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Evaluation of alloplastic mandibular reconstruction combined with a radial forearm flap compared with a vastus lateralis myocutaneous flap as the first approach to two-stage rehabilitation in advanced oral cancer

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Abstract

After continuity resection of the mandible, reconstruction of continuity with a reconstruction plate and soft tissue can be an alternative to immediate osseous reconstruction in patients with advanced oral cancer. We evaluated exposure of the plate in such reconstructions by comparing the results of a radial forearm flap (RFF) with a vastus lateralis myocutaneous flap (VLMF). We also analysed the resection margins and the incidence of secondary osseous reconstructions after one year free from relapse. We retrospectively examined all 48 mandibular reconstructions in which a reconstruction plate and RFF or VLMF had been used between 2007 and 2016. Exposure rates of plates were assessed and local (size and site of resection) and systemic risk factors (age, sex, treatment with radiation, and smoking) evaluated. Reconstruction plates, together with a RFF, were significantly more likely to be exposed than those with a VLMF ($p = 0.01$). There was significantly more exposure in the RFF group in mandibular defects larger than 6 cm, in contrast to the VLMF group ($p = 0.002$). Younger age ($p < 0.001$), lower body mass index (BMI) ($p = 0.05$) and smoking ($p = 0.011$) led to more exposure. In seven cases a second operation was necessary due to macroscopically invaded or close margins. Thirty-one patients had no bony reconstruction because of local recurrence, distant metastases, inadequate resection margins, poor general condition, or a second (different) tumour. Exposure of the plate after mandibular reconstruction happens less often with the VLM flap than with the RFF. The two-step approach can be an option in the treatment of advanced oral cancer.

Keywords: radial forearm flap; vastus lateralis myocutaneous flap; alloplastic mandibular reconstruction; plate exposure; two-step approach

Introduction

Continuity defects of the mandible may be caused by resection of benign or malignant neoplasms, infections, radiation, and trauma.[1] Although there is a diversity of mandibular defects, and many possible ways to reconstruct them, there are several principles that guide the selection of a therapeutic approach.[2]

The options for mandibular reconstruction include free bone grafts, vascularised flaps, and alloplastic implants, in combination with soft-tissue free flaps.[3] Since the 1980s the rate of primary reconstruction with microvascular bone grafting has been increasing. Today, vascularised bony reconstruction is the gold standard, as it is reliable for single-stage mandibular reconstruction.[4] For patients with advanced tumours, severe coexisting diseases, or who expect adjuvant radiotherapy, reconstruction with a bridging plate and soft tis-

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sue free-flap is a good temporary, and sometimes permanent, solution.[5]

With a two-stage procedure, the plate usually remains in place for nearly a year. In the absence of recurrence, a secondary reconstruction may be done with hard tissue and, if necessary, additional soft tissue.[6] Complications after alloplastic reconstruction are well documented and affect 8% - 92% of reconstructions. Exposure of the plate is one of the most common plate-related complications,[4,5,7,8] and a common site is the anterior region of the lower jaw.[3,9] The dehiscence rate also increases with the size of the resected defect.[10]

The two most commonly used soft tissue flaps are the vastus lateralis myocutaneous flap (VLMF) or the radial forearm free flap (RFF), together with alloplastic reconstruction of the mandible.

The vastus lateralis flap can be harvested as a muscle flap or as a myocutaneous flap, which has a strong influence on the thickness of the flap.

The main advantages of the fasciocutaneous RFF flap are its long pedicled vessel, malleability, and good vascular reliability.[11] The two main disadvantages are the relatively small amount of soft tissue, and donor site morbidity.[12]

The aim of this study was to compare the exposure rate of plates after alloplastic mandibular reconstruction with a titanium reconstruction plate, and compare the VLMF with the RFF, depending on the position and size of the defect.

Patients and methods

Patients

After institutional ethics approval we retrospectively reviewed all cases of mandibular reconstruction with reconstruction plates and free soft tissue flaps after segmental mandibulectomy that took place in our Department of Oral and Maxillofacial Surgery between January 2007 and January 2016.

In 2011 we changed the procedure in our department. In previous years, the RFF had been the standard flaps for mandibular reconstruction. After 2011, they were increasingly replaced by the vastus lateralis flap, particularly when an alloplastic mandibular reconstruction was needed.

Patients who required a mandibulectomy were included. The defect was bridged by a stable titanium reconstruction plate with at least three screws/side and a free soft tissue reconstruction with a VLMF or RFF. Exclusion criteria were: preoperative radiotherapy, isolated complications with the hardware such as fracture of the plate or loss of screws, and a follow-up period of less than one year.

The following variables were recorded: sex and age of the patients, body mass index (BMI) on the day of operation, reason for resection, American Society of Anesthesiologists' (ASA) classification, postoperative radiation, T-classification, and coexisting conditions.

The site of the defect was classified according to the Jewer HCL system. "C" means that the defect was located along the central segment between the teeth 33 and 43; "L" defects are located in the area from the canine tooth to the base of the articular process excluding the condyle; and "H" indicates that the defect was located in the area between the symphysis and the condyle.[13–16] The length of the resulting osseous defect was calculated from postoperative computed tomography (CT). The defects were divided into small (up to 6 cm), and large (6 cm or more). The patients were divided into two groups based on type of soft tissue reconstruction and two subgroups (non-exposure compared with exposure).

We chose a follow up of one year as this is when we would do secondary osseous reconstructions. If postoperative radiotherapy was used it was not initiated until six weeks postoperatively, with a maximum total dose of 65 Gy. We analysed all oral dehiscences and subsequent interventions such as removal or change of plate.

Statistical analysis

The chi squared test or Student's t test was used for analysis of categorical or continuous variables. A difference was significant if p was 0.05 or less. For samples of less than five variables Fisher's exact test was used. The relations between size and site of the defect and exposure of the plate were assessed using Spearman's rank correlation coefficient. All tests of significance were two sided. The data were analysed with the aid of the Statistical Package for the Social Sciences (version 12, SPSS Inc).

Results

A total of 48 patients were included in the study. Table 1 summarises the baseline characteristics. The two groups were homogeneous and, in particular, the two main test variables (size and site of the defect) did not differ significantly.

Table 2 shows the exposure rates of both flaps depending on demographic factors and coexisting conditions. Most dehiscences developed in younger patients, with lower BMI (Fig. 1) and patients who smoked (Fig. 2). There were no significant differences between the sexes, ASA, T status, coexisting diseases, or the use of adjuvant radiotherapy. When the individual groups were analysed separately, the RFF group showed significantly higher rates of exposure in men ($p = 0.003$) and smokers ($p = 0.005$).

Table 3 shows a comparison of the two groups in relation to the soft tissue reconstruction, and the position and size of the defect, and there was a significantly higher dehiscence rate in the RFF group ($p = 0.01$) (Fig. 3). Thirteen of all 19 C (C, CL, LCL) defects in both groups had exposed plates as did 7 of the 28 for isolated L defects.

We found a moderate correlation between the site of the defect and exposure of the plate ($r_{RFF} = 0.5$, $r_{VLMF} = 0.55$), and a weak correlation between the size of the defect and

Table 1
Baseline characteristics.

	Total (n = 48)	RFF (n = 28)	VLMF (n = 20)	p value
Sex:				
Male	35	20	15	0.783
Female	13	8	5	
Mean (SD) age (years)	65.4 (10.69)	63.7 (10.90)	67.7 (9.94)	0.213
Median (SD) BMI	26 (5.66)	25.1 (6.25)	27.7 (4.63)	0.694
Diagnosis:				
Squamous cell carcinoma	43	27	16	
Adenocarcinoma	2	1	1	
Sarcoma	2	–	2	
Other (metastasis)	1	–	1	
T-status:				
T1/T2	21	15	6	
T3	7	5	2	0.093
T4	20	8	12	
ASA classification:				
I and II	20	15	5	
III	26	11	15	0.059
IV	2	2	–	
Coexisting conditions:				
Diabetes mellitus	17	8	9	0.240
Heart disease	21	10	11	0.184
Liver disease	4	2	2	0.724
Lung disease	18	12	6	0.364
Hypertension	24	11	13	0.078
Thyroid disease	15	11	4	0.155
Nicotine misuse	22	16	6	0.062
Postoperative radiation	22	12	10	0.624
Soft tissue reconstruction	48	28	20	
Jewer classification (HCL)*:				
L	28	18	10	
CL	6	2	4	
H	1	–	1	
C	2	2	–	0.322
LCL	11	6	5	
Size of defect (cm):				
Up to 6	19	11	8	0.960
6 or more	29	17	12	

RFF = radial forearm free flap; VLMF = vastus lateralis myocuaneous flap; ASA = American Society of Anesthesiologists.

* Jewer classification - the HCL system: C = the defect was located along the central segment between the teeth 33 and 43; “L”defects = located in the area from the canine tooth to the base of the articular process excluding the condyle; and “H” = located in the area between the symphysis and the condyle.[13–15].

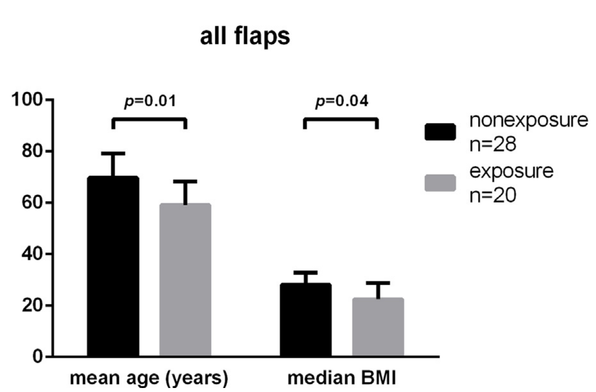

Fig. 1. Boxplot showing the plate exposure for all flaps depending on age and BMI, as well as corresponding p values.

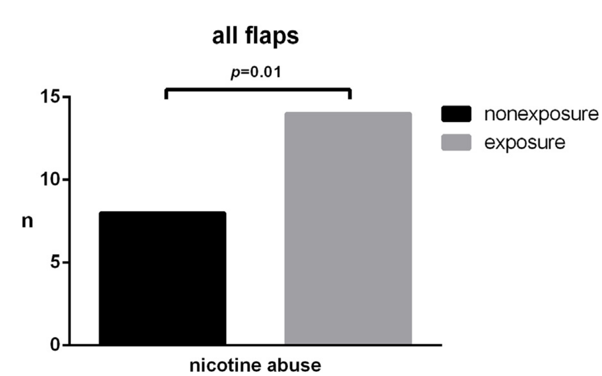

Fig. 2. Boxplot showing the plate exposure for all flaps depending on nicotine consumption.

Table 2
Exposure rate of both flaps depending on demographic factors and coexisting conditions.

	All flaps			RFF		VLMF		p value
	Non-exposure	Exposure	p value	Non-exposure	Exposure	Non-exposure	Exposure	
Sex:								
Female	10	3	0.111	6	2	4	1	Female 0.835
Male	18	17		6	14	12	3	Male 0.003
Mean (SD) age (years)	69.8 (9.42)	59.1 (9.17)	< 0.001	70.39 (9.29)	58.7 (9.18)	69.3 (9.50)	61.1 (8.88)	Non-exposure 0.777 Exposure 0.653
Median (SD) BMI	28.2 (4.68)	22.5 (6.33)	0.05	29.05 (4.85)	22.1 (6.18)	26.6 (4.32)	26.5 (5.72)	Non-exposure 0.242 Exposure 0.461
Nicotine misuse	8	14	0.011	3	13	5	1	0.005
Postoperative radiation	11	11	0.099	4	8	7	3	0.867
Coexisting conditions:								
Diabetes mellitus	12	5	0.202	5	3	7	2	0.49
Heart disease	15	6	0.104	7	3	8	3	0.89
Liver disease	2	2	0.724	2	0	0	2	0.045
Lung disease	9	9	0.364	4	8	5	1	0.045
Hypertension	17	7	0.078	6	5	11	2	0.106
Thyroid gland disease	9	6	0.874	6	5	3	1	0.474
ASA grade:								
I/II	15	10	0.121	6	9	4	1	0.062
III/IV	18	10		6	7	12	3	

RFF = radial forearm free flap; VLMF = vastus lateralis myocutaneous flap. BMI = body mass index; ASA = American Society of Anesthesiologists.

Table 3
Exposure of the plate depending on soft tissue reconstruction, Jewer classification, and size of defect.

	RFF		VLMF		p value
	Non-exposure	Exposure	Non-exposure	Exposure	
Soft tissue reconstruction	12	16	16	4	0.010
Jewer classification*:					
Including C	1	9	5	4	RFF 0.5
Excluding C	11	7	11	0	VLMF 0.55
Defect size:					
Up to 6 cm	9	2	7	1	0.737
> 6 cm	3	14	9	3	0.002
Mean (SD) resection size (cm)	6.34 (1.67)		7.32 (2.37) VLMF 0.38		RFF 0.26
Tstage:					
T1/T2	8	7	5	1	0.200
T3	1	4	2	0	0.053
T4	3	5	9	3	0.093
Timing of plate exposure:					
Up to 6 weeks after operation (early complication)	17	11	18	2	< 0.001
> 6 weeks after operation		5		2	0.176

RFF = radial forearm free flap; VLMF = vastus lateralis myocutaneous flap.

* The HCL system: "C" = the defect was located along the central segment between the teeth 33 and 43; "L"defects = located in the area from the canine tooth to the base of the articular process excluding the condyleand "H" = located in the area between the symphysis and the condyle.[13–15]

exposure of the plate ($r_{RFF} = 0.26$, $r_{VLMF} = 0.38$). However, there was a higher dehiscence rate in the RFF group when the defect was larger than 6 cm ($p = 0.002$), and significantly more plates in the RFF group became exposed during the first six weeks postoperatively ($p < 0.001$) (Fig. 3).

Of our 48 patients, 31 did not have a bony reconstruction. In seven we had to resect further during a second operation because of microscopic residual tumour or close margins. In two other cases, complete resection could not be achieved. Of the 17 bony reconstructions, 10 have already been successfully rehabilitated using dental implants, and two more are planned.

Discussion

Since the 1980s the gold standard for reconstruction after ablative surgery of the lower jaw has been autogenous bony reconstuction. In special cases, however, the alloplastic reconstruction of the mandible in combination with a soft tissue flap is a viable option. In our department we default to two-stage mandibular reconstruction after malignant disease. We think that reconstructive goals are easier to achieve after postoperative histological examination of bony resection margins, with the ability to reconstruct using computer-assisted procedures for accurate mandibular recon-

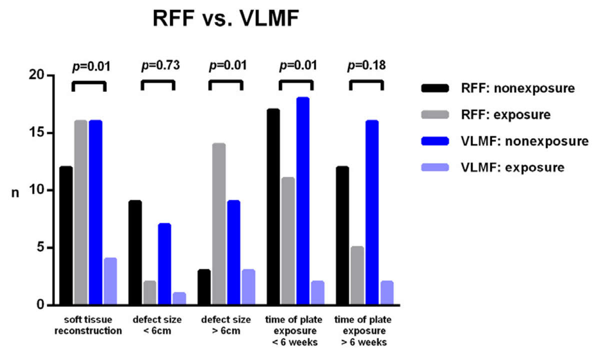

Fig. 3. Boxplot showing the plate exposure as a comparison of RFF and VLMF depending on the defect size and time of dehiscence formation, as well as corresponding p-values.

struction and, last but not least, the possibility to implant in a non-irradiated bone.[17]

The aim of this retrospective study was to compare the exposure rate of plates between the VLMF transplant and the fasciocutaneous RFF after continuity resection of the lower jaw and alloplastic reconstruction with a titanium plate. We chose a follow up of one year for two reasons: most soft tissue complications (exposure of the plate, infections, or necrosis) occur during the first postoperative year,[18–20] and in our department the bony reconstruction is done after the patient has had at least one year without recurrence of the tumour.

The study included 48 patients, the ratio of men to women was 2.7: 1, and the mean age was 65 years. These results are comparable to those reported elsewhere.[15,16]The total dehiscence rate was 20 of 48 for both groups, which are similar results to those reported by Fanzio et al (37.7%).[5] We found a significant correlation between the type of soft tissue reconstruction and exposure of the plate ($p = 0.01$). In the RFF group there were 16 exposed plates among a total of 28 reconstructions. In the VLMF group it was four of 20. Probably the greater volume of the VLMF permitted all four dehiscences to be closed secondarily. In the other group, the plates had to be removed in eight cases, and in six, an adequate secondary occlusion was achieved. In two cases, the plates had to be removed despite secondary closure.

Another interesting aspect is that in the RFF group, most exposures (11 of 16) occurred during the first six weeks ($p < 0.001$) (Fig. 3).

Significantly more plates were exposed among younger patients with a lower BMI. However, Kämmerer et al and Fanzio et al found no connection between complications with the plate and age.[5,16] A higher BMI is obviously associated with a larger flap because of its thicker subcutaneous layer, which was illustrated in earlier studies.[21]

We could not establish any significance between adjuvant radiotherapy and exposure of the plate during the first postoperative year, and similar results have been reported by other authors.[3,5,16,19] A possible explanation for this is that most complications after radiation appear two to five years postoperatively.

The situation is different when it comes to smoking. We found an association between smokers and exposure of the plate, and similar results have been described elsewhere.[15,19]

To describe the site of the defect, we used the Jewer classification.[13,15] The problems of the C defects (C, CL, LCL) are torsional forces, concentration of muscular tension, strength of the masticatory muscles, formation of a dead space, and the thin layer of covering tissue in this segment of the jaw that encourage the development of complications with the plate and, in particular, its exposure.[16,19,22] Many studies have shown the correlation between anterior defects and intraoral exposure of the plate.[22] In total, there were 19 C defects including CL, LCL, and C. There were 13 exposed plates in 19 reconstructions for both types of flap. Some authors even claimed that the use of plates in the anterior region should be restricted because of their high failure rate.[9]

There was a total of 28 isolated L defects, and the total number of plates exposed was 7/28. All seven plates were from the RFF group. Discher et al reported similar results, and recommended the use of reconstruction plates only in patients with isolated L-defects of less than 6 cm.[23] The muscular part of the VLMF allowed fixation on the plate to prevent unwanted movement of tissue and reduce dead space. Because the flap is larger, they do not break down over the reconstruction plate as much as the RFF.

The mean length of resection in the two groups did not differ significantly. The total dehiscence rate for defects up to 6 cm was 3/19, and 17/29 for defects up to 6 cm. There was a significantly higher dehiscence rate in the RFF group when defects were greater than 6 cm ($p = 0.002$). If we analyse the types of flap separately, there was no dehiscence in 9/11 cases for defects < 6 cm in the radial group. In the VLMF group there were no exposed plates with defects of less than 6 cm.

We have shown the advantages of the VLM flaps compared with RFF in large mandibular defects. We think that the RFF has a special role only in the reconstruction of smaller (<6 cm), isolated, lateral defects of the lower jaw. The thin and flexible fasciocutaneous transplant allows a better anatomical reconstruction than the much more voluminous VL flap, which can be significantly more difficult to give an anatomical shape to, particularly in the retromolar region.[4]

Of our 48 patients, 31 had no bony reconstruction, the most common reason for which in 13 cases was local recurrence. Similar recurrence rates between 29% and 45% are published elsewhere.[24] This means that every fourth patient in our clinic developed a local relapse during the first 18 months, which required a salvage procedure. Another eight patients had distant metastases and had to be treated palliatively. The remaining 10 patients developed second tumours of different types, were in very poor general condition, could not have a curative resection, or died.

As most recurrences take place during the first 18 months, we follow a “wait-and-see” approach with intensive, monthly follow-up appointments and then, after one year free of tumour, we start reconstruction. The primary goal of oncological surgery is resection for cure, as invaded margins are associated with a worse prognosis. The soft tissue margins are controlled intraoperatively with histological cryosections. This is not possible with bony tissue intraoperatively, so in seven of our patients we had to resect at a second operation because of microscopic spread or close margins. In two other cases, resection for cure could not be achieved. This means that one in five patients needed a further bony resection, which would endanger the transplant in the case of a one-step reconstruction.

Of the 17 bony reconstructions, 10 have already been successfully rehabilitated using dental implants. Two more are planned. There were no failures of implants or osteoradionecrosis, as the transplanted bone was not irradiated.

Many studies have concluded that dental implants placed in irradiated areas have a lower survival than those placed in non-irradiated areas, and possible complications are a high-risk threat throughout the life of such patients.[25] Last but not least, all bony reconstructions were computer-assisted.

We know that the one-step approach to mandibular reconstruction is the gold standard worldwide, not only to save the patient a second intervention but also for public health as well as economic reasons. In our department, it is also practiced routinely in cases of inflammation, trauma, and benign tumours. However, in advanced oncological cases with clinical or radiological suspicion of bony involvement and the possible need for adjuvant irradiation, we prefer the two-step approach of at least one year free of tumour. The two main reasons are the high local recurrence rate and the possibility of oral rehabilitation in a non-irradiated jaw. The selection of a flap for reconstruction of the jaw with soft tissue alone depends on the size and site of the defect. We therefore recommend the VLMF for its greater volume as the first choice.

Conclusion

Two-step mandibular reconstruction is prone to complications. If the defect is reconstructed with a plate and soft tissue transplant only it tends to develop a dehiscence, particularly in anterior segments of jaw (C-defects). However, when the two-step reconstruction is needed, we recommend using the VLMF because of its greater volume, and because it breaks down less often than the RFF. For smaller (< 6 cm), isolated L-defects, particularly in the retromolar region where thin, flexible flaps are necessary, the RFF can be still a reconstructive option.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

Institutional ethics approval was given, and patients' permission obtained.

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