Microsurgical Free Flap Reconstructions of Head and Neck Region in 406 Cases: A 13-Year Experience

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Purpose: The reconstruction of extended soft tissue and bony defects in the maxillofacial region with microsurgical flaps is considered to be the therapy of first choice. The aim of this retrospective study was to detect different influencing factors concerning flap survival.

Materials and Methods: We examined the data of 406 patient cases (121 female and 285 male cases; mean age, 57 years) undergoing reconstruction with a microsurgical flap in our facility between 1998 and 2010. In these cases 326 soft tissue flaps (radial forearm flap, scapula flap, latissimus dorsi flap, anterolateral thigh flap, lateral arm flap, and jejunum flap) and 80 bony flaps (fibula flap and deep circumflex iliac artery flap) were examined. Evaluated parameters were, among others, the timing of reconstruction, defect localization, and recipient vessels used (external vs internal jugular system), as well as anticoagulative management. We statistically analyzed data by means of a χ^2 test, taking account of the odds ratio with $P < .05$, which was deemed significant.

Results: The overall flap survival rate was approximately 92%, without any gender- or age-specific differences. Primary reconstructions proceeded distinctly more successfully than secondary reconstructions ($P < .01$). Likewise, the defect localization exerted a significant effect on the survival rate ($P = .01$), with a more caudal localization affecting flap survival positively. Finally, neither the anticoagulation regimen nor the choice of recipient vein system exercised an influence on the survival rate.

Conclusions: Microsurgical tissue transfer is a convenient and reliable method in maxillofacial surgery, provided that one is aware of the determining factors for success.

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In the maxillofacial region, microsurgical tissue transfer to cover extensive defects after ablative tumor surgery and severe trauma and inflammation—or from severe hereditary-related facial asymmetry—is currently considered to be the therapeutic gold standard.[1,2] Microsurgical tissue transfer requires well-founded anatomic knowledge and extensive surgical experience, and it is associated with a more or less severe comorbidity in patients, wherefore it still presents an extraordinary challenge in every single case.[3-5] Since, in 1959, Seidenberg et al[6] first described a microsurgical tissue transfer in the form of a jejunum flap to cover an esophageal defect, it has taken several years to develop more flaps for routine clinical use.[1,7] In 1975 the Australian working group led by Taylor et al[8] introduced the fibula free flap as the first microsurgical bone graft, which has meanwhile become an essential element in reconstructive surgery of the facial skeleton.[9-12] Another important milestone was the first description of the vascularized radial free forearm flap (RFF) in the early 1980s, which undoubtedly played a prominent role in soft tissue replacement in the head and neck region.[1,2,13-16] Apart from the fact that the RFF offers a long pedicle, its great advantage is that it can be used for both intraoral and extraoral defects because of its pliability and its low thickness in most cases.[16-18] In addition to the fibula free flap, frequently used as osteocutaneous graft for reconstruction of composite bone and soft tissue defects, the microvascular iliac crest bone flap (deep circumflex iliac artery [DCIA] flap) is particularly suited for mandibular reconstruction because of its large bone offer.[5,7,19-21] However, because of its comparatively unreliable skin paddle, it is not the first choice for composite defects.[11,12,22,23]

The objective of this study was to detect and analyze success and failure parameters for microsurgical

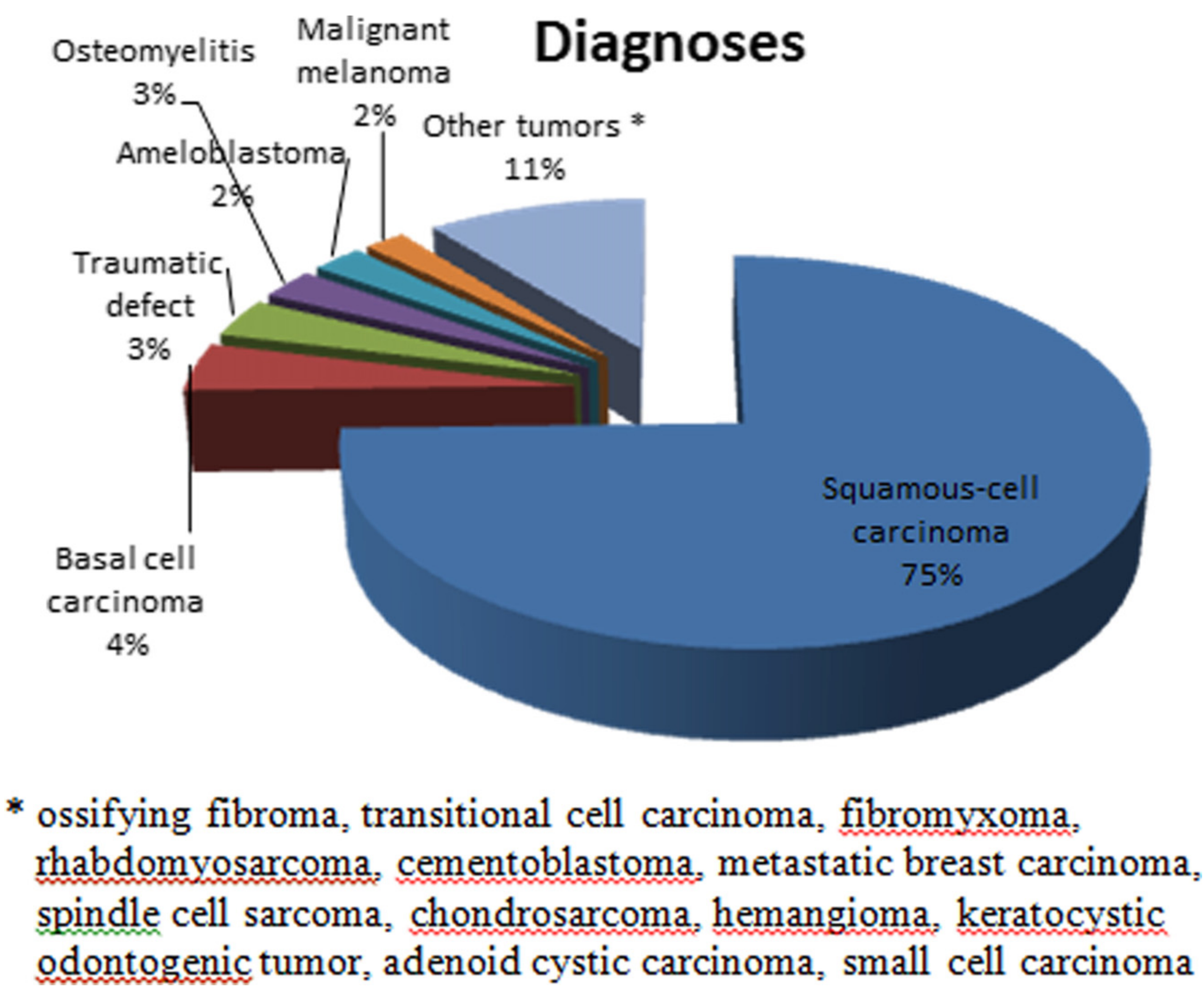

FIGURE 1. Distribution of different diagnoses leading to free flap transfer.

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Table 1. DEFECT LOCALIZATION

	%
Caudal position	63.7
Mouth floor	22.7
Mandible	21.2
Tongue	13.6
Mouth floor and tongue	6.2
Cranial position	14
Maxilla	7.6
Cheek extraorally	6.4
Miscellaneous	22.3

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tissue transfer in the oral and maxillofacial area on the basis of our 13-year microsurgical experience.

Materials and Methods

In a retrospective analysis, we recruited 373 patients undergoing a total of 406 microsurgical reconstructions, all of which were conducted at the Department of Oral, Maxillofacial and Plastic Facial Surgery at the University Hospital of the Aachen University (RWTH), Aachen, Germany, between 1998 and 2010. Only cases with sufficient documentation (with a minimum requirement of complete patient records including surgical reports, as well as the outpatient record with follow-up examinations) were included in the follow-up of our study. In addition to the systematic record research, documents of the internal hospital patient administration system were used for data acquisition. The mean age of the 121 female cases (29.8%) and 285 male cases (70.2%) was 57 years, with the youngest patient being aged 12 years and the oldest patient being aged 87 years. In 303 cases the patients had squamous cell carcinoma representing, with a frequency of 74.6%, by far the most common diagnosis, followed by basal cell carcinoma, traumatic defect, osteomyelitis, ameloblastoma, and malignant melanoma. The remaining cases form a heterogeneous group of other malignant and benign tumors (Fig 1). In the course of the 13 examined years, 326 soft tissue flaps (80.3%) and 80 bone flaps (19.7%) were harvested; in 33 cases a combined reconstruction was conducted in a 2-stage approach: the soft tissue defect was primarily covered by an RFF, whereas the bony reconstruction was performed in a second step with a DCIA flap. Patients were pre-irradiated ($\geq$30 Gy) in 60 cases (14.8%). The exploratory data analysis produced relevant objective parameters that were qualified to determine the surgical success; these included the diagnosis that led to the surgical procedure (Fig 1), as well as the defect localization in the craniocaudal direction. To be precise, the resulting or existing defect was allocated to a caudal or cranial position with reference to the facial skeleton (Table 1). The presence of atherosclerosis or an arteriosclerotic risk profile turned out to be another potentially important factor. Such a risk profile was expected in the case of proven peripheral

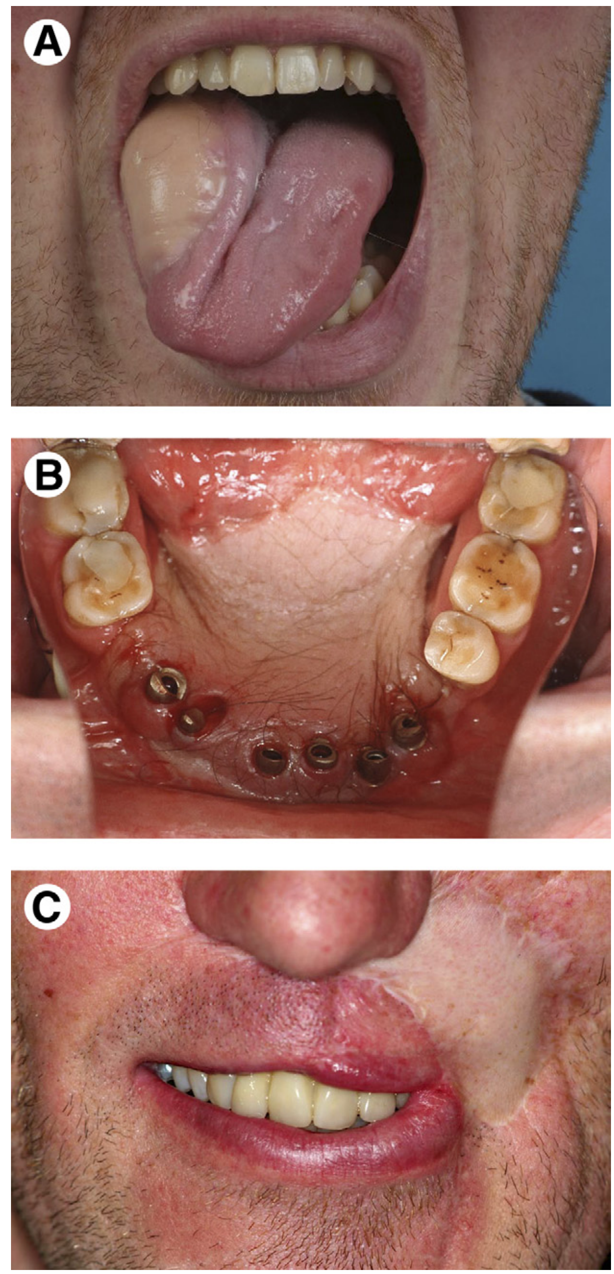

FIGURE 2. *A*, A 29-year-old male patient after reconstruction of the tongue with an RFF because of squamous cell carcinoma. *B*, An RFF for reconstruction of the anterior mouth floor in a 61-year-old man after resection of a squamous cell carcinoma. *C*, An RFF for cheek replacement after resection of an adenoid cystic carcinoma of the upper lip in a 50-year-old male patient (in combination with a cross-lip Estlander flap).

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Table 2. TYPES OF VASCULARIZED FREE FLAPS

	No.	%
Soft tissue	326	80.3
Radial forearm	285	70.2
Scapula	14	3.5
Latissimus dorsi	14	3.5
Latissimus dorsi and scapula	4	1.0
Jejunum	3	0.7
Anterolateral thigh	3	0.7
Lateral arm	3	0.7
Bone	80	19.7
Osseous iliac crest	59	14.5
Osteocutaneous iliac crest	2	0.5
Osseous fibula	4	1.0
Osteocutaneous fibula	15	3.7

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arterial disease or coronary heart disease and, likewise, in the case of the presence of at least 2 of the following risk factors: nicotine consumption, diabetes mellitus, hypertension, and obesity.[24,25] The focus was also directed at the timing of reconstruction (therapeutic concept), that is, whether the primary treatment included complete microsurgical reconstruction or whether the reconstruction was performed in a second surgery, and the perioperative management of anticoagulation, which was modified over time. In fact, in 75.25% of cases, patients received 15,000 to 25,000 IU of unfractionated heparin per day intravenously (target partial thromboplastin time of up to 1.5× local reference standard) (until 2007); whereas in 24.75% of cases, patients underwent anticoagulation subcutaneously with low–molecular weight heparin (LMWH) in a double thrombosis prevention dose (from 2008 onward). In all cases, heparinization was performed for at least 7 days, depending on the postoperative mobility of the patient, and beginning on the day of surgery. Furthermore, we analyzed whether the recipient side at the neck (homolateral vs contralateral) and the venous recipient vessels (internal jugular system [79.6%] vs external jugular system [20.4%]) play a crucial role for successful microsurgical tissue transfer.[26] In this context, we also examined a possible correlation between flap survival and the venous anastomosis technique (end-to-end vs end-to-side). All end-to-side anastomoses were performed with the internal jugular vein because of its large caliber. By contrast, end-to-end anastomoses were conducted with either the external jugular system or side branches of the internal jugular vein.

Data were collected in tabular format with Microsoft Excel (version 2010; Microsoft, Redmond, WA), and the data were filtered according to all eligible target parameters for the subsequent statistical analysis. To statistically compare the calculated flap success rates, we performed a χ^2 test, taking into account the odds ratio (OR) with a confidence interval (CI) of 95%. Effects were considered significant when the P value did not exceed the 5% level. All statistical computations were performed with Statistical Analysis System software (SAS 9.1, TS1M3; SAS Institute, Cary, NC) under Windows XP (Microsoft).

This study was approved by the Aachen University Hospital Institutional Review Board.

Results

Among the soft tissue grafts, the RFF was the flap most often harvested in our patients, with a total of 70.2% in 285 cases (Fig 2), followed by the latissimus dorsi flap and scapula flap, with 3.5% each, and the jejunum flap, the lateral arm flap, and the anterolateral thigh flap, with 0.7% each. The distribution of the individual grafts is presented in Table 2. In 4 cases a combined latissimus dorsi–scapula flap was harvested because of several defect sites (intraorally and extraorally) (1%). Regarding free vascularized bone grafts, the osseous or osteocutaneous DCIA flap ranks first, with 61 cases overall (15%) (Fig 3). The total number of osteocutaneous or osseous fibula free flaps, however, is comparatively small, with just 19 cases (4.7%).

In 406 procedures with microsurgical transplantations, lasting on average 430 minutes, 371 ran successfully, whereas in 35 cases total flap loss occurred, so the overall success rate was 91.4%. Patient age, gender, type of flap (soft tissue vs bone and combined flaps), and presence of atherosclerosis exerted no significant influence on flap survival (P = .0712 for age, P = .1511 for gender, P = .174 for flap type, and P = .8796 for presence of atherosclerosis). Flap revision became necessary in 50 cases (12.31%), which meant either evacuation of hematoma (28%) or revision of the anastomoses (72%). In this respect, the venous anastomosis or venous shank (48%) was affected twice as much by a passage obstacle (thrombus, ablation of the intima with consecutive thrombus formation) as the arterial shank (24%). The proportion of successfully proceeded flap revisions with restoration of regular circulation of the graft stood at 46%, whereby the mean time between the end of surgery and flap revision amounted to 38.6 hours. Of all revisions, 12% were conducted within the first 10 hours (minimum, 6.7 hours) after surgery. When we compared these survival data with the remaining 88% of the flaps that were revised later (10-96 hours), no statistically significant difference could be observed (P = .081).

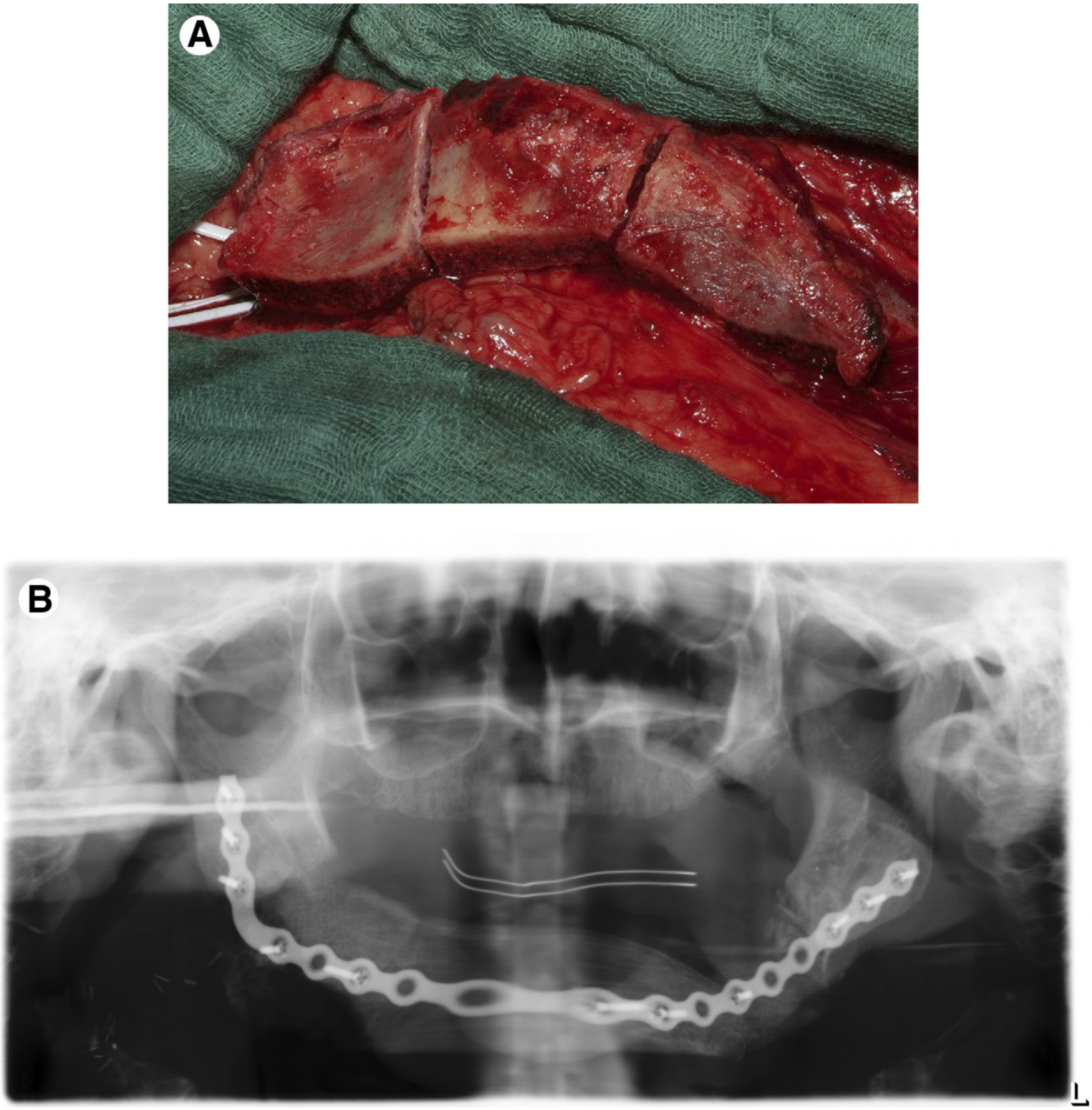

FIGURE 3. *A*, Harvested and osteotomized DCIA flap. *B*, Panoramic radiograph showing the postoperative result after subtotal replacement at the mandibular body by the DCIA flap.

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The perioperative mode of anticoagulation did not have any significant effect on survival either (P = .0964). With regard to the type of anastomosis between the flap and the recipient veins, the end-to-end anastomoses (90.67%) were predominant compared with the end-to-side anastomoses (9.33%). However, this variation in venous anastomosis technique exerted no significant effect on the flap success rate (P = .4062). Similarly, no clear distinction resulted from the selection of the recipient vein system with regard to an increased rate of complications or thrombosis (P = .1071). Rather, the 95% CI of the OR indicates comparable survival data for both vein systems in the microvascular anastomosis (OR, 0.5200; 95% CI, 0.2322-1.1646).

Quite the contrary, the recipient side of the vessels in the neck in relation to the defect site reconstructed by the microsurgical flap turned out to be of fundamental importance for a successful transplantation. However, a statistically significant influence in favor of the homolateral side could only be proved for the RFF. For all remaining flaps, the homolateral connec-

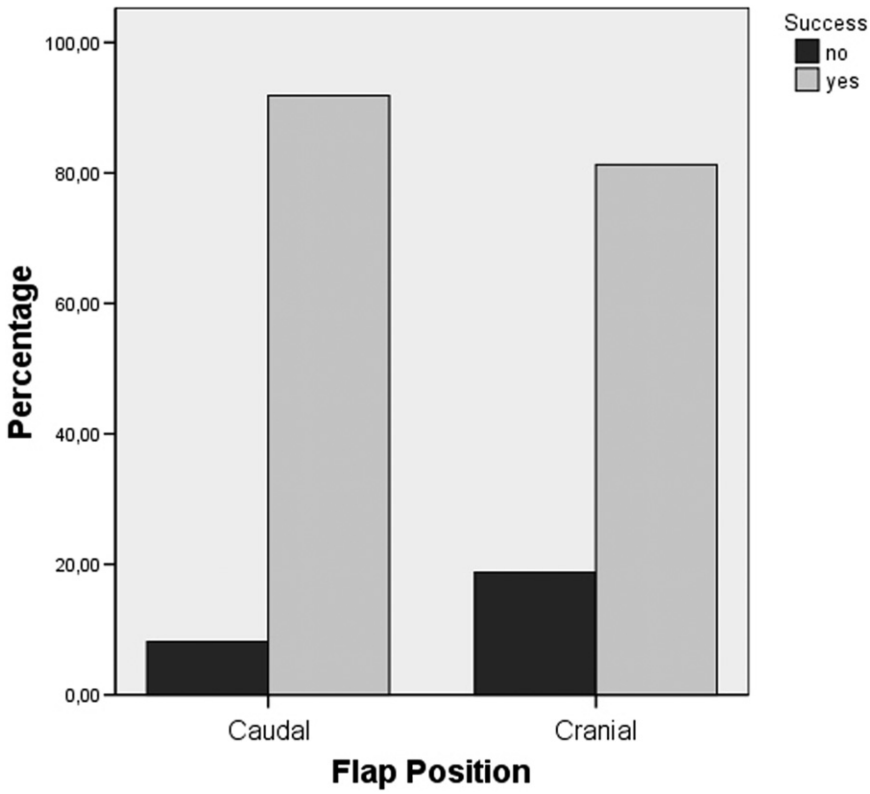

FIGURE 4. Comparison of survival data between cranially and caudally localized flaps.

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tion led to higher success rates, but without statistical significance. Accordingly, the survival rate for all RFFs anastomosed on the homolateral side of the neck was 95.3%, compared with 87.2% for the RFFs anastomosed contralaterally (P = .0328) (OR, 2.5527; 95% CI, 1.0552-6.1756).

Similarly, defect localization played an important role for graft survival. By far, the largest portion of all flaps (80.12%) was used for the lower part of the face (tongue, mouth floor, and composite defects [ie, caudal position]). In comparison to the 19.9% of flaps that were cranially positioned (outer cheek, maxilla including soft palate), showing a success quota of 83.7%, we observed a significantly higher survival rate (93.3%) for the transplants in a more caudal position (P = .0122) (OR, 2.6044; 95% CI, 1.2057-5.6257) (Fig 4).

Likewise, the timing of reconstruction significantly affected flap survival. Of the flaps transplanted within a 1-stage procedure, 94.8% survived, whereby primary surgery was combined with microsurgical reconstruction in 60.76% of all cases. In the remaining cases (39.24%), reconstruction by means of a microsurgical flap was conducted in a second surgery, associated with a notably lower success rate of 86.14% (P = .0042).

Discussion

Extensive soft tissue and bony or combined defects in the maxillofacial area have always represented a major challenge for every reconstructive surgeon in terms of the best possible esthetic and functional rehabilitation. In this context microsurgical tissue transfer is indispensable in most cases. Over the past 50 years, several developments of microsurgical techniques and a variety of potential flaps have been described, such that a suitable microsurgical solution is available for almost all indications.[10,12,27-29] The RFF has established a reputation as a very reliable workhorse flap for soft tissue replacement; along with its widely recognized benefits, it offers the possibility of safe venous drainage by preparing several flap veins together with the prospect of a sensitive reinnervation either by coaptation of an additionally transferred skin nerve or spontaneously.[1,4,15,26,30,31] The integration of the palmaris longus tendon into the flap for reconstruction of the perioral muscle sling is just 1 example of its large variability.[11,32] Consequently, the RFF is by far the leading transplant in our facility, with a share of 70.2%. The significantly higher survival rate of 95.3% for the homolaterally anastomosed RFFs, when compared with the contralateral group (87.2%), is remarkable, because the pedicle is usually so long that its positioning on the ipsilateral side is much more difficult and often associated with a kind of loop formation, leading to the risk of pedicle torsion. However, presumably, the relatively long course beneath the subcutaneous tissue or the platysma is responsible for the fact that anastomoses on the contralateral side may appear less safe. Because of postoperative swelling and hematoma, there is no space for the pedicle to evade, which is why it can be easily clamped, particularly in the medial neck region. Over and above these factors, the head turning in both directions potentially leads to obstruction, especially of the more easily compressible veins.

Analogously, the significant difference in survival rate of transplants in the caudal position (93.3%) and cranial position (83.7%) can be explained. Thus the influencing factor "localization" seems to play an important part for flap success rate; however, the description of this issue is deficient in the available literature.[2,4,29] In fact, the pedicle of cranially incorporated flaps has to cover a considerably longer distance covered by soft tissue or throughout the deep face spaces and is, therefore, in danger of being compressed by the surrounding structures. In maxillary defects, by way of example, the vascular pedicle is frequently channeled through the intermaxillary fold and the lingual side of the ascending mandibular ramus to the submandibular region, implying pressure onto the vessel with every movement of the mandible. In theory, the risk of compression could be limited by anastomosis to the superficial temporal vessels, but in our experience they are less suitable as recipient vessels because of their delicate caliber and the frequent occurrence of vasospasm due to manipulation.[3]

Our therapeutic proceeding essentially depended on 2 factors: *1)* the general condition of the patient, which reduced the length of anesthesia in many cases; and *2)* whether bone resection had to be performed. In the case of bone involvement, we usually preferred a 2-stage procedure to preserve the possibility of a re-resection. Beyond that, in the case of a necessary soft tissue reconstruction in combined defects, the DCIA flap was inserted secondarily as a purely osseous graft according to our internal guidelines. For the investigated collective, there was a considerably better success rate of 94.8% for the 1-stage therapeutic concept, well above the global flap survival rate of 91.4%. This result is in line with the experiences described in the literature, also advocating greater chances of success in a 1-stage procedure.[33]

In contrast, the type of perioperative anticoagulation seems to play a subordinate role. Over the 13 years under study, a clear trend could be observed away from intravenous anticoagulation with unfractionated heparin toward LMWH administered subcutaneously. This development can be explained by the fact that, since the 1990s, LMWH has gained more and more acceptance as a reliable potent anticoagulant because of improved dose-effect relationships and its relatively simple delivery system with excellent bioavailability.[34] Our data confirm that LMWH can be used equivalently to unfractionated heparin without a negative impact on the success rate. In the literature, the benefit and type of anticoagulation are controversial. The generally higher risk of bleeding with the formation of pedicle-compressing hematomas and the possible occurrence of heparin-induced thrombocytopenia II with thrombotic vascular occlusion are opposed by the disputable benefit of perioperative blood thinning with heparin.[3] Much more important for a functioning vascular anastomosis than anticoagulation might be the skill of the surgeon, who should comprehensively master the microsurgical technique.[3,35]

Furthermore, our collected data suggest that both the internal and external jugular systems are equally appropriate for venous anastomosis. In contrast to our findings, other studies describe a significantly higher failure rate in anastomosing the flap to a vein of the external jugular system on the grounds that the vessel caliber is smaller and the blood flow is slower when compared with veins of the internal jugular system.[26,36] According to the physical laws of Bernoulli, quite the opposite ought to be true, because with decreasing vessel diameter, the flow rate actually increases. There was not a noticeable or even statistical significance when we compared the venous technique of anastomosis (end-to-end vs end-to-side), although it has to be remarked critically that the proportion of end-to-side anastomoses was relatively low, at approximately 9%.

The unprettified overall survival rate of 91.4%, considering all flaps, is similar to the survival rates of 90% to 100% mentioned in the literature.[1,3,7,12,22,29,37,38] Speculatively, some aspects can be mentioned that could have led to a failure rate of no less than 8.6%. Indeed, many of the patients were pre-irradiated, alio loco, or multiply operated. Another point is possibly the hesitancy with proceeding with regard to flap revision. Thus our revision success rate of 46% was minor in comparison to the 63.7% rate of successfully performed revisions by Chen et al,[39] published in 2007. Although no statistically significant difference in the success rate emerged between revision within the first 10 hours after surgery and that later on, the time interval from the occurrence of the first symptoms, indicating a possible flap failure, until revision is, however, considerably more important.

Our microsurgical experience recorded in this study shows that, in line with the results of other study groups, microsurgical flap transfer is particularly successful in the long-term if one is equipped with the necessary infrastructure as well as experience. One should rather restrict his or her scope to a small number of well-established flap types that are well mastered.[2,4,11,37] Neither atherosclerosis nor advanced age, a priori, constitutes a contraindication to microsurgical reconstruction. In any case, the positioning of the pedicle should be thoroughly considered and carefully conducted. Whenever possible, primary reconstruction should be undertaken.

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