Eur Arch Otorhinolaryngol (2008) 265:85–95
DOI 10.1007/s00405-007-0410-1

HEAD AND NECK

Head and neck reconstruction with free flaps: a report on 213 cases

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Received: 12 April 2007 / Accepted: 17 July 2007 / Published online: 10 August 2007

Abstract The aim of this retrospective study is to review the experience of our institution in performing microvascular head and neck reconstruction between 2000 and 2004. During this period, 213 free flaps, including 146 radial forearm free flaps, 60 fibular flaps and 7 scapular flaps, were performed. Free flap success rate and complications were reported. The pre-treatment factors influencing these results were subsequently analyzed. Functional and aesthetic outcomes were evaluated by the same clinician. There were 14 free flap failures, giving an overall free flap success rate of 93.4%. Salvage surgery for recurrent cancer was the only factor correlated with a higher risk of free flap failure ($P = 0.0004$). The local complication rate was 20.9%. High level of comorbidity ($P = 0.009$), salvage surgery for recurrent cancer ($P = 0.03$) and hypopharyngeal surgery ($P = 0.002$) were associated with a higher risk of local complications. An unrestricted oral diet and an intelligible speech were recovered by respectively 76 and 88% of the patients. Microvascular free flaps represent an essential and reliable technique for head neck reconstruction and allow satisfactory functional results.

Keywords Microsurgery · Reconstructive surgical procedures · Head and neck neoplasms · Postoperative complications · Risk factors

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Introduction

Head and neck reconstructive procedures are still considered to be a surgical challenge. The development of pedicled myocutaneous flaps in the 1960s represented an important advance in head and neck reconstruction. Principally, the pectoralis major myocutaneous flap has considerably decreased complications of head and neck cancer surgery, particularly in irradiated patients, and has been used worldwide [60, 72]. The complexity of the anatomy and function of this region explains the disappointing functional and aesthetic results obtained with conventional myocutaneous flaps. The ability of free flaps to transfer a large panel of tissue containing skin, mucosa, muscle or well-vascularized bone has allowed considerable progress and refinement of this type of reconstruction, with a higher level of rehabilitation for the patients [18, 29, 69]. Thus, head and neck reconstruction using free tissue transfers has become more and more popular over the past 20 years.

We have used free flaps for head and neck reconstruction since 1992 with more than 350 free flap procedures having been performed to date. This type of reconstruction has been used more frequently since 2000 and we decided, in this study, to focus primarily on these recent free flap reconstructions. The aim of this retrospective study is to review the experience of our institution in head and neck reconstruction involving 213 free flap procedures performed between 2000 and 2004.

Patients and methods

This study is a retrospective review of the medical records of 201 consecutive patients who underwent head and neck free flap reconstruction between January 2000 and December

2004. A total of 213 free flaps (2 separate free flaps were used for 12 patients) were performed to reconstruct different types of defect. These 201 patients ranged in age from 29 to 89 years (mean age, 60.1 years); 150 were men (74.6%) and 51 women (25.4%). Primary reconstruction (reconstruction performed at the time of the ablative surgery) was performed in 197 cases and secondary reconstruction in 4 cases. For primary reconstructions, the initial disease leading to ablative surgery was a malignant tumor in 181 patients (91.9%) including 171 cases of squamous cell carcinoma (SCC) of the upper aerodigestive tract. In these cases of primary reconstruction, the initial disease of the patients ($n = 197$) is given in Table 1. Patients with SCC of the upper aerodigestive tract had a primary cancer (untreated tumor) in 135 cases (78.9%) and a recurrent cancer in 36 cases (21.1%). For the primary cancers, 101 patients (74.8%) had T3 or T4 disease (UICC 2003) and 54 patients (40%) had clinically positive lymph nodes (15 N1, 9 N2a, 18 N2b, 10 N2c and 2 N3). Patient comorbidity was determined using the Kaplan Feinstein Index (KFI) [33]. Ninety-two patients (45.8%) had a low level of comorbidity (KFI = 0 or 1) and 109 patients (54.2%) had a high level of comorbidity (KFI = 2 or 3). The characteristics of the 201 patients included in this study are presented in Table 2.

For the 197 primary reconstructions, the ablative surgery was classified into 4 types of procedures: oral or oropharyngeal surgery without mandibulectomy (type 1, $n = 97$), oral or oropharyngeal surgery with mandibulectomy (type 2, $n = 67$), circular pharyngectomy or circular total pharyngolaryngectomy (type 3, $n = 24$), skin or orbital surgery (type 4, $n = 9$). A tracheotomy was systematically performed after surgery of type 1 or 2. Enteral nutrition (nasogastric tube or gastrostomy) was established after type 1, 2 or 3 surgery. The surgical defect involved different anatomical structures including mucosa, bone and skin. When these three types of tissue were included in the surgical defect, the defect was considered to be through and through. The bone defect was defined with the "HCL classification" as described by Jewer et al. [30]. The exact nature of the surgical defects is shown in Table 3.

Table 1 Initial diseases leading to ablative surgery for primary reconstructions ($n = 197$)

Initial disease	Number of cases	Rate (%)
Malignant tumor	181	91.9
SCC of the upper aerodigestive tract	171	86.8
Epithelial cutaneous cancer	7	3.6
Others	3	1.5
Non-malignant disease	16	8.1
Radionecrosis	8	4.1
Ameloblastoma	5	2.5
Others	3	1.5

Table 2 Characteristics of the 201 patients

Patient characteristics	Number of cases	Rate (%)
Sex		
Male	150	74.6
Female	51	25.4
Age		
<70 years	152	75.6
>70 years	49	24.4
Comorbidity		
Low (KFI < 2)	92	45.8
High (KFI ≥ 2)	109	54.2
Previous radiotherapy		
No	139	69.2
Yes	62	30.8
Tumor status[a]		
Primary cancer	135	79.0
Recurrent cancer	36	21.0
T stage[b]		
T1 or T2	34	25.2
T3 or T4	101	74.8
N stage[b]		
N0	81	60.0
N1, 2 or 3	54	40.0
Tumor localisation[b]		
Oral cavity or oropharynx	120	88.9
Hypopharynx	15	11.1

[a] For the 171 patients with a SCC of the upper aerodigestive tract

[b] For the 135 patients with a primary (untreated) SCC of the upper aerodigestive tract

Various free flaps were used during this period to repair different types of defects, including radial forearm fasciocutaneous flaps, fibular osseous or osteocutaneous flaps and scapular osseous or osteocutaneous flaps. Fibular flaps were used as osseous flaps in 4 cases and as osteocutaneous flaps in 56 cases. Scapular flaps were used as osseous flaps in 1 case and as osteocutaneous flaps in 6 cases. For 12 patients, reconstruction was performed with a combination of 2 separate free flaps, 1 flap provided vascularized bone and the other soft tissue for the external or internal lining. All flaps were revascularized using two separate pedicles. The type of free flap used in this series is shown in Table 4. A pectoralis major muscular or myocutaneous flap was used in conjunction with a radial forearm free flap in 14 cases and with a fibular free flap in 4 cases.

Free flap harvest was performed at the time of the ablative procedure, employing a two-team approach, except for the scapular flap, which was harvested in the lateral decubitus position. The flap remained vascularized by its pedicle

Table 3 Type of surgical defect for the 201 patients

	Number of cases	Rate (%)
Defect type[a]		
Bone alone	12	6.0
Mucosa alone	122	60.6
Skin or orbital tissues alone	12	6.0
Bone + mucosa	43	21.4
Bone + skin	1	0.5
Bone + mucosa + skin	11	5.5
Type of bone defect[b]		
C	8	11.9
L	12	17.9
H	17	25.4
LC	18	26.9
LCL	9	13.4
HC	3	4.5

[a] For the 201 patients

[b] For the 67 patients with a mandibular defect (ablative surgery—type 2), classification of Jewer et al. [7]: *type C* central defect, *type L* lateral defect, *type H* lateral defect including the condyle

Table 4 Type of free flap used for the 201 patients

Type of free flap	Number of cases	Rate (%)
Radial forearm flap	134	66.6
Fibular flap	49	24.4
Scapular flap	6	3.0
Two separate free flaps	12	6.0
Fibular flap + radial forearm flap	11	–
Scapular flap + radial forearm flap	1	–

until transfer to the head and neck area to limit the duration of flap ischemia. It was generally fixed in its definitive position before performing the microvascular anastomoses to prevent traction on the vascular pedicle. The cutaneous skin paddle of the radial forearm flap or osteocutaneous flap was sutured to the soft tissue defect. The bone transplant was shaped to restore the contours of the mandibular defect using preoperative imaging studies (panoramic radiograph and computed tomographic scan) and the resection specimen. Symphysis mandibular reconstruction usually needs two osteotomies and lateral mandibular reconstruction one osteotomy of the bone transplant. The different bone fragments were fixed to the mandible using titanium miniplates and monocortical screws. Microvascular anastomoses were performed with an operative microscope and polypropylene sutures (Prolene 9.0 or 10.0). The recipient vessels were identified and divided during cervical lymphadenectomy when indicated or after the ablative surgery by a distinct cervicotomy. The recipient vessels used for microvascular anastomoses are shown in Table 5.

Table 5 The recipient vessels used for microvascular anastomoses of 213 free flaps

Type of vessels	Number of cases	Rate (%)
Recipient artery		
Superior thyroid artery	114	53.5
Facial artery	59	27.7
Lingual artery	15	7.0
External carotid artery[a]	8	3.8
Transverse cervical artery	6	2.8
Other artery	11	5.2
Recipient vein[b]		
A collateral branch of the internal jugular vein	124	58.2
External jugular vein	61	28.6
Internal jugular vein[c]	16	7.5
Transverse cervical vein	3	1.4
Other vein	9	4.3

[a] End-to-side suture in three of the eight cases

[b] The first vein used in the cases (25 flaps) where 2 venous anastomoses were performed

[c] End-to-side suture in all the cases

Patients were kept in a postoperative care unit during approximately 1 week with a nursing staff highly trained to this type of surgery. The flap was carefully monitored by clinical examination for the flaps with an accessible skin paddle. Suspicion of flap ischemia led to an immediate return to the operating theater to control the patency of the anastomoses. Anticoagulation treatment with low molecular weight heparin following a deep vein thrombosis preventive protocol was systematically given in the postoperative period.

The following report is a retrospective review of the experience of one microvascular surgeon (O. Dassonville) in 201 head and neck reconstruction procedures involving 213 free flaps performed between January 2000 and December 2004. We have analyzed the rate of free flap success and complications, the length of stay, and the factors influencing these results for the following: age, sex, comorbidity, recurrent cancer, preoperative irradiation, tumor stage and site, type of defect, type of free flap. Statistical analyses were performed using the Chi-square test. All tests were performed with the R.1.7.1 software for Windows, with a significant threshold of 5% (bilateral hypothesis).

Functional and aesthetic results were evaluated for the 171 patients with a SCC of the upper aerodigestive tract by the same clinician. The following data were recorded for all patients: quality of oral diet, speech intelligibility, mouth opening and aesthetic outcome. Results were scored from 0 to 2, as follows:

Oral diet:

- 2 normal,
- 1 moderately impaired, restricted diet, soft diet,
- 0 severely impaired or impossible, requiring maintenance of an enteral feeding tube,

Speech intelligibility:

- 2 normal, easily intelligible,
- 1 moderately altered, intelligible with effort,
- 0 severely altered or impossible, patient unintelligible for the listener,

Mouth opening:

- 2 normal, greater than two fingerbreadths,
- 1 moderately limited, between 1 and 2 fingerbreadths,
- 0 severely limited, less than one fingerbreadth,

Aesthetic outcome:

- 2 good,
- 1 acceptable: moderate deformations, depressions or disalignment
- 0 poor: severe disfigurement, major deformations, depressions or disaligment that immediately attract one's attention.

The presented outcomes correspond to the results reported at the last follow-up visit for patients who were still alive and disease free at the end of the study (September 2006), and to the results noted at the last follow-up visit prior to recurrence or death for patients who presented a relapse of the tumor or died before the end of the study.

Results

Of the 213 free flaps performed for head and neck reconstruction, 199 were successful, with an overall success rate of 93.4%. There were 14 free flap failures (total flap necrosis), including 7 radial forearm flaps and 7 fibular flaps. Hence, the free flap success rates for radial forearm flap, fibular flap and scapular flap were, respectively, 95.2, 88.3 and 100%. The success rate of vascularized bone grafts (fibular and scapular flaps) was 89.6%. In the group of 12 patients repaired with a combination of 2 free flaps, there were 4 free flap necroses, giving a success rate for these complex reconstructions of 83.3%. The difference between the osseous and the non-osseous free flap success rates was not statistically significant ($P = 0.11$).

Of the 213 free flaps, 32 (15.0%) required a return to the operating theater to control the patency of the vascular anastomoses, including 20 radial forearm flaps, 9 fibular flaps and 3 scapular flaps. An arterial thrombosis was discovered in 14 flaps, a venous thrombosis in 10 flaps, an arteriovenous thrombosis in 2 flaps and good patency of the anastomoses in 2 flaps. A total of 21 flaps were salvaged, including 15 radial forearm flaps, 3 fibular flaps and 3 scapular flaps, giving an overall successful salvage rate of 63.6%. The successful salvage rates for radial forearm flaps, fibular flaps and scapular flaps were, respectively, 75, 16.7 and 100%.

Among the radial forearm flaps, there were 4 cases (2.8%) of partial flap necrosis (<20% of the flap), which did not require another flap or another surgical procedure. Partial necrosis of the soft tissue component of the vascularized bone free flaps occurred in 3 cases (4.5%).

All the cases of free flap failure occurred in the group of patients with SCC of the upper aerodigestive tract. Among these 171 patients, salvage surgery for recurrent cancer was the only factor that has been shown to significantly decrease the free flap success rate (univariate analysis: $P = 0.0004$; multivariate analysis: $P = 0.004$). The influence of the other studied factors on free flap success is shown in Table 6.

After radial forearm free flap failure, a pectoralis major myocutaneous flap was used alone in 4 cases and in association with another radial forearm fasciocutaneous flap in two cases in order to reconstruct the soft tissue defect. Two cases of fibular free flap necrosis were subsequently repaired successfully using another fibular free flap.

The operative time was 4–14 h, with a median duration of 8 h. The median length of hospital stay was 22 days (7–165 days) and was longer for osseous free flaps than for non-osseous flaps (28 vs. 21 days, $P = 0.003$). None of the previous studied factors was related to the length of hospital stay. Decanulation was performed after a median period of 10 days and the nasogastric feeding tube was removed after a median period of 15 days.

Surgical complications at the recipient site occurred in 42 patients, giving a local complication rate of 20.9%. Several local complications appeared in the same patient. The most common complication was infection, which occurred in 21 cases and was related to salivary fistulas in 16 cases. Among these fistulas, 3 were due to free flap failure. Particularly, after circular total pharyngolaryngectomy (24 cases), there were 11 salivary fistulas, which were linked to free flap failure (radial forearm flap) in 2 cases, giving a fistula rate of 45.8%. Neck hematoma requiring surgical drainage occurred in 16 cases. Furthermore, there were 7 cases of delayed wound healing and 3 cases of osteosynthesis plate exposure. In the group of patients with SCC of the upper aerodigestive tract, patient comorbidity (KFI ≥ 2; $P = 0.015$), salvage surgery for recurrent cancer ($P = 0.03$) and tumor site (hypopharynx; $P = 0.004$) were correlated with a higher risk of recipient site complications in an univariate analysis (Table 7). Multivariate analysis confirmed the influence of patient comorbidity (KFI; $P = 0.017$) and

Table 6 Role of the different studied factors on the free flap success rate among the 171 patients with a SCC of the upper aerodigestive tract

Factors	Number of cases	Number of free flap failures (%)	*P*
Type of flap[a]			0.11
Radial forearm flap	131	7 (5.3)	
Osseous flaps	51	7 (13.7)	
Sex			0.70
Male	125	7 (5.6)	
Female	46	4 (8.7)	
Age			0.56
<70 years	136	10 (7.4)	
>70 years	35	1 (2.9)	
Comorbidity			0.28
KFI < 2	81	3 (3.7)	
KFI ≥ 2	90	8 (8.9)	
Preoperative irradiation			0.07
No	126	5 (4.0)	
Yes	45	6 (13.3)	
Recurrent cancer			0.0004*
No	139	4 (2.9)	
Yes	32	7 (21.9)	
T stage[b]			0.56
T1 and T2	34	1 (2.9)	
T3 and T4	101	3 (3.0)	
N stage[b]			0.35
N0	81	1 (1.2)	
N1, 2 ou 3	54	3 (5.6)	
Tumor site			0.84
Oral cavity or oropharynx	148	9 (6.1)	
Hypopharynx	23	2 (8.7)	

P values were determined by Chi2 (univariate analysis)

*For the *P* values which were statistically significant ($P < 0.05$)

[a] For double free flaps reconstructions, a failure was defined by the necrosis of at least 1 of the 2 flaps. Therefore, 14 free flap failures occurred in 11 different patients

[b] For the 135 patients with a primary (untreated) SCC of the upper aerodigestive tract

Table 7 Role of the different studied factors on the recipient site complications rate among the 171 patients with a SCC of the upper aerodigestive tract

Factors	Number of cases	Number of complications (%)	*P*
Sex			0.75
Male	125	32 (34.4)	
Female	46	10 (21.7)	
Age			0.97
<70 years	136	33 (24.3)	
>70 years	35	9 (25.7)	
Comorbidity			0.009 *
KFI < 2	81	12 (14.8)	
KFI ≥ 2	90	30 (33.3)	
Preoperative irradiation			0.56
No	126	29 (23.0)	
Yes	45	13 (28.9)	
Recurrent cancer			0.03*
No	139	29 (20.9)	
Yes	32	13 (40.6)	
T stage[a]			0.15
T1 and T2	34	4 (11.8)	
T3 and T4	101	26 (25.7)	
N stage[a]			0.53
N0	81	16 (19.8)	
N1, 2 or 3	54	14 (25.9)	
Tumor site			0.003 *
Oral cavity or oropharynx	147	30 (20.4)	
Hypopharynx	24	12 (50.0)	
Bone defect			0.71
No	120	28 (23.3)	
Yes	51	14 (27.5)	

P values were determined by Chi2 (univariate analysis)

* For the *P* values which were statistically significant ($P < 0.05$)

[a] For the 135 patients with a primary (untreated) SCC of the upper aerodigestive tract

tumor site (hypopharynx; $P = 0.05$) on the incidence of recipient site complications.

At the donor site, postoperative complications occurred in nine cases including three infections (fibular flap), one hematoma (radial forearm flap) and five split thickness skin graft partial losses (radial forearm flap). Thus, the overall donor site complication rate was 4.2%.

Medical complications occurred in 13 patients (cases of delirium tremens were not included) giving a general complication rate of 6.5%. Cardiovascular complications were the most common, with three cardiac arrhythmias, one myocardial infarction, one cardiac insufficiency and one lower limb acute ischemia. In addition, there were five cases of pulmonary infection, one case of duodenal ulcer perforation and one hyperosmolar decompensation in a diabetic patient.

Five patients died during 3 weeks following surgery, giving a postoperative mortality rate of 2.5%. Three postoperative deaths secondary to massive arterial hemorrhage (consecutive to a salivary fistula) were due to the surgical procedure. The two others deaths were due to intercurrent diseases (cardiac arrhythmia in one case and cardiac insufficiency in one case).

Functional and aesthetic results for the 171 patients with a SCC of the upper aerodigestive tract are shown in Table 8.

Table 8 Functional and aesthetic outcomes for the 171 patients with a SCC of the upper aerodigestive tract

Score	All patients $n = 171$ (%)	Group 1 $n = 95$ (%)	Group 2 $n = 53$ (%)	Group 3 $n = 23$ (%)
Oral diet				
2	130 (76)	87 (92)	27 (51)	16 (70)
1	33 (19)	6 (6)	22 (41)	5 (22)
0	8 (5)	2 (2)	4 (8)	2 (8)
Speech intelligibility				
2	87 (51)	62 (65)	25 (47)	0 (0)
1	64 (37)	28 (30)	23 (43)	13 (57)
0	20 (12)	5 (5)	5 (10)	10 (43)
Mouth opening				
2	127 (74)	78 (82)	28 (53)	21 (91)
1	38 (22)	16 (17)	20 (38)	2 (9)
0	6 (4)	1 (1)	5 (9)	0 (0)
Aesthetic outcome				
2	107 (62)	81 (85)	26 (49)	0 (0)
1	49 (29)	14 (15)	22 (42)	13 (57)
0	15 (9)	0 (0)	5 (9)	10 (43)

Group 1: oral or oropharyngeal surgery without mandibulectomy

Group 2: oral or oropharyngeal surgery with mandibulectomy

Group 3: circular pharyngectomy or circular total pharyngolaryngectomy

Discussion

The free flap success rate of 93.4% in this series confirms the reliability of these complex reconstruction procedures in the head and neck area. Over the last 15 years, the free flap success rate has increased from 80% in the first studies to 95% in the most recent publications [7, 13, 18, 27, 66]. All free flap failures occurred in the group of patients with SCC of the upper aerodigestive tract. In this group, the failure rate of osseous free flaps was higher than in radial forearm free flaps (13.7 and 5.3%, respectively), although this difference was not statistically significant. Several studies confirm the higher risk of free flap failure in mandibular reconstruction compared to soft tissue reconstruction [43, 66].

The main risk factor of free flap failure in this series was salvage surgery in a context of recurrent cancer. This could easily be explained by the difficulties involved in performing microsurgical procedures in an irradiated or operated area. Moreover, preoperative irradiation seemed to decrease the free flap success rate in this study, but this correlation could not be considered statistically significant. Similar observations have also been reported by several authors [34, 41, 57, 66].

In contrast, advanced age had no influence on the free flap success in this series. The reliability of free flaps in the elderly has been widely reported in the literature [5, 25, 44, 66]. Patient comorbidity had no direct influence on free flap success, but a high level of comorbidity increased the incidence of local complications at the recipient site in this series and, therefore, could influence the outcome of free flap reconstruction of the head and neck [25, 34, 65, 66].

Other factors that have previously been reported to be associated with an increased risk of free flap failure include: the use of interposition vein grafts to perform microvascular anastomoses, recent weight loss, involvement of more than one operating surgeon, flap diameter greater than 4 cm, operative time longer than 11 h, the use of skin grafted muscle flaps and the use of nitrate or bronchodilatator pharmacotherapy [22, 25, 31, 34, 36, 57, 64].

The use of skin grafts to cover muscular free flaps should be avoided because it can interfere with the clinical monitoring of the flap. The role of operative duration and of the number of surgeons enrolling in this surgery is unclear, probably indirect and linked to the surgical difficulties encountered in cases of salvage surgery, particularly after several surgical procedures and radiotherapy to the head and neck area.

Our results show no influence of the recipient vessels used to complete microvascular anastomoses on the free flap success rate. This is confirmed by the majority of publications as is the lack of influence of the type of microvascular anastomoses (end-to-end or end-to-side) [34, 42, 66].

The need for adjuvant treatments, such as antiplatelet agents, vasodilators, anticoagulants (heparin therapy), as well as isovolumetric hemodilution, after free flap head and neck reconstruction, is questionable. Only heparin, according to a preventive treatment protocol for deep vein thrombosis, has been shown to be effective in reducing the risk of thrombosis and free flap failure without significantly increasing the risk of hemorrhage [37, 40, 47, 51].

The rate of surgical reexploration to check microvascular anastomoses was 15% in our series. The type of free flap used made little difference (13.7% for radial forearm flaps and 17.9% for osseous flaps). It is interesting to note that almost two-thirds of the cases requiring verification led to a successful free flap outcome. Identical results are given in the literature [18, 34, 65]. This highlights the importance of early surveillance focused on the viability of the flap and on checking, at the least suspicion, the patency of the vascular anastomoses.

For flaps with a skin paddle that is easily accessible for post-operative examination, we monitor hourly the appearance of the skin paddle (color, tension, abundance and quality of bleeding after pricking with a fine needle). During the first post-operative week, monitoring is performed at least twice a day by the medical team, and the rest of the time by nursing staff specially trained to provide continuous care. This ongoing clinical monitoring of flaps during the early post-operative period seems to be critical since vascular anastomosis thrombosis appears in general during the first 72 h [10, 16]. This clinical surveillance can be optimized using oxymetric techniques and accurate Doppler measurement of blood flow [16, 46, 52, 59, 78].

In cases of circular pharyngolaryngectomy for pharyngeal reconstruction with radial forearm free flaps, monitoring is often difficult due to the anatomical location of the defect. We do not hesitate to extend sectioning of the posterior pharyngeal wall upward into the oropharynx in order to make the upper part of the flap accessible for post-operative examination. If necessary, we use a laryngoscope to visualize the flap at the patient's bedside. Despite this approach, monitoring of flap viability remains difficult in this situation. Thus, in the two cases of radial forearm free flap failure after circular pharyngolaryngectomy in this series, no surgical reexploration of vascular anastomoses was attempted since the ischemic status of the flaps was noted too late, at the stage of necrosis and salivar fistulas.

It should be noted that the consequences of the free flap failures in this situation are often dramatic with a high risk of massive cervical hemorrhage due to the constitution of a large pharyngostoma. A case of post-operative death occurred in this series following necrosis of the flap in this type of reconstruction. With the aim of facilitating flap monitoring, some authors have suggested using a monitoring flap consisting of a small skin paddle placed adjacent to the reconstruction flap (in general, ulnar or more distal) [1, 3, 12].

In the context of composite osteocutaneous free flaps (fibular and scapular flaps in our series), vascularization of the skin paddle does not totally reflect vascularization of the osseous component of the flap. For the fibular flaps, good vascularization of the skin paddle habitually reflects good vascularization of the bone, but ischemia of the skin paddle does not necessarily correlate to defective perfusion of the bone [28, 56].

Thus, in our series, all cases of necrosis of the bone component of fibular flaps were accompanied by necrosis of the skin paddle, while in three cases, complete necrosis of the skin paddle arose despite good viability of the bone component.

For scapular free flap, the skin paddle and the bone component of the flap have their own pedicle, which comes together to form the scapular circumflex pedicle. Thus, the quality of the vascularization of the skin paddle and the bone component can sometimes be completely dissociated [70]. However, in this series, there was no necrosis, even partial, of scapular flap. Furthermore, this flap has the advantage of possessing a vascular pedicle, which as a general rule, is minimally subjected to atherosclerotic lesions [70].

Due to the difficulty of performing a reliable evaluation of the free bone transfers vascularization, particularly in the absence of skin paddle, several authors have proposed to practice a $^{99m-}$technetium scintigraphy the day after the operation. Furthermore, some authors prefer SPECT (single photon emission computed tomography) rather than classical bidimensional scintigraphy, given the superior quality of SPECT images [21, 26, 39].

There are several techniques for repairing the defect after the failure of the initial free flap [4, 76, 77]. The use of a second free flap, where possible, seems to be the best solution [4, 76]. Thus, in this series, two failures of radial forearm flap were subsequently repaired using a new radial forearm flap. The necrotic tissues were rapidly excised and the second free tissue transfer was performed at the same time. Regarding the fibular flaps, two cases of free flap failure were subsequently repaired with a new fibular flap. However, in this situation, after exision of the necrotic soft tissues, the bone component of the fibular flap is generally left in place until the end of the postoperative radiotherapy. This avoids delay in performing necessary radiotherapy and retraction at the zone for future reconstruction. After completion of radiotherapy, the bone component of the flap is removed and a new fibular free flap is performed. There were no failures among the subsequent free flap procedures.

The second solution consists in using a regional pedicle flap [76]. In this series, four radial forearm flap failures were repaired with a pectoralis major muscular or myocutaneous flap. This solution may prove preferable, if it does not jeopardize the quality of the reconstruction, when the anatomical conditions do not favor the use of a new free flap (absence of available recipient vessels or poor vascular status).

Finally, the third solution consists in conservative management with debridement, wound care, and subsequent closure by secondary intention, whether using local flaps or skin grafting. Nevertheless, this approach must not be used when free flap failure results in a salivary fistula into the neck [76, 77].

In this series, partial free flap necrosis occurred in four cases of radial forearm flaps and in seven cases of fibular flaps (partial or complete necrosis of the flap skin paddle without necrosis of the bone component). For free osseous flaps, there was no necrosis of the intermediary bone fragments between osteotomies. Partial free flap necrosis is a relatively rare event (5.2% of cases in this series), confirming the findings reported in the literature [66, 67]. In recent studies, the rates of free flap and pedicle flap failures are comparable, while partial necrosis is significantly more frequent with regional pedicle flaps [38, 66].

Depending on the type of flap used, hospitalization was 3–4 weeks in our series. The length of hospital stay was significantly longer for defects requiring bone reconstruction than for other types of defects. These data are frequently reported in the literature [28, 53]. Other factors, which increase the length of hospitalization in certain series are age, comorbidity and postoperative complications [5, 32, 65].

The level of complications at the recipient site in our series was 20.9% (excluding free flap failures) and similar levels are often reported in published series [25, 66]. For us, the most frequent local complications were infections at the recipient site (10.4% of cases), which can be favored by other local complications (loss of free flap, fistulas and hematoma).

The occurrence of postoperative salivary fistula was higher in the circular pharyngolaryngectomy group (45.8% of cases) than in the rest of the series. Most of these fistulas were managed by conservative procedures. Comparable fistula rates are often reported in the literature [17, 65]. In our series, 50% of pharyngolaryngectomies and circular pharyngectomies were performed after radiotherapy, which classically increases the risk of fistula.

The level of medical complications in this series was relatively low (6.5% of cases) with mainly cardiovascular and respiratory complications. Analysis of the literature also reveals the preponderance of this type of complications in large published studies [25, 65, 71]. This fact could be explained by the smoking history of patients presenting with SCC of the upper aerodigestive tract, who represent the majority of patients included in these studies.

In the group of patients presenting with SCC of the upper aerodigestive tract in this series, the three factors favoring the occurrence of postoperative complications at the recipient site are: a high comorbidity level, a cancer recurrence and a tumor location at the hypopharynx. The significant influence, in our study, of comorbidity on the incidence of postoperative local complications is also clearly demonstrated by several authors who, however, used a different index of comorbidity (Charlson index or ASA score) [20, 65, 66]. Advanced age did not correlate with an increased rate of local complications in our study and it did not increase the risk of free flap failure. Most of the published series confirm the reliability of free tissue transfers in the elderly, but an increased incidence of medical complications and a longer hospital stay are often reported [5, 8, 32, 61, 66].

Salvage surgery for cancer recurrence after primary surgery and radiotherapy to the head and neck area is habitually associated with delayed wound healing and a higher level of complications [65, 66]. Given the poor prognosis of this type of patient and the difficulty in evaluating the limits of the lesion, it is also possible that tumor excision was more extensive in this situation. Thus, it was not surprising that we reported a higher rate of local complications in the group of patients with cancer recurrence [2].

The high rate of local complications after circular pharyngolaryngectomy is essentially related to the high incidence of postoperative fistulas (45.8% of cases). This is the main factor responsible for the increased risk of local complications after hypopharyngeal surgery rather than after oral or oropharyngeal surgery [11, 66].

In addition, it is of interest to note that the presence of a bone defect did not significantly increase the risk of postoperative local complications in our series, while it tended to prolong the hospital stay. This latter phenomenon could probably be explained by the longer time required for wound healing (bone consolidation) and functional recovery (breathing, swallowing) [65].

Functional and aesthetic outcomes were evaluated for patients with a SCC of the upper aerodigestive tract.

They were very satisfactory in group 1 (oral or oropharyngeal surgery without mandibulectomy). The main complaint in this group concerned elocution and intelligibility of speech. This could be explained by the importance of tongue and velopalatal resection [58, 68].

The results were worse in group 2 (oral or oropharyngeal surgery with mandibulectomy) than in group 1 because group 2 patients presented more extensive defects. However, the outcomes of group 2 patients were encouraging and could be explained by the quality of mandible reconstruction. Similar results are commonly reported in the literature [14, 49].

In our study, 70% of group 3 patients were able to resume an inrestricted oral diet (circular pharyngectomy or circular total pharyngolaryngectomy), the rate of stricture was low (8%) and the speech outcome was acceptable. It is of interest to note that more than one half of these patients had an intelligible speech. This result was due to the possibility of voice rehabilitation by tracheoesophageal puncture after circular total pharyngolaryngectomy and reconstruction with radial forearm free flap. This fasciocutaneous flap provides an excellent alternative to jejunal free flap in this situation. Voice restoration by tracheoesophageal puncture is more difficult after hypopharyngeal reconstruction with jejunal free flap than with radial forearm flap. Furthermore, the laparotomy-associated morbidity is not negligible, particularly in debilitated patients [6, 19, 24, 54, 73].

The tubed gastro-omental free flap offers an alternative procedure for pharyngoesophageal reconstruction in selective cases, particularly in a surgical field compromised of previous multimodal therapy [50].

The radial forearm free flap is considered as the flap of choice for oral and oropharyngeal soft-tissue reconstruction [49, 62]. Our study confirms the excellent outcomes habitually reported after free flap reconstruction of oral mucosal defects [35, 49, 62]. The radial forearm flap provides a thin and pliable skin paddle and a long vascular pedicle, which are very appreciated in this type of reconstruction.

The anterolateral thigh flap is another fasciocutaneous flap frequently used for oral and pharyngeal reconstruction

[45, 74]. The donor site morbidity associated with this flap is lower than with radial forearm flap [15, 74]. However, the skin paddle of the anterolateral thigh flap is often too thick particularly in Caucasians, and the dissection of its vascular pedicle is presumed more difficult.

Free, vascularized bone-containing flaps have become the method of choice for reconstructing segmental defects of the mandible and the mucosal lining [48, 71]. The vascularized fibular graft has recently been recognized as the ideal reconstructive option [9, 63, 67]. This flap provides 20–26 cm of well-vascularized cortical bone and tolerates osteotomies at 2-cm intervals to enable accurate reconstruction. The fibular flap-associated skin paddle is reliable and allows simultaneous reconstruction of soft-tissue defects intraorally, extraorally or both. Dental implants can be placed in fibular free flap reconstructed mandibles with a high rate of osseointegration [23, 55].

We have used a scapular free flap in seven cases of mandibular reconstruction. The scapular flap is known to have some disadvantages: the quantity and the quality of bone are low, and it does not accept multiple osteotomies and osseointegration. Furthermore, it requires repositioning the patient [67, 70, 71]. However this flap provides a large amount of soft-tissue (1 or 2 skin paddles and latissimus dorsi myocutaneous flap), which can be harvested with the bone component and allows reconstruction of complex and extensive soft-tissue defects. We choose the scapular flap for mandible reconstruction in cases of counter-indications for a fibular flap (atherosclerosis, trauma of the leg) and when the associated soft-tissue defect is particularly extensive or through and through. In this last situation, it is also possible to use an osteocutaneous fibular free flap combined with a fasciocutaneous free flap or a myocutaneous pedicled flap [71, 75].

Conclusion

Free tissue transfers have proven to be very reliable to repair various types of defects in the head and neck area, with a low incidence of free flap failure and an acceptable level of complications. Careful preoperative assessment, particularly concerning patient comorbidity and history of surgery or radiotherapy, can help to identify patients with a high risk of postoperative complications. Radial forearm free flap and fibular flap were the most used flaps for soft tissue and mandible reconstruction, respectively.

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