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ASA score and procedure type predict complications and costs in maxillofacial reconstructive surgery: a retrospective study using a hospital administrative database

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Summary

BACKGROUND: Reconstruction of osseous and soft tissue defects after surgical resection of oral cavity cancers can be achieved by a single-stage procedure with a microvascular bone flap or by a two-step approach with a soft tissue flap and subsequent bone augmentation. The therapeutic approach should be selected based on the patient’s needs. Economic pressure requires preoperative risk assessment and estimation of the postoperative course. Flat-rate reimbursement systems via diagnosis-related groups with insufficient morbidity adjustments and financial sanction of medical complications might additionally cause false incentives in the choice of treatment.

OBJECTIVE: This study aimed to assess the influence of the type of flap chosen for maxillofacial reconstructive surgery on the total costs. Complication rates of different types of flap surgery and their prediction by a preoperative risk assessment tool (American Society of Anesthesiologists [ASA] score) were determined. Overall, the fairness of the current reimbursement system was rated.

METHODS: Patient characteristics, clinical data, and data on total costs and reimbursement of patients aged 18 years and older having undergone maxillofacial reconstructive flap surgery at the University Hospital of Zurich (Switzerland) between 2012 and 2014 were analysed. The preoperative risk was classified by the ASA score. Complications were graded according to the Clavien-Dindo classification system and the comprehensive complication index (CCI). Statistical analysis included Spearman and Pearson rank correlation, Kruskal-Wallis and Mann-Whitney nonparametric tests, and linear regression analysis.

RESULTS: 129 patients were included in this study. Soft tissue flaps were performed in 82 patients, of which 56 were radial forearm flaps (43.4%), bone flaps in 41 patients, of which 32 were fibula flaps (24.8%), and combined flaps in 6 patients (4.7%). Patients with fibula flaps showed a significantly higher CCI and higher total costs. Higher preoperative ASA scores were significantly associated with increased length of stay, total costs and complications. Both the ASA score and reconstruction with a radial forearm flap were significant predictors of complications and total costs. Total median costs for radial forearm flaps were CHF 50,560 (reimbursement: CHF 60,851; difference: CHF 10,291) and for fibula flaps CHF 66,982 (reimbursement: CHF 58,218; difference: CHF −8,764).

CONCLUSION: The ASA score allows a reliable preoperative assessment of patient outcomes and financial burden in maxillofacial reconstructive flap surgery. The type of flap reconstruction significantly influences complications and ultimately total costs. The current reimbursement system via diagnosis-related groups (DRGs) does not take sufficient account of this fact. Adaptations are therefore needed to prevent misplaced incentives to the detriment of patients.

Introduction

Oral cavity cancer is a major burden for the affected patients. The usual therapy consists of either primary surgical resection or radiotherapy [1, 2]. Primary closure of the resulting surgical defect often requires flap surgery. The radial forearm flap (“radialis flap”) has become the first choice for the reconstruction of soft tissue oral cavity defects. However, if bone has to be resected during primary surgery, either a second surgical approach to augment the bone or bone flaps become necessary [3–6]. Two of the most commonly used options for osseous oral cavity reconstructions are (1) reconstruction with a plate and a radial forearm flap and consecutive augmentation with iliac crest bone in a second step or (2) single-stage reconstruction with a microvascular bone flap (fibula, scapula or iliac crest flap). Patients naturally prefer an all-in-one procedure.

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All surgical procedures carry a risk, and it is the physician's duty to weigh the benefits of treatment against the probability and severity of possible complications. Besides the chosen treatment option, complications are the main driver of treatment costs. Therefore, it is important to identify those patients at risk for a higher rate of complications after reconstructive surgery. Risk assessment tools may help surgeons and patients alike decide whether a specific surgical procedure is beneficial or whether other treatment options should be considered. Also, risk assessment tools may help refine morbidity adjustment of reimbursement systems [7]. One of the most commonly used preoperative risk assessment tools is the American Society of Anesthesiologists Physical Status Classification System (ASA score) [8]. It is simple to use, but it is a subjective assessment for which recent studies have shown poor inter-rater reliability [9–11].

The postoperative course can be evaluated by means of different variables known to influence total costs, such as length of hospital stay, need for revision surgery, or medical complications, the latter being subdivided into number and severity of complications. Complications and surgical morbidity can be assessed with indices such as the Clavien-Dindo classification system [12, 13] or the comprehensive complication index (CCI) [14–16]. In the Clavien-Dindo classification system, postoperative complications are graded by their need for treatment. The CCI quantifies the total burden of postoperative complications by the use of a mathematical formula. Both tools have proved valuable and reliable in patients who have undergone maxillofacial reconstructive flap surgery [17].

Financial considerations should not play a part in deciding on one therapeutic approach or another. However, contemporary legislative changes pushing for pay-for-performance and value-based health care by policymakers are adding pressure by financially penalising adverse outcomes [18–23]. Flat-rate reimbursement systems for inpatient care have been introduced in numerous industrialised countries, mostly via diagnosis-related groups (DRGs) [24]. As DRGs only refund average treatment costs of patients in a similar category, medical complications that lead to higher resource utilisation are financially sanctioned [25, 26]. With the DRG system, two patients with the same leading diagnosis but with different surgical treatments (e.g., radial forearm flap vs fibula flap) are refunded similarly although costs of the two distinct treatment options differ significantly. Maxillofacial reconstructive surgery is coded with either D24a or D37a, depending on the patient's postoperative condition and intensive care treatment needs. The ASA score takes similar criteria into account but is not itself a component of the DRG classification.

This study aimed to assess whether the type of flap chosen for maxillofacial reconstructive surgery influences the total costs in such a way that the reimbursement situation becomes unbalanced. It was determined whether one type of flap surgery has a higher complication rate and whether the complication rate can be predicted by preoperative conditions summarised in a risk assessment tool. The overall objective was to rate the fairness of the current reimbursement system for patients receiving maxillofacial reconstructive flap surgery.

Material and methods

Data

The hospital administrative database was searched for discharges from the University Hospital of Zurich between 2012 and 2014 of patients aged 18 years and older having undergone maxillofacial reconstructive flap surgery. Patients were selected via specific procedure codes defined in the CHOP procedure catalogues: Z27.57.10 (free flap with microvascular anastomosis to the lip or mouth), Z27.57.11 (pedicle flap to the lip or mouth), Z27.57.99 (other flap to the lip or mouth), Z86.78.10 (free flap with microvascular anastomosis to the head, other than lip or mouth), Z86.78.20 (pedicle flap to the head other than lip or mouth) or Z86.78.40 (other flap to the head, other than lip or mouth) [27]. In total, 129 hospital cases were retrieved. The routinely collected variables age, gender, weight, height, malignant disease as leading diagnosis, in-hospital death, length of stay, pre-surgical haemoglobin, and total in-hospital treatment costs were also retrieved from the administrative database. Treatment costs were broken down according to the REKOLE® standard. Clinical data for the corresponding cases were then manually retrieved by the treating physicians from electronic medical records. Clinical data included the preoperative therapy, pre-surgical ASA score, type of flap by provenance (radial or ulnar forearm, upper arm, scapula, fibula, gracilis, anterolateral thigh, deep circumflex iliac artery, latissimus dorsi), as well as flap laterality, and surgical complications. The number of complications was counted and the most severe complication was graded according to the Clavien-Dindo classification system [28]. The comprehensive complication index (CCI) was calculated for each case [15]. Furthermore, the presence of flap failure or loss of the flap and the reason for failure were reviewed from the medical records. Data were pseudonymised before further analysis.

Statistics

The patient cohort was analysed with descriptive statistics. Associations were analysed graphically with scatter plots and box plots as well as with Spearman or Pearson rank correlation. The dependent analyses for outcome analysis were the decimal logarithm of costs (log costs) and the decimal logarithm of the CCI (log CCI). Univariate analyses were performed using the Kruskal-Wallis or Mann-Whitney nonparametric tests. Multivariate analysis was performed with linear regression. Accepting an alpha of 0.05, results were considered significant for $p < 0.05$.

Software

Data were processed using the business intelligence software QlikView (QlikView version 11, 64-bit edition, QlikTech, Radnor, PA, USA) and exported as a Microsoft Excel worksheet before final preprocessing and analyses were performed (Microsoft Excel, version 2010, Microsoft Corporation, Redmond, USA). Statistical analysis was done in IBM SPSS Statistics (version 24, IBM Corp., Armonk, USA). Graphical analysis was performed with IBM SPSS.

Ethics

Institutional review board approval was obtained from the Ethics Committee of the Canton Zurich prior to the start of the study (declaration of no objection, No. 88-2015). All patient data retrieved were pseudonymised before analysis.

Results

In total, 129 cases were retrieved, with an approximately even distribution of 40–45 cases per year over a 3-year period, and an approximate 3:2 predominance of male patients. More than half of patients were classified as ASA II (58.1%), followed by ASA III (33.36%), with few ASA I (7%) and only two patients classified as ASA IV. Most patients had an underlying malignancy as the cause of the need for reconstructive surgery (84.5%), with approximately two thirds of all cases not having received presurgical radiotherapy or chemotherapy. Radial forearm (43.4%) or fibula flaps (24.8%) were the most common, with combined flaps being rare (4.7%). Most procedures were free flaps with microvascular anastomosis (92.2%). Descriptive statistics of the patient cohort are shown in table 1.

Length of stay and total inpatient treatment costs were both strongly correlated with post-surgical CCI (Spearman coefficient of 0.55 and 0.64, respectively, both $p < 0.001$) (fig. 1). An increase in the ASA score was found to be significantly associated with an increase in length of stay, total costs, and complications (increasing CCI) ($p = 0.002$, $p = 0.01$ and $p = 0.01$ respectively). This association was also observed graphically (fig. 2). Patient outcomes by pre-surgical ASA score are depicted in table 2. With an increasing ASA score of I, II, III and IV, respectively, the mean length of stay increased from 11 to 16, 21 and 36.5 days. Mean total costs increased from CHF 41,812 to 59,482, 75,034 and 146,505. Mean CCI increased from 23 to 34.6, 42 and 45. In a very simplified view, an increase by one ASA score point led to a rise in length of stay by 8.5 days, total costs by CHF 34,898, and CCI by 7.3.

Subsequently, patient outcomes by flap type (bone flaps, soft tissue flaps, and combined flaps) were analysed. Fibula, scapula, and deep circumflex iliac artery flaps were classified as bone flaps and upper arm, ulnaris, radialis, latissimus, anterolateral thigh, and gracilis flaps as soft tissue flaps. The results are summarised in table 3. Patients with bone flaps had lower ASA scores than patients with soft tissue flaps (66% vs 52% ASA II, 29% vs 37% ASA III and 0 vs 2 cases ASA IV). Nevertheless, length of stay, costs, complication severity and percentage of flap failures were higher. Although the small number of cases limits the meaningfulness of the results, patients with combined flaps seemed to have markedly worse outcomes. In univariate analysis using non-parametric testing, differences in length of stay, costs or CCI were not statistically significant for patients with combined vs non-combined (single) flaps or bone flaps vs soft tissue flaps vs combined flaps. When patients with soft tissue flaps were compared with those with bone and combined flaps, differences in costs were significant ($p = 0.04$), albeit differences in CCI and length of stay were not. Median total costs were CHF 56,478 for soft tissue flap reconstructions, CHF 66,559 for bone flaps and CHF 95,083 for combined flaps.

In a further step, outcomes for patients with a radialis flap vs patients with a fibula flap were analysed. Although the distribution of the pre-surgical ASA score was similar in both groups, patients with a fibula flap had a longer length of stay, higher costs and more severe complications, and the rate of flap failures was twice as high (22% vs 11%). The results are summarised in table 4. Differences in CCI and costs for patients with a radialis flap vs fibula, combined or other flap were statistically significant ($p = 0.004$ and $p = 0.008$), although not for the length of stay.

Linear regression analyses with log CCI and log costs as dependent variables were performed to analyse the effect of the ASA score and flap type to explain variation in out-

Table 1: Descriptive statistics of the patient cohort (n = 129).

Year	2012	44 (34.1%)
	2013	40 (31.0%)
	2014	45 (34.9%)
Gender	Female	52 (40.3%)
	Male	77 (59.7%)
Age (years)		65 (56–74)
ASA Score	I	9 (7.0%)
	II	75 (58.1%)
	III	43 (33.3%)
	IV	2 (1.6%)
BMI (kg/m^2)*		23.4 (20.7–26.1)
Malignant disease		109 (84.5%)
Pre-surgical therapy	Radiotherapy	12 (9.3%)
	Chemotherapy	7 (5.4%)
	Combined radio-/chemotherapy	25 (19.4%)
	None	85 (65.9%)
Pre-surgical haemoglobin (g/l)		134 (121–143)
Flap type	Fibula	32 (24.8%)
	Radialis	56 (43.4%)
	Anterolateral thigh	15 (11.6%)
	Other	20 (15.5%)
	Combined	6 (4.7%)
Free flap with microvascular anastomosis		119 (92.2%)

ASA = American Society of Anesthesiologists; BMI = body mass index * n = 128. Values given as frequency (%) or median (interquartile range).

comes whilst controlling for age, gender and malignancy as the underlying cause for reconstructive surgery. Both ASA score and radialis flap (excluding combined procedures) were significant when predicting log CCI (p = 0.028 and p = 0.006, respectively) and log costs (p = 0.005 and 0.03, respectively) (table 5 and table 6).

The median total costs of a radial forearm flap reconstruction were CHF 50,560. Reconstruction with a fibula flap cost CHF 66,982. Median reimbursement for radial forearm flaps was CHF 60,851 and for fibula flaps CHF 58,218.

Discussion

It was demonstrated that the preoperative ASA score was a strong predictor of postoperative complications, length of stay and total costs. This is in accordance with previous studies [29–32]. The ASA score is a well-established and easy-to-use risk assessment method, firmly entrenched in clinical practice [33–36]. Some of the information needed for the ASA score is, however, subjective, which led to concern about its reliability in clinical practice. As a matter of fact, there is sufficient evidence for moderate inter-rater reliability [37, 38] and possible upcoding [39, 40] of ASA

Figure 1: Scatter plots of comprehensive complication index (CCI) in points and length of stay (LOS) in days (above) as well as in-patient treatment costs in CHF (below) per patient. Color-coding indicates pre-surgical morbidity as defined by the American Society of Anesthesiologists (ASA) score; n = 129.

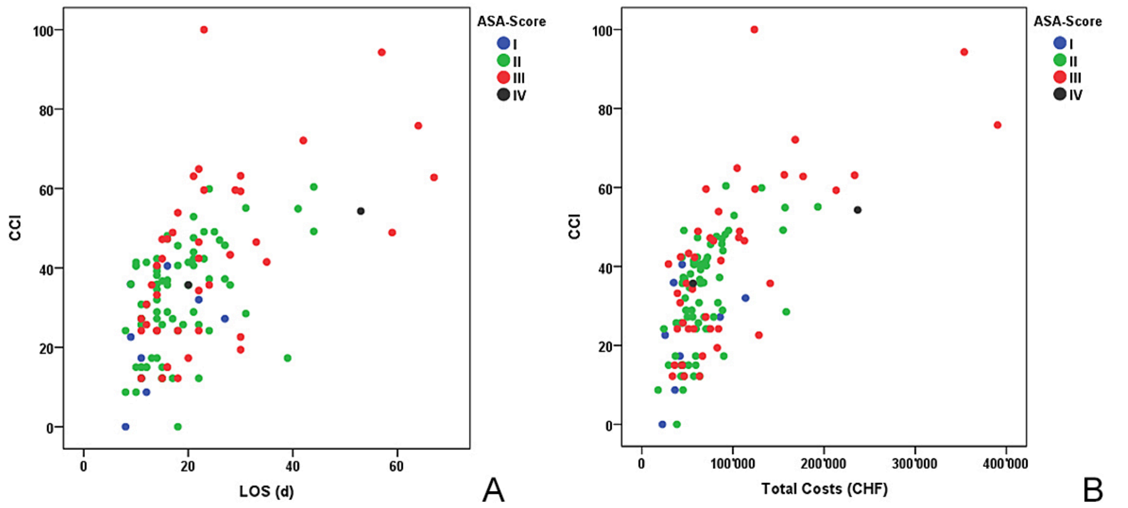


Table 2: Patient outcomes by pre-surgical ASA score (n = 129).

	Total (n = 129)	ASA I (n = 9)	ASA II (n = 75)	ASA III (n = 43)	ASA IV* (n = 2)
Deceased	1 (0.8%)	0	0	1 (2.3%)	0
LOS (d)	16 (13–23)	11 (9–19)	16 (12–21)	21 (15–30)	36.5
Total costs (CHF)	61,140 (45,281–86,267)	41,812 (30,251–65,177)	59,482 (45,592–75,478)	75,034 (48,909–123,467)	146,505
Flap failure	24 (18.6%)	1 (11.1%)	13 (17.3%)	10 (23.3)	0
Number of complications	4 (3–5)	3 (1.5–4.0)	4 (3–5)	5 (3–6)	5.5
CCI	37 (24–46)	23 (10–34)	34.6 (24.2–41.4)	42 (24–59)	45
Clavien-Dindo score most severe complication	2 (2–4)	2 (1–2.5)	2 (2–3)	3 (2–4)	3†

ASA = American Society of Anesthesiologists; CCI = comprehensive complication index; LOS = length of hospital stay * Arithmetic average of two cases; † both cases with value of 3. Values given as frequency (%) or median (interquartile range).

Table 3: Patient outcomes by flap type (bone flap vs soft tissue flap) (n = 129).

		Total (n = 129)	Bone (n = 41)	Soft tissue (n = 82)	Combined (n = 6)
ASA score	I	9 (7%)	2 (5%)	7 (9%)	0
	II	75 (58%)	27 (66%)	43 (52%)	5 (83%)
	III	43 (33%)	12 (29%)	30 (37%)	1 (17%)
	IV	2 (2%)	0	2 (2.4%)	0
Deceased		1 (0.8%)	0	1 (1.2%)	0
LOS (d)		16 (13-23)	18 (14–22)	16 (12–23)	23 (19–34)
Total costs (CHF)		61,140 (45,281-86,267)	66,559 (54,635–83,817)	56,478 (44,064–84,638)	95,083 (74,423–164,522)
Flap failure		24 (18.6%)	7 (17%)	13 (16%)	4 (67%)
Number of complications		4 (3-5)	4 (3–5)	4 (3–6)	6 (4–8)
CCI		37 (24-46)	36 (26–44)	21 (17–43)	48 (36–53)
Clavien-Dindo score most severe complication		2 (2-4)	3 (2–4)	2 (1–4)	3 (3–4)

ASA = American Society of Anesthesiologists; CCI = comprehensive complication index; LOS = length of hospital stay Bone = fibula, scapula, deep circumflex iliac artery flap; soft tissue = upper arm, ulnaris, radialis, latissimus, anterolateral thigh, gracilis flap; combined = more than one flap Values given as frequency (%) or median (interquartile range).

scores. The ASA score alone might therefore be an insufficient risk adjustment measure for financial profit/loss and possibly misleading in selecting treatment options.

Flat-rate reimbursement systems via DRGs create an incentive to minimise complications in order to maximise profit. As our results show, complications are influenced not only by patient morbidity itself, but also by the type and extent of surgery performed. When deciding for or against a specific procedure, surgeons have to bear in mind the imbalance of costs and reimbursement. Bone flaps and combined flaps showed higher length of stay, complication severity, flap failure and costs compared with the radial forearm flap, although they were performed in patients with lower preoperative ASA scores, underlining the substantial influence of the type of flap on both patient and financial outcomes. Knowing that an osseous reconstruction via fibula flap will not be cost-efficient, but a two-stage procedure with a radial forearm flap followed by an iliac crest transplant will be, might distort incentives to the detriment of patients. The more expensive fibula flap did not receive adequately higher reimbursement and is therefore highly uneconomic. This imbalance is aggravated by the fact that a two-stage procedure is reimbursed twice, each stage separately, raising profit even more.

Some of the complications seen in our patient cohort are part of the normal postoperative course after maxillofacial reconstructive flap surgery, especially in the elderly and frail [30, 41–44]. Extensive surgery, tracheostomy and invasive ventilation, nutrition via a nasogastric tube, and intensive care unit stay can lead to delirium, prolonged mechanical ventilation weaning or other medical problems requiring lengthened hospital stay [45–48]. Combined flaps show higher rates of anastomosis failure requiring revision surgery, longer surgery time, and impaired wound healing compared with the radial forearm flap [49–53]. All those factors inevitably prolong hospital stay, lead to higher resource utilisation and therefore cause higher costs. The current reimbursement system does not take into account these unavoidable circumstances and renders more extensive surgical procedures uneconomical.

After maxillofacial reconstructive flap surgery, most patients need inpatient rehabilitation. As a result of limited

Table 4: Patient outcomes by flap type (radialis vs fibula) (n = 129).

		Total (n = 129)	Radialis (n = 56)	Fibula (n = 32)	Combined (n = 6)	Other (n = 35)
ASA score	I	9 (7%)	4 (7%)	2 (6%)	0	3 (9%)
	II	75 (58%)	37 (66%)	23 (72%)	5 (83%)	10 (29%)
	III	43 (33%)	15 (27%)	7 (22%)	1 (17%)	20 (57%)
	IV	2 (2%)	0	0	0	2 (6%)
Deceased		1 (0.8%)	0	0	0	1 (3%)
LOS (d)		16 (13-23)	15 (12–22)	17 (14–22)	23 (19–34)	18 (14–24)
Total costs (CHF)		61,140 (45,281-86,267)	50,560 (43,840–72,590)	66,982 (53,978–83,125)	95,083 (74,423–164,522)	63,327 (52,346–106,336)
Flap failure		24 (18.6%)	6 (11%)	7 (22%)	4 (67%)	7 (20%)
Number of complications		4 (3-5)	4 (3–5)	4 (3–5)	6 (4–8)	5 (3–6)
CCI		37 (24-46)	27 (16–41)	37 (27–42)	48 (36–53)	37 (24–54)
Clavien-Dindo score most severe complication		2 (2-4)	2 (1–4)	3 (2–4)	3 (3–4)	3 (2–4)

ASA = American Society of Anesthesiologists; CCI = comprehensive complication index; LOS = length of hospital stay Radialis = radial forearm flap; fibula = fibula flap; combined = more than one flap. Values given as frequency (%) or median (interquartile range).

Table 5: Coefficients of linear regression with log CCI as the dependent variable (n = 129).

	Non-standardised coefficients		Standardised coefficients	p-value	95% confidence interval for β
	Regression coefficient β	Standard error	β		
Constant	1.259	0.110		0.000	1.042, 1.476
Age (years)	0.003	0.001	0.175	0.047	0.000, 0.006
Gender	−0.006	0.039	−0.012	0.884	−0.082, 0.071
Neoplasm	−0.071	0.057	−0.112	0.219	−0.185, 0.043
ASA score	0.072	0.032	0.193	0.028	0.008, 0.136
Radialis flap	−0.113	0.041	−0.247	0.006	−0.193, −0.032

ASA = American Society of Anesthesiologists; CCI = comprehensive complication index Gender: male = reference group. Neoplasm: no = reference group. Radialis flap: all other flap types including combined flaps = reference group.

Table 6: Coefficients of linear regression with log costs (CHF) as the dependent variable (n = 129).

	Non-standardised coefficients		Standardised coefficients	p-value	95% confidence interval for β
	Regression coefficient β	Standard error	β		
Constant	4.355	0.102		0.000	4.15, 4.56
Age (years)	0.004	0.001	0.254	0.004	0.001, 0.007
Gender	−0.012	0.038	−0.026	0.750	−0.087, 0.063
Neoplasm	0.055	0.056	0.086	0.335	−0.057, 0.166
ASA score	0.089	0.031	0.240	0.005	0.027, 0.151
Radialis flap	−0.087	0.040	−0.188	0.031	−0.166, −0.008

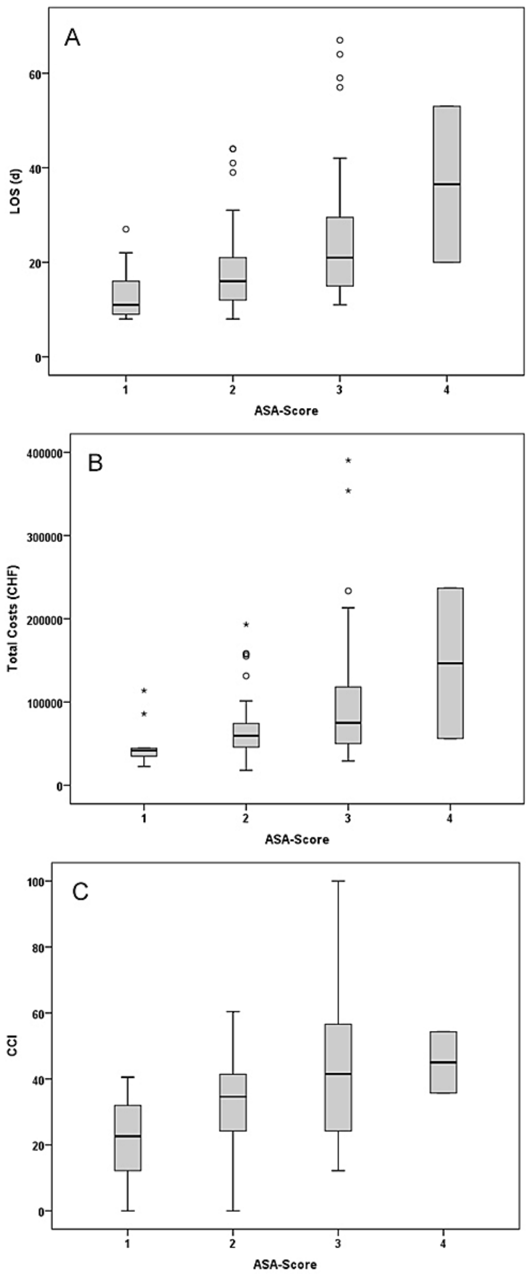
ASA = American Society of Anesthesiologists Gender: male = reference group. Neoplasm: no = reference group. Radialis flap: all other flap types including combined flaps = reference group.

capacity in the rehabilitation clinics, some patients have to wait for their beds. These waiting times will prolong hospital stay for non-medical reasons. Other patients, mainly those with advanced malignancies, need postoperative radiation or other subsequent inpatient therapies. Length of stay is therefore influenced not solely by patient factors represented in the DRGs, but also by institutional processes. The calculation of the standard length of hospital stay in the flat-rate payments for inpatient care does not properly represent these factors.

From the economic point of view, preoperative identification of patients expected to surpass the cost limit is crucial. Our study was able to define two main preoperative risk factors for more expensive treatment, even when controlled for age, gender and malignancy as the underlying cause for reconstructive flap surgery: high preoperative ASA score and type of reconstruction (bone flaps or combined flaps). High CCI was found to be the main postoperative marker for proneness to higher costs.

In conclusion, the ASA score enables a reliable preoperative assessment of patient outcomes and financial burden in maxillofacial reconstructive flap surgery. The type of flap reconstruction must be taken into account, as soft tissue flaps correlate with low CCI and ultimately lower total costs. The current flat-rate reimbursement system does not properly reflect the normal range of complications nor institutional factors leading to a prolonged hospital stay. Adaptations and morbidity adjustments are therefore urgently needed in order to prevent misplaced incentives that might be to the detriment of patients.

Figure 2: Box plots of patient outcomes by pre-surgical American Society of Anesthesiologists (ASA) score: (above) length of stay (LOS) in days, (centre) total inpatient costs per case, and comprehensive complication index (CCI) points (below). n = 129.



Disclosure statement

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