Fibula Free Flap in Head and Neck Reconstruction: Identifying Risk Factors for Flap Failure and Analysis of Postoperative Complications in a Low Volume Setting

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Abstract

The fibula free flap (FFF) has been a workhorse in maxillofacial reconstruction. High success rates of this technique are reported. However, identifying risk factors for flap failure and analyzing complications can open the way to better patient care. A retrospective analysis was conducted of all FFFs performed over a 20-year period at a low-volume single tertiary center to identify risk factors and postoperative complications. A total of 129 FFFs were included (122 mandible, 7 maxilla). Complete flap failure occurred in 12.4% and partial flap failure in 7.8% of patients. A significant relation was found between younger age and flap failure, and most failures were associated with venous thrombosis. In-hospital surgical complications occurred in 60.5%, in-hospital medical complications in 49.6%, and out-of-hospital complications in 77.5% of patients. The in-hospital reintervention rate was 27.1%, and including salvaged flaps, flap survival rate was 87.6%. Osteomyocutaneous FFF failure (complete 12.4%; partial 7.8%) is an important clinical reality in a low-volume head and neck reconstruction center resulting in an in-hospital reintervention rate of 27.1%. Postoperative complications are frequent, both surgical and out-hospital complications. These results provide a better understanding of the limitations of the FFF in a low-volume center and can be used to optimize care in this kind of setting.

Keywords
- fibula free flap
- reconstruction
- risk factor
- flap failure
- complication

Severe trauma cases, osteoradionecrosis, and head and neck cancer can cause extensive defects of the oral and maxillofacial region. Facial defects can be categorized as either soft-tissue defects or as composite defects, in which bone and soft tissue are both needed. The need for reconstruction of these defects has led to the development of multiple tissue-transfer techniques. For composite defects, the free vascularized fibula flap (FFF) has been the primary choice of many reconstructive surgeons since Taylor et al[1] described its harvest and Hidalgo[2] advocated for its use in mandibular reconstruction. It offers multiple advantages: the availability of ample bone length, the possibility of performing osteotomies for anatomical shaping, a versatile soft tissue unit with the option of multiple skin paddles, long vascular pedicles with an adequate diameter of the vessels, bicortical bone stock for dental implant placement, and the use of a two-team approach, reducing operating time.[3–5] Overall success rates of free flap surgery are reported to be over 95%,[6] and recent studies on free fibula flaps reported overall success rates of 90 and 93%.[7,8] However, a subset of FFFs do

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fail, mostly because of arterial or venous thrombosis. In addition, complications after FFF surgery arise often, in the donor site as well as in the acceptor site. These complications are frequently underreported and are difficult to compare among studies.

The current study presents a low-volume single tertiary center's 20-year experience with FFF reconstruction for mandibular or maxillary defects. Most available studies on this topic are derived from high-volume centers.[6,9] This study delivers a thorough review of the long- and short-term results, risk factors for flap failure, and analysis of postoperative complications of a low-volume head and neck reconstruction center with approximately 100 free flap procedures per year. The results provide insights for further improvement of the FFF procedure in other low-volume centers.

Materials and Methods

Patients and Procedure

After consent from the ethics committee (mp14824), every patient who had undergone a FFF reconstruction at the Department of Oral and Maxillofacial Surgery of the University Hospitals of Leuven, Belgium, was identified and included. The study period covered 20 years, from January 1996 until January 2016. At the University Hospitals of Leuven, a two-team multidisciplinary approach is used. Members of the Department of Oral and Maxillofacial Surgery perform the resection, adaptation of the acceptor site, and the fitting and fixation of the FFF, whereas clinicians from the Department of Plastic and Reconstructive Surgery complete the harvesting and microanastomosis of the FFF. In this 20-year period, techniques for this procedure have been altered and optimized. Postoperative care consists of an intensive care unit (ICU) stay of at least 48 hours for close postoperative monitoring and further recovery at the surgical ward. Flaps are monitored clinically and by cutaneous Doppler every hour at the ICU the first 24 hours and every 3 hours for the next 4 days. If a tracheostomy was performed, decannulation protocol was initiated as soon as the natural airway was presumed safe. Each tracheostomy patient received extensive postoperative respiratory physiotherapy. To avoid bias, data were collected by two independent observers (medical doctors) who reviewed the medical records of each patient. Failure of the FFF and its cause were identified.

Flap Failure

Overall flap failure was subdivided into two groups. The first group was defined as the complete failure group, consisting of FFFs that had to be removed completely during the entire follow-up period. All reasons for removal of the flap were included. The second group was defined as the partial failure group and consisted of FFFs that could be salvaged and did not have to be removed, for example, necrotic skin paddles or loss of an osteotomized segment. Possible risk factors for overall flap failure were recorded: age, gender, pathology, American Society of Anesthesiologists score, alcohol use, tobacco use, classification of the defect according to Jewer et al,[10] operation time, simultaneous use of other free flaps, number of osteotomized segments of the fibula, neck dissection, tracheotomy, chemotherapy, and radiotherapy. Concerning the classification system of mandibular defects by Jewer et al,[10] the C-defects range from canine to canine; the H-defect includes the condyle and can range to the canine at one side of the mandible; the L-defect does not include the condyle and does include a lateral part of the mandible that can range to the canine; and combinations of these letters are possible. The Ma-defect (i.e., maxillary defect) was also included.

Statistical Analyses

Statistical analysis for identifying risk factors began with a univariate analysis: a generalized linear model for binary outcomes with a logit link fit to model the relation between the above-mentioned variables and failure. The variable was included in the statistical analysis only if it had five or more registrations. In a second step, a multivariable analysis was performed: a stepwise model selection was used to find the combination of explanatory variables that had the best relationship with failure. Next, postoperative complications were recorded. "Complication" was defined as an unwanted postoperative outcome that compromised postoperative healing or "function as perceived by the patient." Registration of complications was performed by screening the medical records of all included patients in a retrospective manner. All reports of complications were based on either spontaneous mentioning by the patient, detailed anamnesis, or clinical evaluation by the physician during the follow-up visit or radiological images made during the follow-up visit. These complications were subdivided into in-hospital and out-of-hospital complications. In-hospital complications were those arising during the hospital stay and were subdivided into a surgical subgroup (e.g., wound healing, infection of the surgical site, extensive hematoma) and a medical subgroup (e.g., nonsurgical infections, cardiac problems). The out-of-hospital complications were registered during the follow-up visit.

Results

Demographics

A total of 129 FFFs in 122 individual patients were identified and included. All patient characteristics are described in ►**Table 1**. Patient age ranged from 12 to 84 years (mean, 55 years). Operation times ranged between 5 and 22 hours (mean, 11.7 hours). FFFs were used mostly in malignant tumor (66.7%) and osteoradionecrosis (23.3%) cases, and reconstruction was needed primarily for LC (21%) and LCL (24.1%) defects. In most cases, only one bony segment was used (35.6%). In 81.4% of all FFFs, no additional free flap was needed, although in cases requiring one, the anterolateral thigh flap was preferred (10.1%). A double flap was used if an extra soft tissue unit was needed for reconstruction of the defect. A tracheotomy was performed in 81.4% of all patients. In 51.9% of cases, patients had a simultaneous neck

Table 1 Study group characteristics

Variable	Number of cases	Percentage
Total FFF	129	100
Gender		
Male	90	70.0
Female	39	30.0
Pathology		
Benign tumor	4	3.1
Malignant tumor	86	66.7
MRONJ	1	0.7
Osteoradionecrosis	30	23.3
Osteomyelitis	2	1.6
TMJ reconstruction	2	1.6
Trauma	3	2.3
Other	1	0.7
ASA score		
1	20	15.5
2	77	59.7
3	28	21.7
4	2	1.6
NA[a]	2	1.6
Alcohol and tobacco usage		
Alcohol	77	59.7
Tobacco	94	72.7
Defect classification[b]		
H	22	17.1
HC	1	0.7
L	40	31.0
LC	27	21.0
LCL	31	24.1
LL	1	0.7
Ma	7	5.4
Simultaneous use of other flaps		
None	105	81.4
Anterolateral thigh flap	13	10.1
Latissimus dorsi flap	4	3.1
Radial forearm flap	5	3.8
Other	2	1.6
Number of segments		
1	46	35.6
2	45	34.9
3	27	20.9
4	2	1.6
5	2	1.6
NA[a]	7	5.4
Neck dissection		
None	43	33.3
Preoperative	17	13.2
Perioperative	67	51.9
NA[a]	2	1.6
Tracheotomy		
Yes	105	81.4
No	23	17.9
NA[a]	1	0.7
Chemotherapy		
None	81	62.9
Preoperative	9	7.0
Postoperative	24	18.6
Pre- and postoperative	5	3.8
NA[a]	10	7.7
Radiotherapy		
None	24	18.6
Preoperative	48	37.2
Postoperative	57	44.2
Age		
Range	12–84	Mean: 55
Operation time		
Range	5–22 h	Mean: 11.7 h
Follow-up (mo)		
Range	1–213	Mean: 48

Abbreviations: FFF, free vascularized fibula flap; MRONJ, medication-related osteonecrosis of the jaw; TMJ, temporomandibular joint.
[a]NA: not available, data could not be retrieved.
[b]C: canine to canine; H: lateral mandibula, condyle to canine; L: lateral mandibular, not including condyle and ranging to canine; Ma: maxilla.

dissection, and in 13.2% of the study population, a neck dissection had already been performed preoperatively. A total of 10.8% of patients received chemotherapy before the FFF procedure, and preoperative radiotherapy was noted in 37.2% of the study population. Follow-up ranged from 1 to 214 months postoperative. The mean follow-up period was 48 months.

Flap Failure

►**Table 2** shows the data concerning flap failure. Complete flap failure was seen in 12.4% of all cases, and partial failures with necrosis of the skin paddle, but preservation of the remaining flap was noted in 7.8% of patients. One of these patients exhibited partial necrosis of one of the two osteotomized fibula segments. The success rate of the FFF in the study population was 79.8%; flap survival rate, including salvaged flaps, was 87.6%. Venous thrombosis was identified

Table 2 Failure group characteristics

Variable	Number of failures[a] (total number of cases)[b]	Percentage[c]
Failures	16 (129)	12.4
Partial failures	10 (129)	7.8
Success	103 (129)	79.8
Age		
Range	19–75	Mean: 50
Gender		
Male	16 (90)	17.8
Female	10 (39)	25.6
Pathology		
Benign tumor	0 (4)	0
Malignant tumor	18 (86)	20.9
MRONJ	0 (1)	0
Osteoradionecrosis	5 (30)	16.7
Osteomyelitis	0 (2)	0
TMJ reconstruction	2 (2)	100
Trauma	0 (3)	0
Other	1 (1)	100
ASA score		
1	2 (20)	10.0
2	16 (77)	20.8
3	7 (28)	25.0
4	1 (2)	50.0
NA[d]	0 (2)	0
Alcohol and tobacco usage		
Alcohol	18 (77)	22.4
Tobacco	21 (94)	19.2
Defect classification[e]		
H	7 (22)	31.9
HC	1 (1)	100
L	7 (40)	17.5
LC	4 (27)	14.8
LCL	5 (31)	16.1
LL	0 (1)	0
Ma	2 (7)	28.6
Simultaneous use of other flaps		
None	19 (105)	18.1
Anterolateral thigh flap	3 (13)	23.1
Latissimus dorsi flap	0 (4)	0
Radial forearm flap	2 (5)	6.3
Other	1 (2)	6.3
Number of segments		
1	9 (46)	19.6
2	8 (45)	17.8
3	3 (27)	11.1
4	0 (2)	0
5	2 (2)	100
NA[d]	4 (7)	57.1
Neck dissection		
None	7 (43)	16.3
Preoperative	3 (17)	17.6
Perioperative	15 (67)	22.4
NA[d]	1 (2)	50
Tracheotomy		
Yes	20 (105)	19
No	6 (23)	26.1
NA[d]	0 (1)	0
Chemotherapy		
None	19 (81)	23.5
Preoperative	1 (9)	11.1
Postoperative	4 (24)	16.7
Pre- and postoperative	1 (5)	20.0
NA[d]	1 (10)	10.0
Radiotherapy		
None	7 (24)	29.2
Preoperative	9 (48)	18.8
Postoperative	6 (57)	10.5

Abbreviations: MRONJ, medication-related osteonecrosis of the jaw; TMJ, temporomandibular joint.
[a]Number of failed fibula free flaps, complete or partial, in this category.
[b]Total number of fibula free flaps in this category.
[c]Percentage of fibula free flaps that failed, complete or partial, in this category.
[d]NA: not available, data could not be retrieved.
[e]C: canine to canine; H: lateral mandibula, condyle to canine; L: lateral mandibular, not including condyle and ranging to canine; Ma: maxilla.

as the major cause for complete flap failure (37.5%). Concerning timing of flap failure, 43% of all complete failures occurred within 11 days, and 75% occurred within 30 days (►**Table 3**). ►**Table 4** provides an oversight of the distribution of overall flap failure over the study period.

Statistical analysis (►**Table 5**) showed a significant relation between young age and flap failure ($p = 0.0456$). No clear cutoff age was identified. No other statistically significant risk factors could be identified. Higher overall failure rates were seen with malignant tumors, in cases requiring a

Table 3 Complete failure of FFF

Variable	Number of cases
Reason	
Venous thrombosis	6
Arterial thrombosis	1
Refractory arterial bleeding	1
Unidentified vascular crisis	6
Recurrent malignant disease	1
Refractory pain with trismus	1
Timing	
< 11 d	7
11–30 d	5
> 30 d	4

Abbreviation: FFF, free vascularized fibula flap.

Table 4 Failure distribution over study period

Years	FFFs	Complete failure	Partial failure	Overall failure
1996–2000	13	1	3	4
2001–2005	24	3	1	4
2006–2010	37	2	2	4
2011–2016	55	10	4	14

Abbreviation: FFF, free vascularized fibula flap.

condyle reconstruction (H and HC) or using additional free flaps, and in patients for whom no tracheotomy was performed. Patients who underwent pre- or postoperative chemo- or radiotherapy did not have higher failure rates. None of these associations was significant, however.

Multivariable analysis showed that a longer operation time ($p = 0.1494$), younger age ($p = 0.0788$), pre- or postoperative radiotherapy ($p = 0.1686$), and a malignant tumor

Table 5 Results of the statistical analysis

Parameter	Measured variable	Odds ratio	CI (LL)[a]	CI (UL)[b]	*p*-Value
Age	Continuous variable	–	–	–	0.0456
Gender	Male:Female	0.627	0.2511	1.5655	0.3147
Pathology	Malignant tumor:ORN	0.8553	0.2411	3.0344	0.8073
ASA score	ASA1:ASA2	0.4236	0.0626	2.8687	0.5374
	ASA1:ASA3	0.3333	0.0419	2.6528	0.4225
	ASA2:ASA3	0.7869	0.2262	2.7368	0.8918
Alcohol usage	Yes:No	1.3511	0.4998	3.6527	0.5501
Tobacco usage	Yes:No	1.2082	0.3982	3.666	0.7364
Defect type[c]	H:L	2.2	0.3832	12.6309	0.7226
	H:LC	2.6833	0.3618	19.9005	0.6517
	H:LCL	2.4267	0.3663	16.078	0.6929
	H:Ma	1.1667	0.0789	17.2616	0.9999
	L:LC	1.2197	0.1771	8.4023	0.9986
	L:LCL	1.103	0.1801	6.7573	0.9999
	L:Ma	0.5303	0.0378	7.4307	0.9635
	LC:LCL	0.9043	0.1152	7.0992	0.9999
	LC:Ma	0.4348	0.026	7.2647	0.9244
	LCL:Ma	0.4808	0.0311	7.4223	0.9464
Operation time	Continuous variable	–	–	–	0.16
Simultaneous flaps[d]	ALT:None	1.3105	0.2402	7.1495	0.9242
	ALT:RFF	0.45	0.0301	6.7347	0.7637
	None:RFF	0.3434	0.0352	3.3512	0.5076
Osteotomized segments	1:2	1.125	0.3079	4.1099	0.9747
	1:3	1.9459	0.3474	10.8988	0.6304
	2:3	1.7297	0.3018	9.9148	0.7372
Neck dissection[e]	None:Simultaneous	0.6741	0.1998	2.274	0.7225

(*Continued*)

Table 5 (*Continued*)

Parameter	Measured variable	Odds ratio	CI (LL)[a]	CI (UL)[b]	*p*-Value
	None:Previous	0.9074	0.1469	5.6063	0.9913
	Simultaneous:Previous	1.3462	0.2505	7.2346	0.9078
Tracheotomy	Yes:No	0.6667	0.2289	1.9417	0.4544
Chemotherapy	Post-op:Pre-op	1.6	0.0762	33.5807	0.9245
	Post-op:Both	0.8	0.0334	19.1359	0.9839
	Pre-op:Both	0.5	0.0098	25.4471	0.9027
Preoperative radiotherapy	Yes:No	1.8462	0.5899	5.778	0.289
Postoperative radiotherapy	Yes:No	0.517	0.1651	1.6188	0.2543

Abbreviations: ALT, anterolateral thigh flap; ASA, American Society of Anesthesiologists score; ORN, osteoradionecrosis; RFF, radial forearm flap.
[a]CI (LL): 95% confidence interval, lower limit.
[b]CI (UL): 95% confidence interval, upper limit.
[c]Defect classification according to Jewer et al.[10]
[d]Simultaneous flaps: additional free flaps used during fibula free flap procedure.
[e]Neck dissection: either none, a previous or a simultaneous (during free flap surgery) neck dissection was recorded.

as the indication ($p = 0.2037$) trended toward a higher risk of overall flap failure, although these results also were not statistically significant.

Complications

Postoperative complications were recorded using the definition given earlier (►**Table 6**). The in-hospital surgical subgroup included 78 patients (60.5%) who developed at least one complication during their hospital stay. Surgical intervention for these complications was needed in 35 patients (27.1%; ►**Table 7**). Compromised wound healing at the donor and acceptor sites was most frequently reported, and infection of the acceptor site was noted in 15 patients (11.6%). Venous insufficiency of the fibula or additional flap without FFF failure was noted in six patients (4.7%). Compartment syndrome of the donor site was registered in two cases, and one patient developed a vascular crisis at the donor site for which an amputation of the lower leg was eventually performed.

The in-hospital medical subgroup had 64 patients (49.6%) who developed at least one complication during their hospital stay. Respiratory infections in particular were of interest: 23 patients (17.8%) developed a respiratory infection that was treated successfully with antibiotics; a post hoc analysis of the relation between tracheostomy and respiratory infection was performed and showed a statistically significant association (Fisher's exact test: $p = 0.0447$). Pulmonary embolism occurred in three patients (2.3%).

A variety of gastrointestinal complications (e.g., gastric ulcers, liver function disturbances) was registered among 13 patients (10.1%). Postoperative delirium occurred in seven patients (5.4%), eight (6.2%) had cardiac arrhythmias, and three patients (2.3%) died during their hospital stay (two sudden cardiac deaths and one antibiotic-induced anaphylactic shock).

Out-of-hospital complications were identified in 100 patients (77.5%). Donor-site morbidity was frequently recorded: delayed healing of the donor site was present in 32 patients (24.8%), infection of the donor site in 4 patients (3.1%), and neuromuscular deficiency of the donor site in 22 patients (17.1%). Complications of the acceptor site were also frequently reported: 22 patients (17.1%) developed an out-of-hospital infection of the acceptor site, and delayed wound healing was noted in 16 patients (12.4%). Functional problems such as swallowing and speech problems were reported by15 (11.6%) and 8 patients (6.2%), respectively, and a reduced mouth opening was present in 17 patients (13.2%). Marked neurological complaints at the acceptor site, ranging from paresthesia to neuropathic pain, were mentioned in eight cases (6.2%). Osteoradionecrosis progressed in seven patients (5.4%), and a malunion between fibula and the remaining mandible occurred in nine (7%). All complications were recorded over the entire follow-up period.

Discussion

The FFF has been one of the workhorses of oral and maxillofacial reconstruction, especially in mandibular defects. The ample bone length, long vascular pedicle, and promise of less donor-site morbidity compared with an iliac crest flap[11] have made it the preferable free vascularized flap in mandibular reconstruction. Also, because of its septocutaneous perforators and its periosteal blood supply, the FFF can be osteotomized and shaped to fit the anatomy of the defect that needs reconstruction.

The success rate of 79.8% found here is lower than other reports, probably because of the use of strict criteria to define failure and success: if a FFF was taken with a skin paddle and the skin paddle did not survive, this event was classified as a partial failure. If these salvaged flaps had been included in the success rate, a success rate of 87.6% would have been obtained, which is still slightly lower than other reports.[3,8,12] Four flap failures occurred more than 30 days after initial surgery. Two of them presented with initial loss of the skin

Table 6 Postoperative complications

Variable	Number of cases	Percentage
In-hospital: surgical		
Compromised wound healing acceptor site	19	14.7
Compromised wound healing donor site	21	16.3
Bleeding acceptor site	9	7.0
Hematoma donor site	1	0.7
Hematoma acceptor site	5	3.8
Venous insufficiency acceptor site	6	4.7
Infection acceptor site	15	11.6
Infection donor site	4	3.1
Salivary gland fistula	2	1.6
Facial nerve damage	1	0.7
Compartment syndrome	2	1.6
Amputation donor site	1	0.7
Drop foot donor site	1	0.7
In-hospital: medical		
Respiratory infection	23	17.8
Pulmonary embolism	3	2.3
Deep venous thrombosis	1	0.7
Marked electrolyte disturbances	6	4.7
Arterial hypertension	6	4.7
Gastrointestinal disturbances	13	10.1
Urinary infection	6	4.7
Kidney failure	2	1.6
Sepsis	3	2.3
Cardiac arrhythmia	8	6.2
Heart failure	2	1.6
Stroke	2	1.6
Pressure injuries	5	3.8
Delirium	7	5.4
Death	3	2.3
Out-hospital		
Infection acceptor site	22	17.1
Infection donor site	4	3.1
Delayed wound healing acceptor site	16	12.4
Delayed wound healing donor site	32	24.8
Reduces mouth opening	17	13.2
TMJ complaints	8	6.2
Swallowing complaints	15	11.6
Speech complaints	8	6.2
Skin paddle hair growth	3	2.3
Marked neurological complaints acceptor site	8	6.2
Osteoradionecrosis	7	5.4
Intra-oral scar fibrosis	17	13.2
Osteosynthesis material problems	6	4.7
Malunion	9	7.0
Salivary gland fistula	2	1.6
Accessory nerve damage	3	2.3
Neuromuscular deficiency donor site	22	17.1

paddle which eventually progressed to total flap failure. The third flap had to be removed due to recurrent malignant disease affecting the free flap 1 year after reconstruction. The remaining failure was a patient who had a FFF for reconstruction of the temporomandibular joint due to severe ankylosis. During the first postoperative months, the patient developed refractory pain at the reconstructed joint as well as severe trismus for which the flap was eventually removed. Also, follow-up of flaps was done by residents, both junior and senior, which may cause a delay in flap revision. Vascular crisis and venous thrombosis in particular formed the main reason for flap failure. Venous crisis has been reported as the main reason for salvage procedures[6,13,14] and can be regarded as the most fragile vascular component of the pedicle. The venous anastomosis is susceptible to spasms, compression by hematoma or edema, and kinking by postoperative head and neck flexion or extension.[14] This leads to venous congestion and eventually venous thrombosis. Although careful postoperative monitoring of these risk factors is standardly performed, some flaps could not be salvaged in time. To improve vascular outcome for the transferred tissue, an adequate preoperative evaluation of vascular structures should be performed. Computed tomography (CT) angiography of the lower limbs is the standard when a FFF is planned, with a dual goal: detecting and evaluating peripheral vascular disease and evaluating anatomical anomalies of the lower limb vasculature. Critical infra-popliteal vascular anomalies are found in 10% of the population and 5.2% of limbs, meaning that if the peroneal artery were to be sacrificed, the result could be ischemic complications of the donor site.[15] Also, the CT data can be

Table 7 Surgical reinterventions for in-hospital surgical complications[a]

Variable	Number of cases	Percentage
Acceptor site		
Salvaged arterial anastomosis	1	0.7
Salvaged venous anastomosis	6	4.7
Bleeding	6	4.7
Infection	4	3.1
Salivary fistula	1	0.7
Skin graft	2	1.6
Total	20	15.5
Donor site		
Wound debridement with skin graft	12	9.3
Fasciotomy for compartment syndrome	2	1.6
Amputation	1	0.7
Total	15	11.6

[a]These do not include procedures for complete or partial flap failure.

used with virtual-planning software in preparation for the procedure.[16,17]

Furthermore, ischemia time should be limited to a maximum of 5 hours.[18] This threshold has proven to be a critical point at which flap failure rates increase. This is due to hypoxia of the transferred tissue, which causes cellular and vascular damage that can lead to total partial flap loss.[18] Virtual planning and the use of digital surgical guides can help the surgeon to reduce ischemia time.[16,17] This study did not include ischemia time in the analysis for risk factors of flap failure. This was due to incoherent or absent reporting in the operating reports of this parameter. Finally, close and rigorous postoperative monitoring is key to obtaining good results. If circulation problems do arise and flow cannot be re-established within 8 to 12 hours, the flap has a high chance of failing.[19] Early detection of vascular problems is therefore essential. Bedside clinical monitoring is mostly used by evaluating color, capillary refill, turgor, temperature, and pinprick testing with the addition of Doppler surface monitoring, although the superiority of this method has not yet been confirmed.[20] Other techniques such as implantable venous Doppler probes and contrast-enhanced Doppler are promising but have yet to be confirmed as superior and currently seem less practical.[20] Close monitoring is essential in the first 5 days, the period when a vascular crisis tends to occur.[13]

This study found a statistically significant relationship between younger age and a higher rate of flap failure. The statistical analysis identified a significant relationship but no cutoff value. A total of 65% of patients with a total or partial failure of the FFF were 55 years old or younger. Failure occurred early as well as late postoperatively in this group. A significant relation between younger age and flap failure was identified, but the authors could not provide an evidence-based explanation for this phenomenon. Some reports mention a debatable higher risk of excessive vasospasm in a pediatric population.[21–23] However, previous studies investigating risk factors for flap loss did not identify younger or older age as a risk factor.[9,12] As the included number of patients in this study is low, this finding should therefore be interpreted with caution and should be further studied in larger study groups.

No other statistically significant risk factors were identified. Perioperative radiotherapy was not found to be a risk factor for flap failure, in agreement with other reports.[9,24–26] Chemotherapy also was not identified as a risk factor for flap failure, in contrast to the results of Chang et al,[9] who found an increased flap failure risk with chemotherapy. Higher failure rates in reconstructed defects that included the condyle (H-HC) were noted, although this finding was not statistically significant. In our opinion, this trend could be attributed to the vascular pedicle being more prone to kinking due to its position when reconstructing defects extend to the condyle. Obtaining a tension-free anastomosis with adequate space for the vascular pedicle and providing clear postoperative posture instructions are keys in these cases.

Although failure rates are important, they give only a limited view of the total patient experienced with FFF. Complications are difficult to compare between studies because definitions vary. The present study included every reported complication as defined earlier, yielding a complete overview of all adverse events following FFF reconstruction. Using broad inclusion criteria for complications produced higher numbers of postoperative complications than otherwise found in literature. However, identifying these pitfalls leads to a more complete informed consent as well as an opportunity for optimizing the procedure and perioperative care.

Delayed wound healing at the acceptor site (14.7%) and the donor site (16.3%) was the most reported surgical in-hospital complication, followed by infection of the acceptor site (11.6%). When reconstructing oral defects, a higher risk of infection from the nonsterile environment should be countered with prophylactic antibiotics and adequate flap design. One patient developed an acute arterial crisis of the donor site with ischemic pain refractory to endovascular procedures, which eventually led to amputation of the lower limb. This patient was preoperatively evaluated only with duplex sonography, which showed no anomalies. Today, a CT angiography is always performed to identify vascular anomalies, as recommended.[15]

In-hospital medical complications should not be underestimated because they can cause considerable morbidity and even mortality. Every patient received low-molecular-weight heparin in a prophylactic dose after a FFF procedure. However, three patients still developed a pulmonary embolism, and two patients had a stroke. Three patients died during admission, two with unexplained sudden cardiac

death and one who developed anaphylactic shock caused by vancomycin, given for an extensive infection of the donor site. Cardiac arrhythmia occurred in eight patients, mostly atrial fibrillation. Given the extent of the procedure and the often-fragile patient population, close monitoring during admission and a proper antithrombotic regime using low-molecular-weight heparin in prophylactic dosing is advocated. Delirium occurred in seven patients; this condition can pose a challenge during the first days postoperatively because adequate posture for preventing traction and kinking of the vascular pedicle is key in this period. Delirium should be actively screened for, and rapid intervention is desirable if it occurs. Finally, a relatively high rate of respiratory infections (17.8%) was noted in this study. Given the post hoc finding of a statistically significant association of tracheostomy and respiratory infection, careful clinical evaluation and decannulation as soon as possible should be the goal if tracheostomy is performed.

The number of out-of-hospital complications was high (77.5%), and donor-site morbidity played an important role in this category. Li et al[27] also identified late donor-site morbidity as a frequent postoperative problem using the FFF. Delayed donor-site wound healing occurred in 24.8% of all patients. More important, 17.1% of patients reported a neuromuscular deficit of the donor site, ranging from ankle instability to pain or cramps and paresthesia of the calf. A recent study of Feuvrier et al[28] showed that patients who had had a FFF procedure walked more slowly and had a slower cadence and shorter stride length than control subjects more than 2 years after the procedure. Sieg and colleagues[29] performed a long-term evaluation of donor-site morbidity in FFFs and described a small group of patients with serious donor-site morbidity that led to use of walking aids or persistent sensory or motor deficits. Although the FFF is advocated as being associated with less donor-site morbidity than the iliac crest free flap,[11] some reports claim the opposite.[30] Donor-site morbidity should therefore not be underestimated, and adequate informed consent and postoperative physiotherapy should be provided.[28]

A reduced mouth opening (13.2%) and difficulties with swallowing (11.6%) and speech (6.2%) are also underreported postoperative complications that pose a challenge for postoperative rehabilitation. In 6.2% of patients, marked neurological complaints of the acceptor site were present, including neuropathic pain in the operated region, extensive paresthesia, and absent taste sensation. Although some patients with long-term follow-up showed signs of calcification of the vascular pedicle, no interventions for ossification of the vascular pedicle as described by Autelitano et al[31] were needed.

The FFF procedure still has a high number of postoperative complications resulting in high morbidity for patients in spite of adequate preoperative planning, optimized operative techniques, adequate postoperative care, and close follow-up. This high number of registered postoperative complications should be read in the light of the definition that was used in this study. This study opted to define complication broadly as any unwanted result of the surgery that compromised healing or function as perceived by the patient. An argument could be made that some reported functional complications are inherently bound to this type of surgery (e.g., temporomandibular joint complaints or swallowing difficulties). However, these types of complications are not mentioned by every patient or recorded by the attending physician during follow-up which renders their "inherent character" questionable. Individual perception of complications by patients seems to play an important role in how patients handle postoperative sequelae.

This study reported on failure rates, risk factors, and postoperative complications of the FFF in oral and maxillofacial reconstruction in a low-volume setting. The presented results differ from other reports.[6,9] This can be attributed to several factors. First, strict definitions were set for complete and partial failure. Second, the study opted for a broad view on complications. Finally, these are the results of a low-volume center. An argument can be made that a higher number of procedures lead to better survival rates and a lower complication rate due to more experience and more standardized way of care. However, these results provide a better understanding of the limitations of the FFF in a low-volume center and can be used to optimize care in this kind of setting. The retrospective design is an obvious weakness of the study. Not all data were reported in a standardized way, and some data could not be retrieved. Also, the power of the study was low because the group consisted of only 129 patients. A higher number of patients could have resulted in the detection of other risk factors. The finding that younger age was associated with higher risk of flap failure should therefore be interpreted with caution. In spite of a standardized policy, minor interpersonal differences could have led to different outcomes. Observer and reporter bias in the registration of complications, especially for the out-of-hospital group, could not be avoided given the retrospective design, long study period, and multiple senior surgeons and residents in a residency training program performing the procedures and providing follow-up. On the other hand, the fact that all patients at the University Hospitals of Leuven have had a unique electronic medical patient file since 2007 leaves little room for loss of data for hospitalized patients.

Conclusion

This retrospective analysis reports on a 20-year experience with the FFF in oral and maxillofacial reconstruction at a low-volume tertiary teaching center. Complete flap failure occurred in 12.4% of patients and partial flap failure in 7.8% of patients. Most failures were caused by venous thrombosis, and younger age was associated with higher flap failure. Other statistically significant risk factors could not be identified. Postoperative complications were frequently recorded. Out-of-hospital complications occur in most patients, and donor-site morbidity should not be underestimated. Close postoperative follow-up and rehabilitation are essential. These results provide a better understanding of the limitations of the FFF in a low-volume setting and should lead to further improvement of patient care.

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