307, in G1, G2 and G3 respectively (p values were 0.23 and 0.065 respectively; Table 3).

Table 2 | Patients overview and statistical analysis.

	Groups				Total (54)
	G1 (16)	G2 (18)	G3 (20)	p*	
Age (yrs), mean (SD); range	58.2, (6.32); 45–70	69.6, (9.41); 55–83	69.6, (6.8); 64–81	p<0.01	64.7, (9.5); 45–83
Gender, n (%)					
male	12 (75)	12 (66)	16 (80)	p=0.88	40 (74)
female	4 (25)	6 (34)	4 (20)		14 (26)
Tumor Site	9 OC 7 OP	12 OC 6 OP	11 OC 9 OP	p=0.61	32 OC 22 OP
Primary Tumor	12	15	3		30
Recurrent Tumor	2	2	7		11
Second Primary	2	1	10		13
pT					
1	—	—	4		4
2	7	5	5	p<0.01	17
3	8	9	8		25
4a	1	4	3		8
pN (10 G3 patients had no neck dissection)					
0	4	8	2		14
1	2	2	—		4
2a	1	—	—	p=0.07	1
2b	5	6	3		14
2c	4	2	2		8
3	—	—	3		3
Skin Paddle Surface (cm^2) mean (SD) range	44.7 (15.5); 20-63	22.7 (4.5); 18–40	44 (16.9); 32–56	p<0.01	34.7 (15.9); 18–63
Operative time, (h), mean (SD); range	9.5 (1.6); 7–12.4	6.6 (0.8); 5.2–8	7.4 (0.9); 6.1–8.3	p=0.14	8 (1.8); 5.2–12.4
Blood loss (Hb g/dL), mean (SD); range	3.25 (1.4); 1.1–6.2	2.6 (1); 0.4–3.5	3.6 (2.6); 1.7–5.5	p=0.59	3.04 (1.4); 0.4–6.2
Patients blood-transfused, n (%)					
Yes	3 (19)	3 (17)	4 (20)	p=0.96	10 (19)
No	13 (81)	15 (83)	16 (80)		54 (81)
Tracheotomy closure, mean (days)	6 (4.2); 3–9	7.4 (2.7); 4–11	7 (2.1); 5–10	p=0.83	7.3 (2.8); 3–11
Oral intake restoration, mean (days)	14.8 (10); 8–40	11.5 (5.9); 6–25	12.6 (4.7); 9–18	p=0.63	13.2 (7.9); 6–40
Discharge, (days), mean (SD) range	23.2 (7.5); 16–39	21.8 (12); 12–61	26.5 (9.9); 16–38	p=0.63	23.2 (9.8); 12–61

Table 2 | Patients overview and statistical analysis.

	Groups				Total (54)
	G1 (16)	G2 (18)	G3 (20)	p*	
Diet score, n, mean (SD); range	1.33 (0.4); 1–2	1.28 (0.4); 1–2	1.6 (0.7); 1–3	p=0.29	1.42 (0.6); 1–3
Speech score, mean, n	1 (0); 1–1	1.07 (0.2); 1–2	1.2 (0.4); 1–2	p=0.28	1.06 (0.2); 1–2

SD: Standard deviation, ChT: Chemotherapy, RT: Radiotherapy, Hb: Hemoglobin, OC: Oral Cavity, OP: Oropharynx, * Differences in mean values among groups were tested with ANOVA, for categorical variables Chi-Square Pearson test was used.

Table 3 | Real costs in Euro *(Continued)*.

	Groups			
	G1	G2	G3	p*
Pre-operative	333	458	393	0.23
Operative	9.673	5.751	6.172	0.034
Post-operative	12.919	11.828	13.307	0.065
Total cost	22.924	18.037	19.872	0.043

* tested using ANOVA, for categorical variables, chi-square test of Pearson.

DISCUSSION

The main goals in modern head and neck reconstructive surgery are restoration of form and function [20]. In oral cavity and oropharyngeal reconstructions, the surgeon is faced with several challenges: ensuring optimal healing; increasing residual function; preventing scar formation and anchylosis of mobile structures; ensuring effective deglutition, intelligible speech, and airway patency. Failure in some of these aspects, in addition to jeopardizing the patient's quality of life, produces an increase in health care costs. In the present study, we analyzed reconstructions performed by a single surgeon (AD) to avoid inter-operator differences, and focused on soft tissue reconstructions to obtain a homogeneous cohort. We selected oral cavity and oropharyngeal defects in communication with neck spaces to represent a similar level of complexity. In fact, transoral resections are mostly performed for small tumors, where the reconstruction in these cases is less difficult, employing primary closure, local flaps or skin grafts. Furthermore, since we focused our study on head and neck surgery, we excluded the costs of adjuvant therapies, since these are independent of the type of reconstructive procedure and could have created a bias (i.e. pre-irradiated patients). In recent years, at our Institution, the free radial forearm lap has represented the main reconstructive option for soft tissue reconstruction of oral cavity and oropharyngeal defects following cancer ablation. In fact, microvascular reconstructions represent a major advancement in the management of head and neck tumors; nevertheless, our philosophy

of carefully considering all anatomical and general conditions for each patient drove us to reconsider pedicled alternative flaps in selected cases. With this study, we wanted to verify our preliminary impression that this philosophy was not only oncologically sound, but also cost effective. Indeed, the infrahyoid flap has proven to be a valuable alternative in elderly patients suffering from severe comorbidities (G2 patients), ensuring excellent functional results [9,10,21,22]. The temporal flap and pectoralis major flap can still be useful in patients with a vessel depleted neck or when the expected quality of the recipient vessels is questionable (G3 patients) [11,23]. Looking at our data, and calculating the total real costs in the three groups, we immediately realized the inadequacy of the DRG system, which always assigned the highest hierarchical remuneration to the tracheotomy, rather than any other accompanying demolition/reconstruction.

The advantages of the DRG system should consist in fixing an anticipated "price" for hospitalizations, but the DRG miserably fails when dealing with major head and neck oncologic resections and reconstructions. In our series, the obtained refund per patient, based on the DRG, was €7,650; the gap between the real costs and the refund has been as high as €15,274 for G1 patients, €10,387 for G2 and €12,222 for G3 patients. These data reflect a large disconnection between the DRG system and true treatment costs; the DRG seems undeniably unsuitable to calculate and compare healthcare costs, and therefore to be used as a parameter for policy choices. The results of our analysis showed a significantly increased cost for microvascular procedures vs. pedicled alternatives. We must highlight that pedicled alternative flaps were used in elderly, unfavorable and weak patients, where medical costs usually tend to rise rather than decrease. In fact, the average preoperative costs for the more "fragile" patients of Group 2 and Group 3, requiring specific additional preoperative assessments were higher than preoperative costs in Group 1 (Table 4). These data show that our philosophy is not only valid from a medical point of view, but it is also economically sound. Nevertheless, our findings warrant further confirmation in a larger cohort of patients. It seems difficult to conduct a comparison with other studies because there are significant differences due to: the different criteria for choosing the type of reconstruction, the diverse systems of remuneration and the various costs of human and material supplies among different institutions and countries.

Kroll [24] in 1997 compared 145 oral cavity and oropharyngeal free flap reconstructions (using free radial forearm flaps or rectus abdominis free flaps) with 33 pectoralis major flap reconstructions. The operative costs were slightly higher for free flaps, but the total costs were lower: $37,314 for free flaps and $48,917 for pectoralis major flaps.

Ten years later, de Bree [25] matched 40 oral cavity/oropharyngeal reconstructions with free radial forearm flap with 40 patients receiving the pectoralis major flap for similar defects; total costs were lower for the free radial forearm flap group: €38,709 vs. €42,733. However, in both these studies, free flaps were tested against the pectoralis major flap, which unfortunately

is known to cause some healing delay for frequent necrosis of the most distal edge of the skin paddle; this usually doesn't require further interventions, but it does increase hospital stay and costs. In fact, where conservative transmandibular approaches are employed, the bulkiness of the pectoralis major flap produces less than ideal functional outcomes, because the mandible presses upon the flap favoring hypovascularization and necrosis of the distal portion, and because the thickness and bulkiness of the flap hinders the motility of the preserved structures.

Table 4 | Pre-operative costs in Eur.o

	Group		
	G1	**G2**	**G3**
Patient admission time			
Medical time (10 min)	6	6	6
Paramedical time (10 min)	2	2	2
Pre-operative exams			
Routine blood screenings	126	126	126
Extra blood screenings	36	113	102
Urinalysis	3	3	3
Chest X-ray	45	45	45
ECG	20	20	20
Paramedical time (15 min)	4	4	4
Pre-operative evaluations from various professionals			
Head and neck surgeon	22	11	11
Anaesthesiologist (20 min)	11	11	11
Nurse	9	4	6
Specific additional preoperative assessments	6	53	6
Side costs			
15% direct and indirect costs	43	60	51
Total	333	458	393

According to previous studies, the incidence range of total necrosis and partial necrosis for the pectoralis major flap has been reported to be from 0–2.7% and 4–29%, respectively [26-34].

It is our policy, however, to use the pectoralis major lap for defects mainly lying below an imaginary line between the labial commissure and tragus; instead, the temporal flap is chosen for defects mainly lying above this line. Furthermore, for reconstructions following mandibular sparing procedures, we prefer to use the pectoralis major flap as myofascial transposition, reducing its bulk, and consequently reducing the pressure of the mandible.

These two specific indications decreased the occurrence of distal marginal necrosis and the related costs.

In our series, the mean length of hospitalization was 23.2 days in G1, 21.8 days in G2 and 26.5 in G3, which was not significantly different (p=0.63). The intraoperative costs for G1 patients were significantly higher (p=0.034) than costs for G2 and G3 patients: €9,673, €5,751, and €6,172 respectively (Table 5). The highest intra- operative costs for G1 patients are due to longer operative time, and, above all, to the simultaneous work of a double medical and paramedical team (lap harvest during tumor resection; Table 5).

Table 5 | Operative costs in Euro.

	Group		
	G1	**G2**	**G3**
Materials			
Intubation kit	5	5	5
Sterile gloves	288	96	96
Thread	73	52	57
Microsurgical kit	22	—	—
Gauze	24	16	12
Scalpel	2	1	1
Tracheal cannula	75	75	63
Syringe	5	4	4
Sterile drape	12	8	8
Surgery disposable mask and cuff	4	1	2
Drugs			
Anaesthesia (fluids included)	232	188	196
Sodic heparin	7	—	—
Antibiotics	6	6	6
Histology			
Frozen sections	320	344	315
Definitive pathological report	880	865	846
Transfusions	70	62	7
Blood gases analysis	97	55	70
Operative room costs	1.900	1.320	1.546
Personnel			
Surgeons	3.008	1.091	1.223
Anaesthesiologist	523	364	408
Paramedical staff	858	447	502
Side costs			
15% direct and indirect costs	1262	751	805
Total	9.673	5.751	6.172

Longer operative times in G1 were mainly dependent on the microvascular reconstruction times, not only technically related to preparation of the recipient vessels under microscopic magnification and revascularization times, but also to "meticulous" and "patient/delayed" surveillance of micro-anastomosis patency prior to definitive skin closure (of course this step could be omitted or quickened, but we feel that "it is better to be safe than sorry"). On the other hand, higher operative costs in G1 were less dependent on operative times and mainly related to personnel-related costs (medical and paramedical).

Table 6 | Post-operative costs in Euro.

	Group		
	G1	**G2**	**G3**
Ordinary hospital stay	9.744	9.156	11.130
Hospital stay in ICU	1.219	867	195
Medications (hospital ward)			
Materials	97	79	81
Medical time	31	14	22
Paramedical time	16	7	19
Other specialists in consultation	63	98	38
Exams			
Imaging, ECG	30	26	38
Rehabilitation			
Speech therapy	27	24	31
Physiotherapy	8	14	16
Side costs	1.684	1.543	1.737
Total	12.919	11.828	13.307

The analysis of postoperative expenses (Table 6) showed a substantial parity between G1 and G3, with slight best performance again for G2. The inappropriate use of post operative intensive care recovery (ICU) in 4 G1 patients did deny a saving in this group of healthier patients, and instead raised postoperative costs (Table 6). Postoperative ICU monitoring was not related to protracted operative times, but only for the lack of the appropriate subintensive facility and it was no longer used for the 12 more recent cases.

Our reconstructive philosophy has provided successful results in functional terms, also in terms of "cost-effectiveness". The use of alternative pedicled flaps in high risk patients probably reduced the risk of flap failure, with consequent expenditure restraints. The use of microvascular techniques for these patients might have led to an increase in production costs linked to the increase of indirect costs arising from possible complications. The limits of our study are mainly represented by the retrospective setting and the small cohort. It would be beneficial, for subsequent analyses, a perspective evaluation with a larger cohort,

possibly multi-institutional. In our opinion, satisfaction and quality of life of the patient must, however, precede any economical concern [35-38].

Conclusions

Our analysis shows that the use of alternative non-microvascular techniques in high risk patients, does not affect the result in oncologic and functional terms, and can even produce a cost saving. In particular, the infrahyoid flap ensures excellent functional results accompanied by the best economic performance in the most fragile patients.

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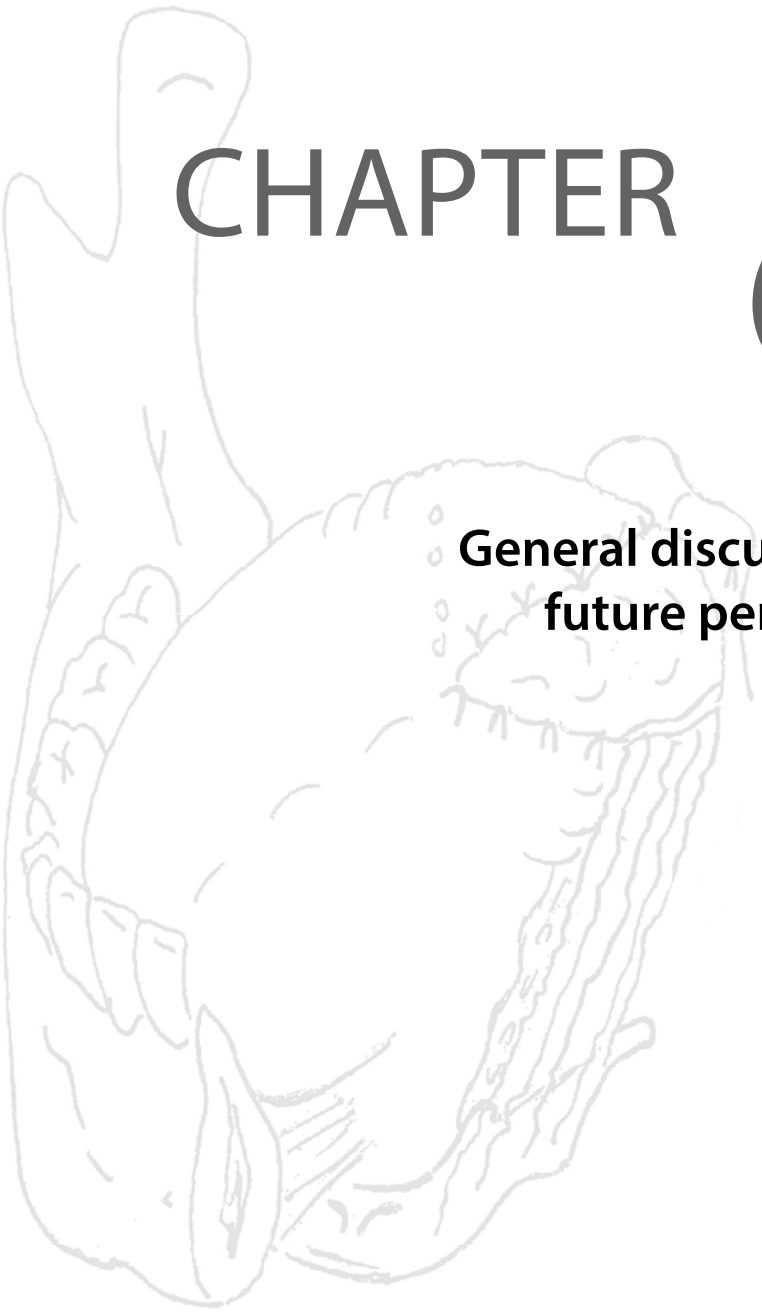
CHAPTER 8

General discussion and future perspectives



In head and neck surgery, the type of flap used for reconstruction depends on the needs of the recipient site, in some situations free flaps are required (e.g. in segmental bony reconstructions), whereas pedicled flaps cannot always offer the amount or type of desired tissue, or the defect can result out of reach when the arc of rotation of the vascular pedicle limits the required distance of transfer. However, premorbid patient factors and regional anatomy (e.g. comorbidity or previous head and neck cancer treatment) are also important in deciding which flap is employed for reconstruction [1].

Randomized controlled trials, comparing microvascular free flaps with regional pedicled flaps in head and neck reconstructions, are not feasible; consequently, the nature of studies comparing these two procedures is restricted to descriptive reports, stratifying, wherever possible, for patient and tumor factors, without the possibility of eliminating inevitable bias. Several authors report that free flaps have advantages over pedicled flaps in head and neck reconstruction, and this is certainly true as respect to the fact that tissue dimensions and thickness can be tailored to the size of the defect and vascularized bone can be used to reconstruct complex defects, all leading to superior restoration of form [2]. Some reports state that free flaps provide superior speech and swallowing outcome over pedicled flaps [1,3], while other authors were unable to substantiate this finding [1,4]. Many reports regarding the elderly in relation to microvascular free flap reconstruction agree that age is a risk factor for poor surgical outcome [5-8]; older patients prove to be less capable of coping with large fluid shifts and significant blood loss [5], and free flap reconstructions are known to be more often associated with the need for blood transfusion [7]. In addition, cardiovascular disease proves to be an important factor in free flap reconstructive failure [5], a condition which is more prevalent in adults past the age of 60 years [9], furthermore with increasing age there is a greater likelihood of postoperative complications after free flap reconstruction [10], even with successful microvascular reconstructions [11]. McCrory et al. described that operative time, resection-reconstruction, was statistically much longer for free flap than for pedicled flap procedures (9 hours 35 min versus 4 hours 58 min) [6]; long surgical times was a significant factor for the development of postoperative complications in a series of 104 free flaps in patients aged 65 and older [5].

Besides age, also diabetes appears to interfere with free flap survival [12], however its impact on healing outcome following microvascular reconstruction is still much debated. While some authors support a negative effect [13,14], Cooley et al. reported that patients with diabetes were not at increased risk either for flap failure or for abnormal healing of the anastomoses as long as normal glycaemia is maintained [15].

The use of free flaps reconstruction in previously irradiated patients or patients who underwent prior (chemo)radiation is also much debated in literature. In a review, Wong et al. pointed out that prior (chemo)radiotherapy can cause significant scarring and vessel damage to the recipient vessels with obvious negative consequences [16]. Furthermore, Schultze-

Mosgau et al. reported a reduced clinical success rate (84%) of free flaps in head and neck patients with previous radiotherapy of 60-70 Gy [17]. Moreover, in a study of 429 patients who underwent free flap reconstruction in the head and neck, preoperative radiotherapy (irrespective of irradiation doses) was significantly associated with fistulae formation and wound infection, while previous neck irradiation at doses of more than 60 Gy proved to be a significant risk factor for free flap failure, overall local complications, hematoma, longer duration of enteral nutrition and hospital stay [18].

Since intake of alcohol ≥30g/day is related to the development of head and neck cancer [19], many head and neck cancer patients suffer from alcohol related problems. Both acute alcohol withdrawal as well as other alcohol-induced disorders prove to negatively influence the outcome of microvascular free flap tissue transfers [20-22].

Consequently, those patients presenting with the above mentioned clinical conditions, which are associated with a higher rate of free flap failure or postoperative complications, are less eligible for microvascular free flap reconstructive surgery, whereas locoregional pedicled flaps may offer a reliable alternative for reconstruction [23-25]. A pedicled flap reconstruction brings some benefits for both patient and surgeon: the surgical procedure is usually less time consuming corresponding with a decrease in the morbidities of prolonged general anesthesia; most donor sites have low morbidity and usually are amenable to primary closure; the admission length of patients receiving a pedicled flap reconstruction are shorter than those undergoing a free flap reconstruction, with shorter intensive care stay [6,13]. Consequently, in Italy, free flap reconstructions can result more expensive than pedicled flap reconstructions [6,26,27] and pedicled flaps, in selected cases, even seem to be preferable over free flaps [10,27,28].

In a matched paired analysis comparing 40 oral cavity/oropharyngeal reconstructions with free radial forearm flap with 40 patients receiving the pectoralis major flap for similar defects, de Bree et al. [29] found shorter admission times and lower treatment costs in the free flap group. Nevertheless, the pectoralis major flap can produce some healing delay for frequent necrosis of the most distal edge of the skin paddle; this usually doesn't require further interventions, but it does increase hospital stay and costs. In fact, where conservative transmandibular approaches are employed, the bulkiness of the pectoralis major flap produces less than ideal functional outcomes, because the mandible presses upon the flap favoring hypovascularization and necrosis of the distal portion, and because the thickness and bulkiness of the flap hinders the motility of the preserved structures.

Differing from the majority of pedicled myocutaneous flaps for head and neck reconstruction, the infrahyoid flap is thin and pliable and this intrinsic characteristic carries an advantage in terms of functional results, making this flap even competing with fasciocutaneous free flaps in the management of medium sized defects of the floor of mouth, alveolar ridge,

and base of tongue. For these sites the infrahyoid flap produces particularly high-quality functional results, the pliable skin paddle is placed and sutured all around the mucosal defect allowing a good mobility of the surrounding structures, and the infrahyoid muscles fill the deep tissue loss coming from resections carried en block with neck dissection, restoring a separation between different compartments created by tumor resection. In case of marginal mandibulectomy, the flap's muscles cover the denuded mandibular bony surface; moreover, the oval/rectangular shape of the infrahyoid flap perfectly matches the usual shape of the resections in these cases. Excellent functional results are also obtained for base of tongue reconstructions [30,31], especially if the flap is not detached from the hyoid bone, using the personal technique described in Chapter 5 of this thesis [13].

The infrahyoid flap is a quick, easy, and reliable reconstructive method, when specific contra-indications are respected and when used with knowledge of its clinical utility and limitations, the functional results are excellent with great patient's satisfaction; therefore, this overlooked reconstructive method should enter in the toolbox of the modern head and neck surgeon.

The advantages of IHF may be summarized as [32]:
- excellent reliability, and low complication rate;
- the donor site is near the defect, 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 primarily closed;
- high pliability, the paddle is thin and flexible not impairing the movements of the preserved oral-oropharyngeal structures, and when the ansa cervicalis is intentionally not included in the pedicle its pliability will increase overtime as direct consequence of the atrophy of the muscular portion of the flap;
- the inclusion of the ansa cervicalis in the pedicle, which prevents atrophy of the muscular portion of the flap, guarantees a consistent neo-tongue bulk overtime in case of oral/base of tongue reconstruction;
- the paddle allows good coverage of the defect without excessive volume;
- the flap is quickly harvested during the neck dissection by the same surgical team;
- postoperative immobilization of the patient is not required;
- the flap dissection does not require microsurgical expertise and vigilant monitoring; as free flaps do.

Disadvantages of IHF mainly coincide with its contraindications: previous thyroid surgery or neck dissection, N3 neck metastasis, and positive lymph nodes at level III–IV. All these contraindications pose consistent limitations to the use of this reconstructive option. The IHF must always be planned in advance and cannot represent a back-up solution in case of other flap failure, since it cannot be used in a previously operated neck. In fact, probable damages to the superior thyroid artery and/or vein and/or possible elevation of the skin overlying the strap muscles prevent the possibility to rely on this myocutaneous flap.

Nowadays surgical techniques are evolving towards the maximization of the possibility to obtain adequate tumor resection through the natural cavities, avoiding the surgical division of healthy structures in order to gain appropriate exposure [33-35]. This entails the development of sophisticated surgical tools at the service of a simple philosophy: the possibility to obtain a sound oncologic resection through natural cavities. Since oral cancer is already mostly addressed transorally, this shift will particularly impact the surgical treatment of pharyngeal cancer. Surgical cancer resection therefore is becoming less and less invasive with proportional fewer demands for reconstruction. In fact, one of the major indications for reconstructive surgery in the head and neck district is the need of restoring a separation between different compartments that were put in communication to facilitate tumor resection. This specific indication vanishes or is highly restrained when advanced endoscopic or robotic resections are applied through the upper aerodigestive natural cavities, because in most of these cases healing for secondary intention can effectively resurface the defect without the need of transposing a flap. Therefore, the shift of ablative head and neck surgery away from aggressive demolitions in favor of minimally invasive approaches will probably reshape also the indications for reconstructive surgery.

In general, transoral robotic resection applies for small/medium sized oropharyngeal cancers, the resulting defect is usually left to heal by secondary intention, nevertheless it is well known that postoperative bleeding is a recognized threatening complication of transoral robotic procedures [36]. The degree of vascularity can vary significantly among patients as well as the proximity of the tumor to larger vessels supplying the oropharynx. In this light an easily harvestable flap, brought to fill the defect with the aim of protecting major vessels from the erosive action of the saliva, could play an important role enhancing safe healing and preventing excessive scar tissue formation. This opens a perspective for the diffusion of the infrahyoid flap in combination with transoral robotic surgery.

Recently Perrenot et al. [37] published a series of 8 patients who underwent transoral robotic surgery for oropharyngeal squamous cell carcinomas associated with immediate reconstruction using the infrahyoid myocutaneous flap. After tumor resection and neck dissection the flap was harvested and transposed into the oropharynx in a minimally invasive way and sutured either completely or partially with the robotic instrumentation.

Currently head and neck reconstruction is mostly performed using flaps, in the near future bioengineered materials will certainly play an important role in surgery [38].

One of the most exciting areas of surgical nanotechnology is that of nerve repair, reconnecting nerves can be extremely difficult; primary repair of severed axons has not been successful traditionally due to practical difficulties of operating on a subcellular level. Surgical tumor resection removes voluntary dynamic and sensate structures, which are replaced by static flaps impairing the possibility of restoring a full functional integrity. Nanomaterials showed

a potential ability to guide organization and formation of new tissues for reinnervation on a nanoscale, serving as a temporary scaffold mimicking cellular characteristics to promote axon repair [39].

Nanotechnology will undoubtedly lead to advancements in the art and science of head and neck reconstructive surgery, and the availability of bioengineered tissues might render the harvest of an autologous free flap something that belongs to the past, in favor of patient-compatible tissues, even vascularized, created in the laboratory. The future is exciting, although much research is, however, needed to fine-tune and perfect these materials to tailor them to clinical needs.

The constant human progress and technical evolution will open new perspectives for cancer treatment and surgical oncology, it will be our duty to walk the path of progress with enthusiasm but without completely leaving behind useful tools that belong to the past, but that in the future could still represent a valid option in selected cases. And this is probably the point where the infrahyoid flap stands today in the modern free flap era.

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CHAPTER 9

Summary

The aim of this thesis is to define the role of head and neck reconstruction with the infrahyoid flap in the era of free flaps.

The thesis is structured in 9 chapters, **chapter 1** displays a general introduction on head and neck squamous cell carcinoma, with a brief overview on the peculiar characteristics of this cancer and its surgical treatment, announcing the reasons why the role of infrahyoid flap will be investigated throughout the following chapters of the thesis.

In **chapter 2** some general aspects of the decision making process when choosing between a free flap and an alternative pedicled flap reconstruction are addressed. The overall superiority of microvascular reconstructions in terms of restoration of form and function is not a matter of argument; nevertheless, in the philosophy of a tailored surgical approached based on specific patient's conditions, this chapter underlines the helpfulness of alternative pedicled flaps even in modern head and neck reconstructive surgery.

Chapter 3 is a comprehensive review of all published papers about the infrahyoid flap, highlighting the usefulness of this reconstructive method and the particular scenarios in which it can even compete with free flaps. Contrasting with the most popular myocutaneous pedicled flaps for head and neck reconstruction (pectoralis major, latissimus dorsi, trapezius), the infrahyoid flap is thin and pliable and this characteristic makes it very suitable for effective repair of small/medium sized defects of the oral cavity and the oropharynx, combining the same functional results that would be provided by pliable fasciocutaneous free flaps with the simplicity and ease of a pedicled flap surgery.

Chapter 4 shows how the infrahyoid flap can represent a valid alternative to the free radial forearm flap in head and neck reconstructions. In a series of 13 patients, 12 squamous cell carcinomas arising from the oral cavity and oropharynx and 1 Merkel cell carcinoma of the submental skin, reconstruction with the infrahyoid flap was used as an alternative to free radial forearm flap. A new personal technical change was introduced in the harvesting of these flaps and proved to be successful, so creating the new infrahyoid facio-myocutaneous flap; all reconstructions healed quickly without wound complications and with good functional results, all donor sites were closed primarily with good aesthetic results.

Chapter 5 highlights how this flap is particularly trustful in fragile patients. In a series of 34 consecutive oral cavity and oropharyngeal reconstructions after squamous cell carcinoma resection, healing and functional results of 18 patients in poor general conditions, unfit for a microvascular procedure and therefore receiving infrahyoid flap reconstruction, were as good as those of the 16 patients in good general conditions receiving microvascular free radial forearm flap transposition: in this paper a new personal technique for base of tongue reconstruction using the infrahyoid flap was described.

Chapter 6 shows the reliability of the infrahyoid flap for soft palate reconstructions as alternative to free radial forearm flap or maxillofacial prosthesis. In a series of 23 consecutive patients with squamous cell carcinoma involving the oropharynx, reconstruction of defects encompassing a soft palate resection not extending beyond the midline was achieved with the infrahyoid flap. Every reconstruction healed quickly without major wound complications; the functional results evaluated by speech and swallowing capacities were good for 17 patients, fair for 4 patients and bad for 2.

Chapter 7 demonstrates how the infrahyoid flap produces a savings reducing healthcare costs in times of increasing economic constraints. Fifty-four consecutive patients underwent soft tissue reconstruction of oral cavity and oropharyngeal defects. The cohort included 16 patients in good general conditions that received free radial forearm flap reconstruction; 18 high-risk patients that received a reconstruction with infrahyoid flap; 20 patients that received temporal flap (10 cases) or pectoral flap (10 cases) reconstruction. Pedicled alternative flaps were used in elderly, unfavorable, and weak patients, where usually the medical costs tend to rise rather than decrease. The health care costs of the three groups were compared, calculating real costs in each group from review of medical records, and operating room registers, and calculating the corresponding DRG-system reimbursement. A statistically significant difference among groups was found, the analysis showed that the use of alternative not-microvascular techniques, in high-risk patients, was functionally and oncologically sound, and produced a saving. In particular, the infrahyoid flap ensured excellent functional results, accompanied by the best economic performance in the worst group of patients. The data reflected also a huge disconnection between the DRG reimbursement system and real treatment costs.

Chapter 8 contains a discussion on the clinical aspects that might overburden a microvascular reconstructive procedure, justifying the consideration of proposing an alternative pedicled flap reconstruction instead. The specific advantages of the infrahyoid flap are displayed and in this light its possible use in combination of transoral robotic surgical resection for oropharyngeal tumors is presented and discussed as future perspective.

Chapter 9 contains the summary of the thesis in English, Italian and Dutch.

Lo scopo di questa tesi è quello di definire il ruolo del lembo infrajoideo per le ricostruzioni del distretto testa collo nell'era dei lembi liberi.

La tesi è strutturata in 9 capitoli, il ***capitolo 1*** *presenta una introduzione generale sul carcinoma squamoso del distretto testa collo, con una breve panoramica sulle caratteristiche peculiari di questo tipo di tumore e del suo trattamento chirurgico, annunciando le ragioni per le quali verrà studiato il ruolo del lembo infrajoideo nei successivi capitoli della tesi.*

Nel ***capitolo 2*** *vengono affrontati alcuni aspetti generali del processo decisionale nella scelta tra un lembo libero e una ricostruzione alternativa mediante un lembo peduncolato. La superiorità complessiva delle ricostruzioni microvascolari in termini di ripristino morfologico e funzionale rimane un punto fermo; tuttavia, nella filosofia di un approccio chirurgico personalizzato in base alle condizioni specifiche del paziente, questo capitolo sottolinea l'utilità dei lembi peduncolati alternativi anche nella moderna chirurgia ricostruttiva del distretto testa collo.*

Il ***capitolo 3*** *è una rassegna completa di tutti gli articoli pubblicati sul lembo infrajoideo, che mette in evidenza l'utilità di questo metodo ricostruttivo e gli scenari particolari in cui esso può anche competere con i lembi liberi. A differenza dei lembi peduncolati miocutanei più utilizzati per le ricostruzioni del distretto testa collo (gran pettorale, gran dorsale, trapezio), il lembo infrajoideo è sottile e flessibile e questa caratteristica lo rende molto adatto per una efficace riparazione di difetti della cavità orale e dell'orofaringe di piccole e medie dimensioni, sommando gli stessi risultati funzionali che sarebbero stati forniti da lembi liberi fasciocutanei con la semplicità e la facilità di un intervento chirurgico con lembo peduncolato.*

Il ***capitolo 4*** *mostra come il lembo infrajoideo possa rappresentare una valida alternativa al lembo libero di avambraccio nelle ricostruzioni del testa collo. In una serie di 13 pazienti, 12 carcinomi squamosi del cavo orale e dell'orofaringe e 1 carcinoma a cellule di Merkel della cute sottomentoniera, la ricostruzione con lembo infrajoideo è stata utilizzata come alternativa al lembo libero di avambraccio. Nell'allestimento di questi lembi è stata introdotta una nuova variante tecnica che ha dimostrato di essere efficace, creando il nuovo lembo infrajoideo fascio-miocutaneo; tutte le ricostruzioni sono guarite rapidamente senza complicazioni della ferita e con buoni risultati funzionali, tutti i siti donatori sono stati chiusi mediante sutura diretta con buoni risultati estetici.*

Il ***capitolo 5*** *mette in evidenza come questo lembo sia particolarmente affidabile nei pazienti fragili. In una serie di 34 ricostruzioni consecutive dopo resezione di carcinomi squamosi del cavo orale e dell'orofaringe, la guarigione e risultati funzionali dei 18 pazienti in cattive condizioni generali, non adatti ad una ricostruzione microvascolare che avevano ricevuto un lembo infrajoideo, sono stati altrettanto buoni rispetto a quelli dei 16 pazienti in buone condizioni generali che avevano avuto una ricostruzione con lembo libero di avambraccio: in questo articolo*

è stata descritta una nuova tecnica personale per ricostruzione della base lingua utilizzando il lembo infrajoideo.
*Il **capitolo 6** espone l'affidabilità del lembo infrajoideo per le ricostruzioni del palato molle, in alternativa al lembo libero di avambraccio oppure all'utilizzo di protesi maxillo-facciale. In una serie di 23 pazienti consecutivi con carcinoma a cellule squamose a partenza orofaringea, la ricostruzione di difetti che comprendevano una resezione del palato molle che non si estendeva oltre la linea mediana è stata effettuata con il lembo infrajoideo. Ogni ricostruzione è guarita rapidamente senza complicazioni della ferita; i risultati funzionali valutati per la capacità del linguaggio e della deglutizione sono stati buoni per 17 pazienti, soddisfacenti per 4 pazienti e scarsi per 2.*

*Il **capitolo 7** dimostra come il lembo infrajoideo produca un risparmio riducendo i costi sanitari, in tempi di crescenti vincoli economici. I costi sanitari sono stati calcolati in 54 pazienti consecutivi sottoposti a ricostruzione di difetti dei tessuti molli del cavo orale e dell'orofaringe. La coorte comprendeva 16 pazienti in buone condizioni generali che hanno ricevuto una ricostruzione con lembo libero di avambraccio; 18 pazienti ad alto rischio che hanno ricevuto una ricostruzione con lembo infrajoideo; 20 pazienti che hanno ricevuto lembo temporale (10 casi) o lembo pettorale (10 casi). I lembi peduncolati alternativi sono stati utilizzati in pazienti fragili, anziani e con condizioni anatomiche sfavorevoli, dove di solito le spese mediche tendono ad aumentare, piuttosto che diminuire. I costi sanitari dei tre gruppi sono stati confrontati calcolando i costi reali in ogni gruppo desunti delle cartelle cliniche e dai registri di sala operatoria, e calcolando il corrispondente rimborso dal sistema DRG. Le differenze tra i gruppi sono risultate statisticamente significative, l'analisi ha mostrato che l'uso di tecniche ricostruttive alternative non microvascolari, in pazienti ad alto rischio, era appropriato ed oncologicamente efficace, e inoltre ha prodotto un risparmio. In particolare, il lembo infrajoideo ha garantito ottimi risultati funzionali, accompagnati dai migliori risultati economici nel peggior gruppo di pazienti. I dati riflettono anche un enorme scollamento tra il sistema di rimborso DRG e costi reali di trattamento.*

*Il **capitolo 8** contiene una discussione sugli aspetti clinici che potrebbero complicare una procedura ricostruttiva microvascolare, giustificando quindi l'appropriatezza nel proporre una ricostruzione alternativa mediante lembo peduncolato. I vantaggi specifici del lembo infrajoideo vengono elencati in questo capitolo e, nell'ottica di un nuovo ambito di impiego in prospettiva futura, le ragioni per il suo possibile utilizzo in combinazione a resezioni chirurgiche transorali robotiche per i tumori orofaringei viene discussa nel capitolo.*

*Il **capitolo 9** contiene la sintesi della tesi di dottorato in inglese, italiano e olandese.*

Het doel van dit proefschrift is om de rol van de infrahyoidale lap opnieuw te bepalen in het tijdperk van vrije gevasculariseerde lappen. Het proefschrift is opgebouwd uit 9 hoofdstukken.

***Hoofdstuk 1** geeft een algemene inleiding over het plaveiselcelcarcinoom in het hoofd-halsgebied met een kort overzicht van de kenmerken van deze vorm van kanker en de chirurgische behandeling hiervan. Tevens wordt uiteen gezet waarom de rol van de infrahyoidale lap wordt onderzocht in de volgende hoofdstukken.*

*In **hoofdstuk 2** worden de algemene aspecten in het besluitvormingsproces bij de keuze tussen een reconstructie met een vrij gevasculariseerde lap en een gesteelde lap besproken. De superioriteit van reconstructies met vrije lappen wat betreft herstel van vorm en functie wordt niet in twijfel getrokken. Echter in het kader van een op maat gemaakte geïndividualiseerde behandeling waarbij ook patiëntfactoren worden meegenomen lijken gesteelde lappen waardevol te zijn, zelfs in de moderne reconstructieve chirurgie van het hoofd-halsgebied.*

***Hoofdstuk 3** is een uitgebreid overzicht van alle gepubliceerde artikelen over de infrahyoidale lap met aandacht voor de bruikbaarheid van deze reconstructieve techniek en de specifieke scenario's waarin deze zelfs met vrije lappen kan concurreren. In vergelijking met de meest gebruikte myocutane gesteelde lappen voor reconstructies in het hoofd-halsgebied (de grote borstspier- (pectoralis major), brede rugspier-, monnikskapspierlap) is de infrahyoidale lap dun en plooibaar. Hiermee is deze lap uitermate geschikt voor reconstructie van kleine tot middelgrote defecten van de mondholte en de orofarynx, waarbij deze dezelfde functionele resultaten als fasciocutane vrije lappen combineert met de eenvoud en het gemak van een reconstructie met een gesteelde lap.*

***Hoofdstuk 4** toont dat de infrahyoidale lap een waar alternatief is voor de vrije radialis onderarms lap bij reconstructies in het hoofd-halsgebied. Bij 13 patiënten, 12 met een plaveiselcelcarcinoom van de mondholte of orofarynx en 1 met een Merkelcelcarcinoom van de submentale huid, werd de infrahyoidale lap gebruikt als alternatief voor de vrije radialis onderarmslap. Een nieuwe gemodificeerde (zelf ontworpen) techniek voor het oogsten van deze lap werd geïntroduceerd in de klinische praktijk. Deze nieuwe infrahyoidale fascio-myocutane lap bleek succesvol te zijn: alle reconstructies bleken snel te genezen, zonder wondcomplicaties en met goede functionele resultaten. Alle donorlocaties konden primair worden gesloten met een goed esthetisch resultaat.*

*In **hoofdstuk 5** wordt getoond hoe deze lap ook bijzonder betrouwbaar is bij fragiele patiënten. De resultaten van reconstructies middels een infrahyoidale lap bij 18 patiënten met een slechte algemene conditie en daardoor niet geschikt voor een microvasculaire vrije lap procedure, bleken even goed te zijn als die van reconstructies met een vrije radialis onderarmslap bij 18 patiënten met een goede algemene conditie. In dit hoofdstuk wordt tevens een nieuwe techniek voor de reconstructie van de tongbasis met de infrahyoidale lap beschreven.*
***Hoofdstuk 6** toont de betrouwbaarheid van de infrahyoidale lap voor reconstructies van het zachte verhemelte als alternatief voor een vrije radialis onderarmslap reconstructie of maxillofaciale*

prothese. In een serie van 23 opeenvolgende patiënten met een defect van het zachte verhemelte zonder overschrijding van de mediaanlijn na resectie van een plaveiselcelcarcinoom van de orofarynx was wondgenezing voorspoedig zonder grote complicaties. De functionele resultaten voor wat betreft spreken en slikken waren goed bij 17 patiënten, redelijk bij 4 patiënten en slecht bij 2 patiënten.

*In **hoofdstuk 7** wordt getoond hoe het gebruik van een infrahyoidale lap in tijden van toenemende economische beperkingen tot een kostenbesparing kan leiden. Vierenvijftig patiënten ondergingen verschillende reconstructie van weke delen in de mondholte of orofarynx: 1) vrije radialis onderarmslap reconstructie bij 16 patiënten met een goed algemene conditie, 2) infrahyoidale lap reconstructie bij 18 patiënten met een hoog risico, en 3) temporalis lap en pectoralis major lap bij ieder 10 patiënten. De gesteelde lappen werden gebruikt bij oudere en zwakkere patiënten, waarbij de medische kosten doorgaans hoger zijn. De kosten voor de gezondheidszorg werden vergeleken tussen de drie groepen waarbij de daadwerkelijke kosten werden bepaald door gebruik te maken van de medische statussen en registraties op de operatiekamers. Tevens werden deze kosten vergeleken met de vergoeding die via het DRG-systeem verkregen wordt. Het gebruik van niet-microvasculaire technieken bij patiënten was kosteneffectief, zelfs wanneer de gesteelde lappen worden toegepast bij patiënten met een hoog-risico en de vrije lappen bij patiënten met een goed algemene conditie. Een grote discrepantie tussen de gemaakte kosten en de vergoeding voor de behandeling van deze patiënten werd gevonden.*

***Hoofdstuk 8** bevat een discussie over de klinische aspecten en beperkingen van microvasculaire vrije lappen en gesteelde lappen als alternatief. De specifieke voordelen van de infrahyoidale lap worden besproken, evenals de toepassing bij robotchirurgie.*

*In **hoofdstuk 9** staat de samenvatting van het proefschrift in het Engels, Italiaans en Nederlands.*

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Curriculum Vitae

Prof. dr. Alberto Deganello was born in Conselve, 10 January 1973. In 1997 he received his MD degree at the University of Padua, Italy, and in 2001 he completed a 4 years' residency program in Otolaryngology at the Otolaryngology Clinic of the University of Padua. In February 2004 after the completion of a 2 years' official fellowship program in Head and Neck Oncologic Surgery at the VU Medical Center, Amsterdam, he received the title of Head and Neck Oncologic Surgeon. From 2004 to 2006 he worked as Head and Neck Surgeon at the VU Medical Center – The Netherlands, at "San Giacomo Apostolo" Hospital in Castelfranco Veneto, at the National Cancer Institute "Regina Elena" in Rome – Italy. From 2006 to present, working at the "Careggi" University Hospital in Florence – Italy. In 2010 he was appointed Assistant Professor in Otolaryngology at the University of Florence, in 2011 he completed a PhD graduation at the University of Florence, and in 2015 he was appointed Associate Professor in Otolaryngology. His clinical and research activities are mainly focused on head and neck oncology, head and neck surgery and head and neck reconstructive surgery.

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