Shoulder Morbidity in Patients after Head and Neck Reconstruction with the Pedicled Supraclavicular Island Flap

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Background: The pedicled supraclavicular artery island flap (SCAIF) for reconstruction of the head and neck has been shown to be a pliable alternative to established pedicled flaps, such as the pectoralis major myocutaneous flap. Because there are limited published data regarding shoulder morbidity after SCAIF procedure, we aimed to investigate it with 2 established questionnaires for the upper extremity [Constant-Murley score and Disabilities of the Arm, Shoulder and Hand Outcome Measure (DASH) score].

Methods: The authors designed and implemented a retrospective cohort study of patients who received a defect reconstruction by SCAIF. Analyzed parameters were demographics, comorbidities, donor-site morbidity and shoulder morbidity in terms of range of motion, pain, strength, and daily activities evaluated and compared between the donor site and contralateral arm.

Results: Of the 61 consecutively performed head and neck reconstructions with SCAIF, 20 met inclusion criteria (curative intended treatment, head and neck squamous cell cancer, follow-up time more than 4 months). Mean follow-up was 17.3 months (±10.4 months) ranging from 4–35 months. Donor-site complication rate was low with 5% major (surgical revision) and 30% minor complications (conservative management). Overall Constant-Murley-Score ($P = 0.334$), pain ($P = 0.150$), overall range of motion ($P = 0.861$), and strength of the extremity ($P = 0.638$) of the shoulder receiving a SCAIF showed no significant differences to the contralateral extremity. Mean of Disabilities of the Arm, Shoulder and Hand Outcome Measure score was 32.5 (±28.6).

Conclusion: The results of the present study suggest very low shoulder morbidity in patients after SCAIF procedure with no significant functional impairment of the donor shoulder compared with the contralateral side. *(Plast Reconstr Surg Glob Open 2018;6:e1711; doi: 10.1097/GOX.0000000000001711; Published online 12 April 2018.)*

INTRODUCTION

The supraclavicular artery island (SCAIF) flap is an axial pedicled fasciocutaneous flap supported by the supraclavicular artery. In the last 10 years, it has increasingly been used to reconstruct complex oncologic defects in the head and neck region, which provides a reconstructive challenge.[1,2] These reconstructions do not only cover 3-dimensional defects but also aim to restore swallowing function and production of speech.

In 1979 Lamberty[3] first described the SCAIF as an axial pedicle flap. It was hardly used during the 80s and 90s due to reported high incidence of necrosis and poor reliability and widespread use of the pectoralis major myocutaneous flap (PMF) and the radial forearm fasciocutaneous free flap (RFFF).[4]

Pallua et al.[5,6] extensively described the anatomy and physiology of the flap, reporting several successful cases in the reconstruction of cervicomental scar contractures and since then, it has increasingly been used in head and neck

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reconstruction. It currently provides a reliable alternative regional flap and has been used in the reconstruction of sternal, cervical, pharyngeal wall, oromandibular, and posterolateral skull base defects.[7–11]

Long-term functional donor-site morbidity presents 1 of the significant factors that need to be taken into consideration before selecting the mode of reconstruction in head and neck surgery. Several publications have documented donor-site morbidity for all reconstruction options that are traditionally used in oncologic procedures of the head and neck including the PMF, deltopectoral flap, trapezius flap, and microvascular free flaps such as the RFFF or anterolateral thigh free flap.[12–22] Regarding the SCAIF, flap harvest is easy and the donor site wound can be closed primarily in defects up to 7 cm width compared with the RFFF in which a skingraft is required for secondary closure.[23]

During flap harvest, the supraclavicular nerves are very likely to be dissected. Those are superficial sensory nerves that provide sensation over the clavicle, anteromedial shoulder, and proximal chest. Originating from the C3 and C4 nerve roots of the superficial cervical plexus, these nerves arborize proximal to the clavicle.[24–26] Preservation during surgery is challenging due to high variety in branching pattern and unknown distances of the nerves from anatomic landmarks. However, the surgical technique of flap harvest does not require the dissection of any major motor nerve nor does it incorporate any of the muscles which act on the shoulder girdle. Thus, should not lead to severe functional impairment and preservation of shoulder strength and range of motion (ROM). By now, several studies have reported a low recipient-site morbidity and mortality, with low rate of surgical-site infection.[8–10,27–31]

Herr et al.[32] is the only group that has formally assessed the effects of SCAIF harvest on shoulder strength and flexibility, showing that SCAIF produces limited postoperative morbidity at the donor site even when incorporating large flap volumes. The present study aimed to evaluate donor-site morbidity and shoulder function in a larger cohort of patients operated in our institution between May 2014 and December 2016.

METHODS

The study is based on a retrospective data analysis of 61 consecutive patients with advanced head and neck squamous cell cancer (HNSCC) who received a SCAIF procedure with intention to treat, or after cancer therapy at the Department for Otorhinolaryngology of the University Medical Center of the Georg-August-University Goettingen Germany between May 2014 and December 2016. All patients underwent neck dissection (ND) and SCAIF for reconstruction, either simultaneously or in their past medical history (PMH). The follow-up time was at least 4 months to the date of surgery. The study was approved by the institutional board.

Patients and Methods

We included all patients receiving SCAIF for reconstruction of head and neck tumor defect or for closure of pharyngeal fistula after cancer therapy. Inclusion criteria comprised curative intended treatment, HNSCC, and follow-up time more than 4 months. Patients who underwent more than 2 flap procedures were excluded.

The data included patients' demographics, PMH, smoking history and alcohol consumption, indication for SCAIF procedure, adjuvant therapy, and postoperative donor-site complications (major complication = required surgical intervention, minor complications = managed conservatively[23]). Cancer treatment in the head and neck before the SCAIF procedure was recorded and evaluated. The HNSCC tumor stage was categorized using the Union for International Cancer Control TNM seventh edition classification. The hospital's electronic database, paper charts, documentations of the procedures and 2 different types of questionnaires for assessment of the shoulder function were used for data collection.

All flap procedures were performed with the standard technique as described by several authors.[7,8,30,48] Before the dissection, the length of the flap needs to be assessed and the anatomical landmarks (clavicle bone, sternocleidomastoideus muscle and trapezoid muscle) identified. As mentioned above, defects up to 7 cm width can be closed primarily.[23] With a Doppler-ultrasound the pedicle of the flap, the supraclavicular artery, is detected and marked to its very lateral site (**see Supplemental Digital Content 1**, which displays anatomical landmarks. Using the doppler-ultrasound to detect the supraclavicular artery, *http://links.lww.com/PRSGO/A737*). Measuring from the last sonographic mark point, the maximum length a flap can be harvested to maintain a sufficient blood supply, is 5 cm lateral from it[23] (**see Supplemental Digital Content 2**, which demonstrates measuring the lateral end of the SCAIF, *http://links.lww.com/PRSGO/A738*; **see Supplemental Digital Content 3**, which displays landmarks and flap before the flap harvest, *http://links.lww.com/PRSGO/A739*).

After performing the subfascial dissection, a subcutaneous tunnel is formed, the required area de-epithelialized and the defect closed (**see Supplemental Digital Content 4**, which displays the harvested SCAIF with the de-epithelialized pedicle, *http://links.lww.com/PRSGO/A740*). The donor-site defect was closed primarily in a 2-layer suture with a compact cutaneous suture. Two surgical drains were applied, 1 at the donor site and the other one at the pedicle. A compression dressing was applied for 2 days, and patients were mobilized as soon as the first dressing was changed. All patients received an early swallowing and physical rehabilitation as soon as the dressing came off around the tenth postoperative day during the hospital stay.

Shoulder Morbidity Assessment

Assessment of the shoulder morbidity was achieved by 2 questionnaires. On the 1 hand, we used the Constant-Murley-Score (CS), an established tool to evaluate pain, daily activities, ROM, and strength of the shoulder.[33,34] It is 1 of the first shoulder score systems developed and considered the most frequently applied scoring system for the evaluation of various disorders of the shoulder. The CS is a validated questionnaire and often used to evaluate treat-

Table 1. Parameters of the Constant-Murley Score

	Parameter CS	Score
Pain	"None," "light," "moderate," "high"	0–15
Daily activities		0–4
Work	"0%," "25%," "50%," "75%," "100%"	0–4
Recreation	"0%," "25%," "50%," "75%," "100%"	0–4
Affected sleep	"Severe," "moderate," "none"	0–2
Arm positioning	"Up to waist," "up to xiphoid," "up to neck," "up to top of head," "above head"	2–10
ROM		0–40
Flexion	"0–30°," "31–60°," "61–90°," "91–120°," "121–150°," "151–180°"	0–10
Lateral elevation	"0–30°," "31–60°," "61–90°," "91–120°," "121–150°," "151–180°"	0–10
External rotation	"Hand on scalp, elbow forward"	2
	"Hand on scalp, elbow to the side"	2
	"Hand on occiput, elbow forward"	2
	"Hand on occiput, elbow to the side"	2
	"Above head"	2
Internal rotation	"Lateral thigh," "buttock," "lumbosacral junction," "waist (L3)," "T12 vertebra," "interscapular region (T7)"	0–10
Strength of abduction	1 point equals 1 pound (= 0.45 kg)	0–25
Total score		100

ment progress and to compare results of clinical trials for several specific shoulder disorders. It analyzes the subjective functionality in daily challenges.[35] All categories and parameters are listed in Table 1. The score adds up to a maximum of 100 points, which correlates with a fully functioning extremity without any impairment. Evaluation of the CS was performed on both extremities. In addition to the CS, the "Disabilities of the Arm, Shoulder and Hand Outcome Measure"-score (DASH) helped to analyze the subjective management of daily tasks and problems within 30 items. The score ranges from 0 to 100, which is synonymous with a high impairment in the assessed extremity. Standard score in a normal cohort, without any disorder of the upper limb, has been shown to range between 10 and 13.[36,37] Pain sensation was assessed via a visual analog scale. Moreover, the patients were questioned for sensation issues in the donor site, such as numbness, pain, and paresthesia in terms of temperature or phantom sensation and tingling.

At the postsurgical routine oncologic consultation, each patient was asked to participate in the study and consented to the evaluation. They filled out the questionnaires and were examined using objective shoulder function tests that are included in the CS. Those patients without planned consultation received the questionnaires via mail.

Statistical Analysis

The data were statistically analyzed with the program R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria). Before comparison of donor site and contralateral extremity, the Kolmogorov-Smirnov goodness-for-fitness test assessed no normal distribution. To test for equality of variances, the Levene test was performed. Regarding comparing analysis, the chi-square test and the Wilcoxon-Mann-Whitney *U*-test was applied. Differences were considered significant at *P* values less than 0.05.

RESULTS

Between May 2014 and December 2016, 61 consecutive head and neck reconstructions with SCAIF were performed at the Department for Otorhinolaryngology of University Medical Center of the Georg-August-University Goettingen. After applying the inclusion and exclusion criteria, we identified 20 patients who underwent reconstructive head and neck surgery using a SCAIF. The mean follow-up time was 17.3 months (±10.4 months) and ranged from 4 to 35 months.

Patients' Demographics and History

Twelve patients (60%) were male and 8 (40%) female. The mean age was 66.7 years (±7.1 years). Sixteen patients (75%) had a flap procedure due to primary tumor; 2 patients had a recurrent tumor, and in 3 patients, SCAIF was performed to reconstruct a persistent fistula after cancer treatment.

Six patients (30%) had previous malignancies, and 5 of these received adjuvant radiochemotherapy (RCT). Thirty-five percentage of the included patients had no PMH before the diagnosis of HNSCC. The other 65% had at least an underlying cardiovascular disease and more than 1 other systemic disease. The PMH data are depicted in Table 2. None of the study cohort cases had a history of previous shoulder surgery, dysfunction, or trauma. All patients received tumor resection and ND, 17 (85%) bilateral ND, and 3 (15%) unilateral. In 90%, ND was performed simultaneously to the flap harvest, 10% received ND before the SCAIF procedure. In all cases, level V was resected. Eleven patients (55%) received adjuvant RCT following the surgery and were in remission at the time of last follow-up. Six patients (30%) did not undergo any adjuvant therapy, 2 (10%) rejected adjuvant treatment and were subsequently diagnosed with a recurrence, and 1 patient (5%) rejected the aRCT and was in remission at the time of last follow-up.

Complications, Accessory Nerve, and Dominant Extremity

Thirteen patients (65%) had no postoperative donor-site complications. Only 1 patient (5%) required a surgical wound revision (major complication). Six patients (30%) had a minor complication (Table 3). In 85% (n = 17), the accessory nerve could be preserved during the ND and SCAIF procedure, and only 1 patient required a radical

Table 2. Demographics and History

Demographics and History	n	(%)
Indication		
Primary tumor	15	75
Recurrence	2	10
Fistula	3	15
Therapy		
Reconstruction with SCAIF	2	10
Tumor resection, ND both sides, reconstruction with SCAIF	15	75
Tumor resection, ND ipsilateral, reconstruction with SCAIF	3	15
Adjuvant therapy		
None	6	30
Radiotherapy	11	55
Recurrence—palliative	2	10
Rejected	1	5
PMH		
Cardiovascular risk factor	1	5
Two secondary diseases	6	30
Three secondary diseases	2	10
More than 3 secondary diseases	1	5
Other oncologic disease	2	10
Other disease	1	5
None	7	35
Smokers and alcohol consumption		
Alcohol	8	40
Current smoking	13	65
Both alcohol and smoking	8	40

Table 3. Donor-site Complications

Complications	n	(%)
Complications donor site		
None	12	60
Impaired wound healing	5	25
Dehiscence	3	15
Therapy donor site		
None	13	65
Secondary wound healing	6	30
Wound revision	1	5

ND with resection of the accessory nerve on the donor side. Regarding the remaining 2 patients, there were no data about the preservation of the accessory nerve. In half of the patients (n = 10), SCAIF originated from the dominant extremity.

Shoulder Morbidity

The analysis focused on the following 4 main categories: pain, strength, ROM, and daily activities. Mean value of total CS was 65.5 (±20.0) on the donor extremity and 71.4 (±28.2) on the contralateral side. Statistical analysis of total score of the CS showed no significant difference between the donor and the contralateral shoulder side ($P = 0.334$; Fig. 1). Comparison of pain was quantified by a visual analog scale in both extremities, and no significant differences were identified ($P = 0.150$). Half of the cohort reported no pain at all on the operated extremity (Fig. 2). Strength of abduction was assessed for both extremities and showed no significant difference ($P = 0.638$; Fig. 3). The analysis for ROM included internal and external rotation, lateral elevation, and flexion. There was no significant difference identified in any of the ROM between the donor and con-
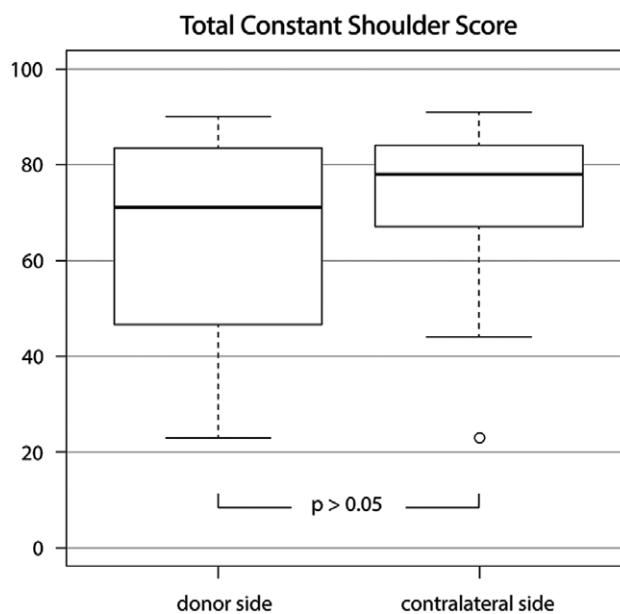

Fig. 1. Mean value of total constant score was 65.5 (±20.0) on the donor extremity and 71.4 (±28.2) on the contralateral side.
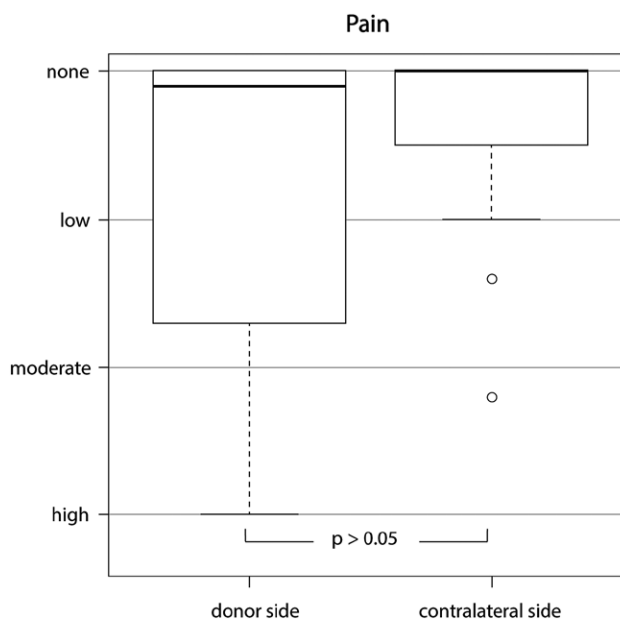

Fig. 2. Mean value of the donor site extremity was 10.8 (±5.02) and 13.0 (±5.39) on the contralateral side.

tralateral extremity (all $P \geq 0.05$; Table 4). Analysis showed that 40% of the cohort did not complain of any impairment affecting daily activities, and sleep was not affected at all in 60% (Table 5). The DASH was analyzed in the donor extremity only, with the mean value being 32.5 (±28.6) and single values ranging from 0 to 91.7 (Fig. 4). Fifteen patients (75%) reported numbness at the donor site, and 4 (20%) of a tingling sensation. Five (25%) patients did not complain of any paresthesia at all. None of our patients reported temperature or phantom sensation at the donor site during the consumption of meals or fluids.
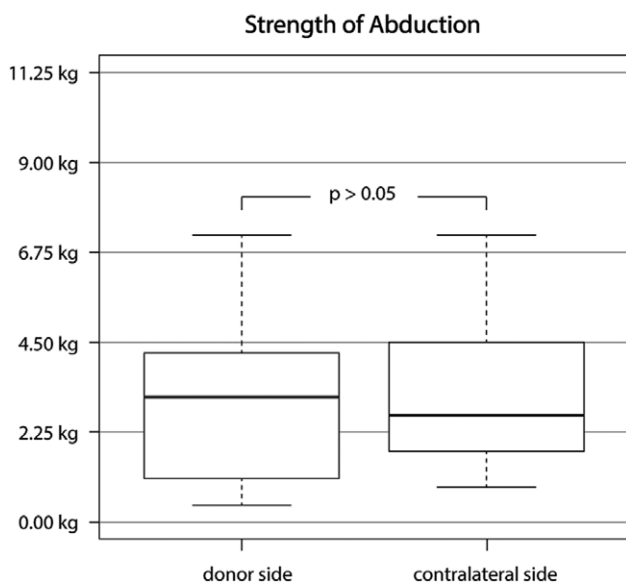
Strength of Abduction

Fig. 3. The mean value for the donor extremity was 6.80 (±4.54) and for the contralateral side 7.17 (±4.62).

Table 4. Range of Motion: The Analysis of Range of Lateral Elevation Showed Full ROM in 50%, Both in the Ipsilateral and Contralateral Extremity ($P = 0.986$)

ROM				
	Ipsilateral Side		Contralateral Side	
	n = 20	(%)	n = 18	(%)
Abduction and lateral elevation				
30–60°	0	0	0	0
61–90°	3	15	1	5.6
91–120°	4	20	4	22.2
121–160°	3	15	3	16.7
161–180°	10	50	9	50
Forward flexion				
30–60°	0	0	0	0
61–90°	2	10	1	5.6
91–120°	3	15	3	16.7
121–160°	3	15	2	11.1
161–180°	12	60	12	66.7
Internal rotation				
Lateral thigh	1	5	1	5.6
Buttock	1	5	1	5.6
Lumbosacral junction	0	0	0	0
Waist (L3)	3	15	1	5.6
T12 vertebra	8	40	5	27.8
Interscapular region (T7)	7	35	10	55.6
External rotation				
Hand on scalp, elbow forward	20	100	18	100
Hand on scalp, elbow to the side	16	80	16	88.9
Hand on occiput, elbow forward	17	85	17	94.4
Hand on occiput, elbow to the side	13	85	15	83.3
Above head	13	65	15	83.3
No impairment in ROM	13	65	14	77.8

In terms of forward flexion of the shoulder, 60% were able to move it in full ROM on the operated extremity and 66.7% on the contra lateral side ($P = 0.929$). Regarding internal rotation only, 35% were able to reach the interscapular region with their operated extremity, whereas more than half of the cohort could reach it with their healthy arm ($P = 0.344$). By examining the external rotation of the shoulder, in 65% the patients were able to do all of the listed exercises with the ipsilateral extremity and in 77.1 % with the contralateral arm ($P = 0.408$).

Table 5. Daily Activities: The Assessment of Arm Positioning Showed No Significant Difference between the 2 Extremities ($P = 0.861$)

Daily Activities				
	Ipsilateral Side		Contralateral Side	
	n = 20	(%)	n = 18	(%)
Work/recreation: rate of impairment				
100%	2	10	1	5.6
75%	2	10	2	11.1
50%	4	20	3	16.7
25%	4	20	1	5.6
0%	8	40	11	61.1
Affected sleep: rate of impairment				
Severe	1	5	1	5.6
Moderate	7	35	6	33.3
None	12	60	11	61.1
Position of the arm				
Up to waist	0	0	0	0
Up to xiphoid	1	5	1	5.6
Up to neck	2	10	1	5.6
Up to top of head	3	15	2	11.1
Above head	14	70	14	77.8

Regarding Arm Positioning, the mean for the ipsilateral side was 9 (+/-1.8) and for the contralateral side 9.2 (+/-3.3; $P = 0.861$).

DISCUSSION

The study results demonstrated a low complication rate at the donor site. Only 1 patient (5%) required a surgical wound revision (major complication), and 6 cases (30%) had minor donor-site complications, which were managed conservatively. This is in accordance with existing data reporting a 17% major complication rate and minor complication rate ranging between 22% and 33.3%.[23,27,28] Minor complications included impaired wound healing and wound dehiscence. Sixty-five percentage of our patients either suffered from cardiovascular disease or admitted currently smoking, both of which are well known in delaying the healing process.[38]
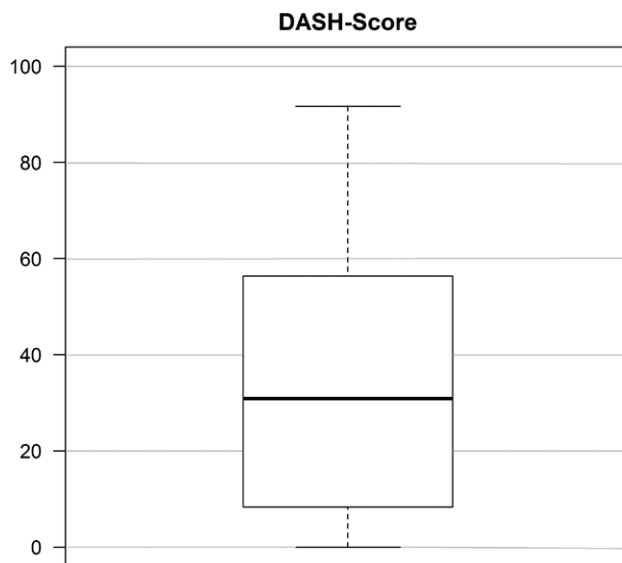
DASH-Score

Fig. 4. Mean value of DASH-score was 32.5 (±28.6).

Herr et al.[32] is the only publication that has formally investigated the shoulder function in 10 patients with HNSCC undergoing a SCAIF procedure. The majority of those patients demonstrated normal ROM with minor impairments in abduction and external rotation reporting no donor-site complications. We formally assessed a larger number of patients (n = 20) and did not find any significant differences in the shoulder ROM. In addition to CS, we addressed further parameters, including the issue of simultaneous ND with level V resection and evaluated the functional abilities of the shoulder using DASH. Herr et al.[32] reported a mean follow-up of 6 months (range, 1–18 months), whereas our study had a longer mean follow-up time of 17 months (range, 4–35 months) showing results after completed wound healing and tissue remodeling. It is well documented that primary remodeling of tissue takes weeks to months with secondary remodeling taking up to 24 months after surgery or injury.[39]

Shoulder morbidity after reconstructive surgery with SCAIF is challenging to investigate on its own, since the majority of those patients undergo an ND simultaneously. It is known, that postsurgical morbidity after ND correlates with higher shoulder morbidity even if the accessory nerve is intraoperatively identified and preserved.[40–44,39–43]

A minor impairment of overall ROM and in all subcategories of ROM can be seen in the donor-site extremity compared with the contralateral (Table 4). In our opinion, the impaired ROM in the donor extremity is associated with a postoperative relieving posture of the affected side. In addition, SCAIF elevation is achieved by dissecting superficial to the muscle. Donor sites that are usually up to 7 cm wide are closed primarily.[8] This can lead to adhesion of the deltoid and trapezius muscle to the overlying subcutaneous tissue and skin after removal of the tissue used for SCAIF. These adhesions and fibrosis of the underlying muscles result in shoulder movement limitation, thus increasing the risk of adhesive capsulitis and myofascial pain.[45] Prolonged wound healing probably promotes fibrosis and adhesions as seen in the patients with minor and major donor-site complication who had the worst overall scores.

Daily activities of oncologic patients with HNSCC are known to be affected by surgery and radiotherapy. It is therefore difficult to independently analyze these parameters after a SCAIF procedure.[46] In terms of pain, no significant difference was identified between the donor and contralateral sides.

We investigated the daily coping and activities after SCAIF procedure using the DASH score. This is the first study that has used this tool after reconstruction using SCAIF. In our present study, a mean DASH score of 32.5 (±28.6) was identified. This appears high when compared with the already mentioned study of Goldstein et al.,[41] which found a mean DASH score of 12.9 (range, 7.5–17.7) in 96 patients after unilateral SND, MRND, and radical ND. Our result could be due to the advanced Union for International Cancer Control stages in our cohort, resulting in a decreased general health condition of our patients. In addition, half of our patients received a SCAIF

from the dominant upper extremity adding to the functional impairment.

Although phantom limb syndrome has been thoroughly evaluated over the years,[47] it has not been investigated to date in association with pedicled flaps. In our cohort, no patient reported symptoms of phantom limb syndrome, though all of our patients complained of mild numbness in the surgical area, even 35 months postoperatively. We believe that phantom limb syndrome was unlikely to occur in our cohort as the thorough harvest technique already described dissects all of the sensory nerves at the donor site.[7,8] However, it is worthwhile to investigate the subject of phantom limb syndrome in pedicled flaps in a prospective study with a larger cohort. Regarding other flaps as the RFFF, donor-site morbidity is reported to be high even in long-term follow-up periods up to 24 months.[14,15]

The present study is so far the largest cohort of SCAIF patients (n = 20) on investigation of the postoperative shoulder morbidity. To date, there is only 1 publication with a smaller number (n = 10) of Herr et al.[32] The flap procedure was performed by a team of 2 very skilled head and neck surgeons (M.C. and C.W.); therefore, the probability of a bias concerning the surgical technique is expected to be rather low. The limitations of our study lie in the nature of a retrospective analysis and the small sample size of 20 patients. This could probably influence the results. To verify our results, a prospective study with a larger cohort will be conducted.

The SCAIF appears to be a very pliable choice with acceptable donor-site morbidity and very low overall postoperative shoulder morbidity. It is easy to harvest and in terms of economic aspects a very cost-effective solution.[7,23,30,48] Currently, the working horse for reconstructive surgery in HNSCC is still the RFFF.[1] When reconstruction with a free flap is not possible due to comorbidity reasons, pedicled flaps such as the PMF are commonly used in current practice. In our opinion, the SCAIF qualifies to be a feasible alternative to established pedicled flaps.

CONCLUSIONS

In our study, all parameters after SCAIF including ROM, pain, strength, and daily activities showed no significant differences between donor and contralateral shoulder, with only minor impairments recorded. In our opinion, the SCAIF is a very versatile flap with low donor-site complication rate and very low shoulder morbidity.

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