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Functional and aesthetic treatment outcomes after immediate jaw reconstruction using a fibula flap and dental implants☆

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ABSTRACT

Purpose: Microvascular fibula flap surgery is a reliable and effective procedure for reconstructing the jaws after tumour surgery. This procedure allows the placement of dental implants after bone consolidation. This study was designed to evaluate the oral, functional, and aesthetic rehabilitation of tumour patients with immediate fibula transfer and dental implants and included assessment of diet, speech, and aesthetics.

Materials and methods: The study included 34 patients who underwent ablative tumour surgery and immediate jaw reconstruction using a fibula free flap with consecutive rehabilitation by dental implants. In total, 134 implants were inserted into the transferred fibula. The functional and aesthetic results were assessed using a questionnaire. Implant loss and oral excursion were compared with diet type, speech ability, functionality, and patient satisfaction.

Results: Of the 34 patients included in this study, 33 completed the questionnaire. Twenty-six patients (76%) could eat normally without the limitation of a hard or soft diet, 73% could speak intelligibly, and 31 rated the aesthetic result from good to excellent.

Conclusion: The fibula flap with the early application of endosseous implants allowed primary immediate reconstruction of the jaw, significantly leading to functional and aesthetic satisfaction in patients who underwent ablative tumour surgery.

1. Introduction

Treatment of oral tumours by ablative surgery is the current standard and often results in jaw defects (Roumanas et al., 2006). These defects lead to functional and aesthetic impairment, such as impairments in speech and mastication, swallowing limitations, and disfigurement (Chiapasco et al., 2006). The role of rehabilitation is to restore oral functions, including speech, swallowing, and chewing and to obtain acceptable aesthetic results in these patients to allow them to resume a normal lifestyle (Hayter and Cawood, 1996). Functional rehabilitation is very important for the well-being of tumour patients (Rogers, 2001). The importance of functional rehabilitation is well known but is always difficult to achieve. The possibilities of good oral function following surgery depend on several factors, such as tumour location and size, dental status, and the remaining teeth. The location of the tumour has a very important role in the functional rehabilitation phase, and it depends on the site of the resection when soft tissue and hard tissue are involved (Schliephake et al., 1998). Regarding the size of the tumour, patients with larger tumours and larger defects have worse functional rehabilitation outcomes. Patients with residual dentition have a better rehabilitation than those who do not have teeth after tumour surgery. Differences between radical neck dissection and function-preserving selective neck dissection were observed (Rogers, 2001).

The treatment of maxillomandibular tumours with respect to the primary or secondary reconstruction is handled differently

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worldwide and is often discussed. For both treatment options, there are advantages and disadvantages. An individual decision for each patient is necessary, and such decisions should be made in consideration of patient age, tumour size, risk factors, and recurrence rate. Resection and reconstruction in one surgical procedure is possible with a two-team approach.

Reconstruction after surgical resection using microvascular free tissue transplantation allows the surgeon to replace bone, muscle, and skin (Baker et al., 2001; Millard et al., 1967; Rogers, 2001). The use of endosseous implants improves the quality of oral rehabilitation by enabling the patient to chew with an implant-supported prosthesis. Dental implants may be inserted into bone grafts at the same time of the grafting surgical procedure, or secondarily (Barber et al., 1995). However, not every patient with jaw reconstruction can obtain dental implants, and the decision needs to be based on various factors such as oral hygiene, prognosis, and patient cooperation (Wei et al., 1997). The definitive dental prostheses used most frequently are implant tissue-supported overdentures and implant-fixed or implant-removable prostheses. The removable prostheses make it easier for the patient to maintain good oral hygiene (Renk, 2007). Therefore, implant-supported prosthetic construction is preferred. Promising survival rates of the fibula flap and dental implants in patients who undergo ablative tumour surgery and immediate reconstruction with the fibula flap and subsequent dental implants have been reported (Attia et al., 2018). The aim of this study was to retrospectively evaluate the oral functional and aesthetic rehabilitation of the same patients.

2. Materials and methods

2.1. Patients and procedures

This study was approved by the local research ethics committee of the Faculty of Medicine of Justus-Liebig-University Giessen (Document Number 25/10), and it was supported by the Organization for Cancer Research in Giessen (registered society).

In this retrospective study, 34 patients from 2000 to 2011 who were undergoing mandibular or maxillary resection and reconstruction with microvascular fibula flap and insertion of dental implants were included. In brief, the tumour ablative surgery and immediate reconstruction of the jaw were carried out and the healing was attempted for at least 6 months. The recurrence of tumour was excluded and bone consolidation was ensured using panoramic X-ray, after which implant planning was pursued. Patients were then scheduled for dental implant oral surgery in which all implants are placed in one session. After osseointegration of the implants (4–6 months), the dental implants were exposed using healing abutments (gingival former). To gain a vestibule with attached gingiva, vestibuloplasty using a free mucosal graft from the palate is performed. The patients are then referred to the Department of Prosthetic Dentistry to start the prosthetic procedure. Due to the high vertical displacement in some cases with divergence of implants over 40°, double-crown overdentures were planned. A fixed-bridge was implemented in all other cases regarding the number and position of lost teeth and in accordance with the guidelines of the German Association for Dental Prosthetics and Biomaterials (DGPro).

Radiologic and photographic documentation after prosthetic rehabilitation was carried out at all follow-up time points. Fibula and implant survival were documented previously (Attia et al., 2018). All patients were treated in one centre. The data collected from the patient records included age, sex, indications for surgery, location of defect, and implant and prosthetic rehabilitation. The patients were selected based on their obligation to the regular follow-up, at which a clinical examination and an interview using a customised questionnaire (combined from three published ones Iizuka et al, 2005, Takushima et al, 2001, Peng et al, 2005 are routinely performed according to the institutional guidelines. The purpose of the assessment of functional outcome, such as nutrition, speech, mouth opening, and aesthetic outcome, was to determine the extent to which our patients enjoyed a reasonable quality of life after ablative tumour surgery. The patients completed the customised questionnaire themselves. The terminologies were explained to the patients (e.g., soft diet is referred to a pudding-like consistency regardless of the original contents). The type of nutrition was classified as follows: 1, normal; 2, soft diet; and 3, nutrition with a feeding tube.

The quality of speech included the following criteria: intelligible, intelligible with concentration, and unintelligible. Speech capacity was self-assessed by the patients to avoid subjective bias by the researcher in this retrospective study. No baseline assessment was performed preoperatively.

The facial aesthetic result from the patient's point of view was rated as follows: satisfactory, acceptable, and unsatisfactory. After the prosthodontics rehabilitation, every patient rated the dental aesthetic result as follows: excellent, good, fair, and poor. The maximum mouth opening for each patient was measured and recorded in millimetres.

Of 34 patients, only 5 had radiation therapy, 1 pre-operative and 4 post-operative. Furthermore, the 3 patients with T4 and positive neck results had all rejected any radiation therapy. Therefore, as the number is not statistically representative to carry out a significance analysis, the radiation treatment was excluded as an investigation criterion so as to avoid misleading conclusions. The data were collected from the patient's digital file (KAOS® software clinical administration system of the University Hospital Giessen), categorised, and analysed using Microsoft Excel, Version 2007 (Microsoft Corporation, Redmond, WA, USA). The raw data are provided as Supplementary Table S2.

2.2. Statistical analysis

The data were not normally distributed. Therefore, the Mann–Whitney *U*-test with the Bonferroni post hoc test was performed, with significance set at $p \leq 0.05$. Statistical analysis was performed using SPSS statistical software version 24.0 (IBM Corporation, Armonk, NY, USA).

3. Results

From January 2000 to December 2011, a total of 34 patients underwent immediate microvascular fibula transplantation and dental implant placement. All patients were surgically treated at the Department of Oral and Maxillofacial Surgery and prosthetically rehabilitated at the Department of Prosthodontics of the University Hospital Giessen in Germany. Data on the patients' general conditions and personal habits were collected at the time of follow-up examination. The functional outcome was evaluated in 33 patients during the clinical examination using a standardised questionnaire. One patient did not answer the questionnaire and was considered a drop-out.

Tables S1A–D summarise the patient data regarding age, sex, stage of tumour, and extent of bony defect. The Brown and Iizuka classifications for the maxillary/mandibular defect were considered (Brown et al., 2000; Iizuka et al., 2005).

Fig. 1 shows a patient with squamous cell carcinoma of the anterior mandible and treatment procedures until oral rehabilitation.

The type of nutrition after dental rehabilitation was recorded. Of the patients, 26 (76%) could eat normally without the limitation of a hard or soft diet, and 7 (20.6%) could eat only a soft diet. As

expected, patients with implant loss (n = 5) showed a significantly stronger tendency to eat a soft diet (Fig. 2A). Soft-diet consumers had a significantly smaller oral excursion than normal-diet consumers (Fig. 2B).

The quality of speech was intelligible in 25 patients (73.53%) without effort. In 7 cases (20.6%), speech was intelligible with effort. In 1 case, speech was unintelligible under the usual conditions of conversation. The worst speech ability was correlated with more lost implants (Fig. 3A). However, the pattern was reversed with oral excursion (Fig. 3B).

Regarding the mandibular or maxillary contour, 20 patients (58.83%) felt satisfied, 12 patients (35.3%) found the result acceptable, and 1 patient declared an unsatisfactory outcome.

Regarding dental aesthetics, 8 patients (23.5%) were satisfied with the dental aesthetic result and marked it as excellent. A total of 23 patients (67.7%) evaluated the result as good, 1 patient evaluated the result as fair, and 1 patient evaluated the result as poor (2.9%). The degree of satisfaction with the dental aesthetics was negatively correlated with the number of lost implants (Fig. 4A). Whereas oral excursion was not directly related to aesthetic satisfaction apart from the low oral excursion, 1 patient reported “poor” satisfaction. Other patients evaluated their satisfaction independently of oral excursion (Fig. 4B). The maximum mouth opening ranged from 5 to 60 mm. The mouth opening of most patients (n = 32) was adequate (between 25 and 60 mm) for reasonable mastication.

The overall functionality reflected the degree of satisfaction and speech and eating abilities. Patients with higher numbers of lost implants (at least 6) and those with smaller oral excursions evaluated the rehabilitation as nonfunctional (Fig. 5A and B).

4. Discussion

Ablative surgery is the treatment of first choice in oral tumour treatment, but it results in the destruction of soft tissue and bone structures. The consequence is the loss of teeth in these regions. Reconstruction with a fibula graft and soft tissue rebuilds the speech and swallowing functions, particularly while other important functions, such as masticatory and aesthetic functions, are still absent because of missing teeth. To restore masticatory and aesthetic functions, as well as to improve speech, the use of dental implants and implant-supported dentures is necessary. Furthermore, the implants and their implant-supported dentures stimulate the fibula graft bone, avoiding atrophy of the transplanted fibula graft (Linsen et al., 2008).

In general, the rehabilitation of tumour patients is based on the techniques and methods used for conventional dentures; the challenge in these cases is to adapt the techniques and methods to the individual tumour and defect situation. Another special aspect is that the restored tissue, especially the soft tissue, is not comparable to normal gingiva or oral mucosa and cannot be used as a prosthesis base. Therefore, prosthodontics rehabilitation should consider that the fibro-elasticity of the peripheral soft tissue is reduced, and the removable partial denture should be supported mainly by implants. Furthermore, the implants improve the retention and stability of the removable partial denture. Moreover, implants should be placed in posterior regions, because the use of implants on the distal edentulous site is an advantage in these cases (Bortolini et al., 2011; Gonçalves et al., 2014; Ohkubo et al., 2008). Furthermore, lost implants affected the assessment of function in patients when no prosthesis could be provided. However, our data show that only 2 patients with 6 lost implants and a double-crown removable prosthesis assessed the function with a response of “no” referring to non-usable prosthesis.

A vertical and horizontal displacement between the original bone jaw and the fibula graft as a result of ablative surgery and fibula transfer can also be frequently noticed (Sieg et al., 1999). This discrepancy can be solved either by prosthetic compensation or by additional bone augmentation. In high vertical displacement cases resulting in an implant divergence over 40°, neither a fixed-bridge nor a bar-retained approach is feasible. The functional advantage of the latter is the distribution of mechanical loading evenly on the implants (Gbara et al., 2007). Furthermore, the prosthetic restoration should be easy to clean. Moreover many oral malignant tumours are associated with poor oral hygiene in the patient (Talamini et al., 2002). The use of removable dentures is necessary to avoid extra-axial forces and poor crown/implant relations. Most likely, a removable denture—especially a double-crown prosthesis—should be favoured in these patients. In cases of large vertical displacements, a double-crown prosthesis has a static advantage because of its splinting effect (Elsyad and Mostafa, 2018; Goswami et al., 2013). There is also an aesthetic advantage: the long teeth could be compensated for by a simulated gingiva on the prosthesis.

Double-crown prostheses also have the advantage of removability for cleaning, repair, and clinical examination during follow up (Frisch et al., 2015; Krennmair et al., 2012; Zou et al., 2013).

Regarding deglutition, this study found that 76% of patients could eat a normal diet; this is higher than the comparable figures of 50% (Lin et al., 2011; Shpitzer et al., 2000) and 46.4% (Iizuka et al., 2005) reported by other investigations. The higher rates of good

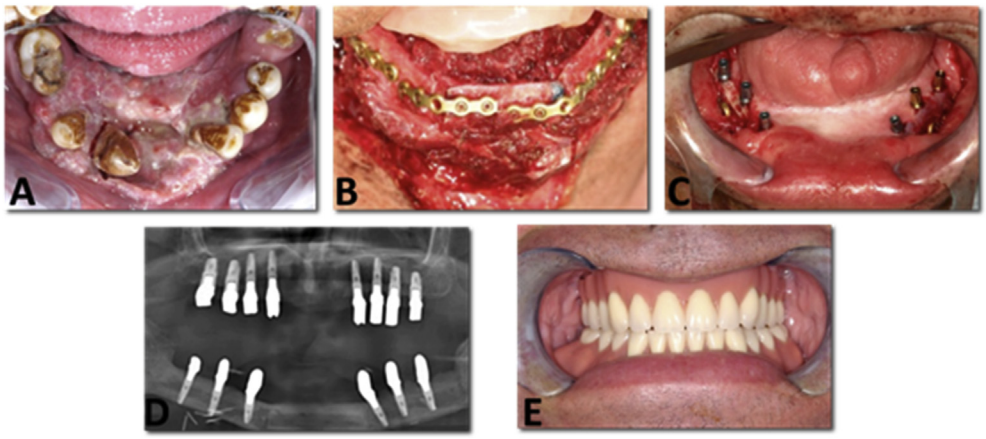

Fig. 1. Treatment procedures from tumour resection to oral rehabilitation. (A) Preoperative view of a patient with squamous cell carcinoma of the anterior mandible. (B) Intraoperative surgical view shows the immediate reconstructed mandible using the fibula free flap. (C) Intra-oral appearance after application of six dental implants (Friadent Xive®). (D) Panoramic view of the reconstructed mandible using the fibula flap and dental implantation in the upper and lower jaw. (E) Prosthetic rehabilitation using dental implants.

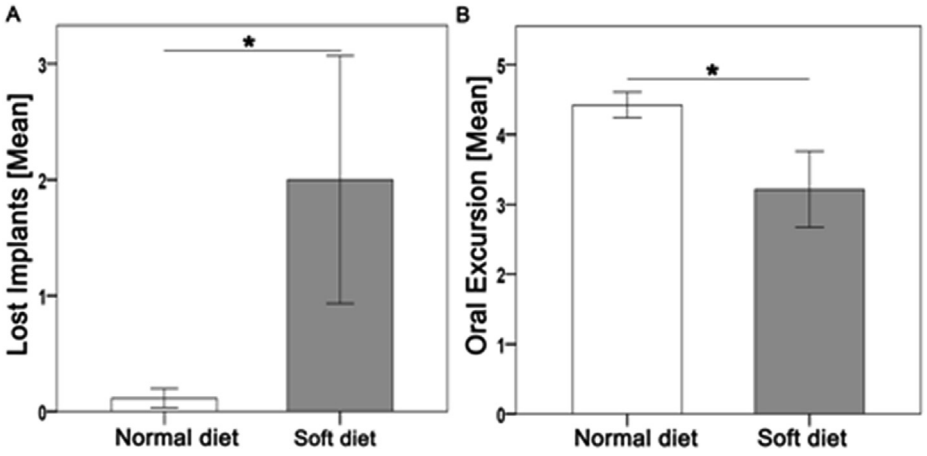

Fig. 2. Eating ability correlates negatively with the number of. (A) lost implants and positively with. (B) oral excursion. Eating ability and mouth opening ability after dental rehabilitation are important factors in a patient's satisfaction and treatment following fibula transfer and dental implant procedures.

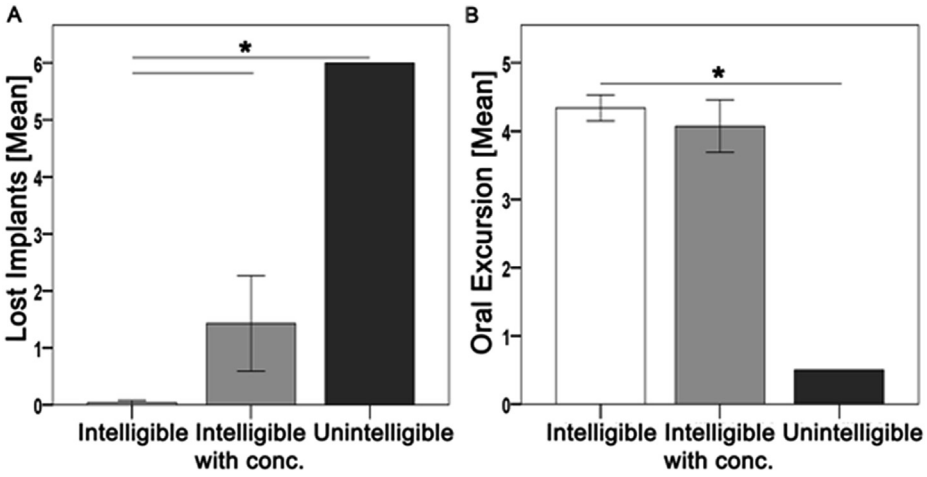

Fig. 3. Speech ability is affected by the functionality and number of successful implants. (A) The increase in the number of lost implants resulted in less intelligible speech. (B) Better oral excursion resulted in better speech clarity.

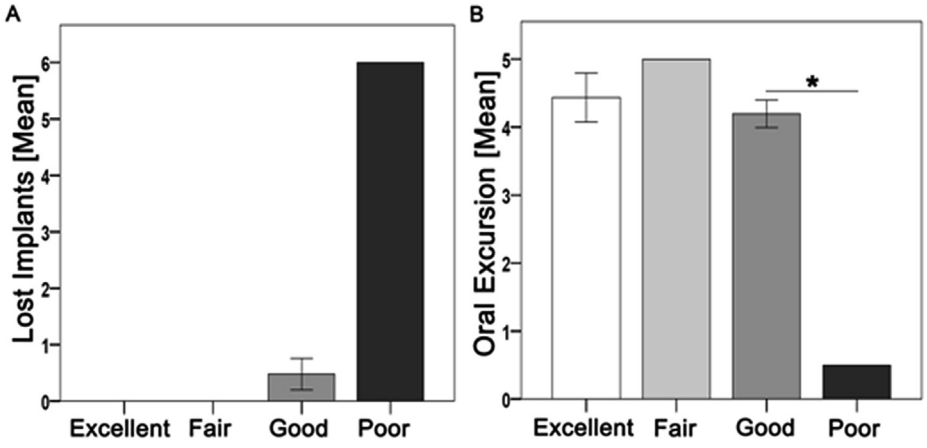

Fig. 4. Dental aesthetic results after fibula transfer and dental implantation. (A) Degree of patient satisfaction correlated negatively with implant loss. (B) Patient estimate of aesthetics did not depend on oral excursion.

eating may be derived from better outcomes for dentures supported by dental implants.

The phonetic rehabilitation observed in this study was comparable to that in the literature. In the present examination, 73.53% of patients could speak intelligibly, whereas other studies documented 92.9% (Shpitzer et al., 2000) and 60.7% (Iizuka et al., 2005). Our results showed no relevance between the classification of fibula augmentation, the size of defect, the number of implants and

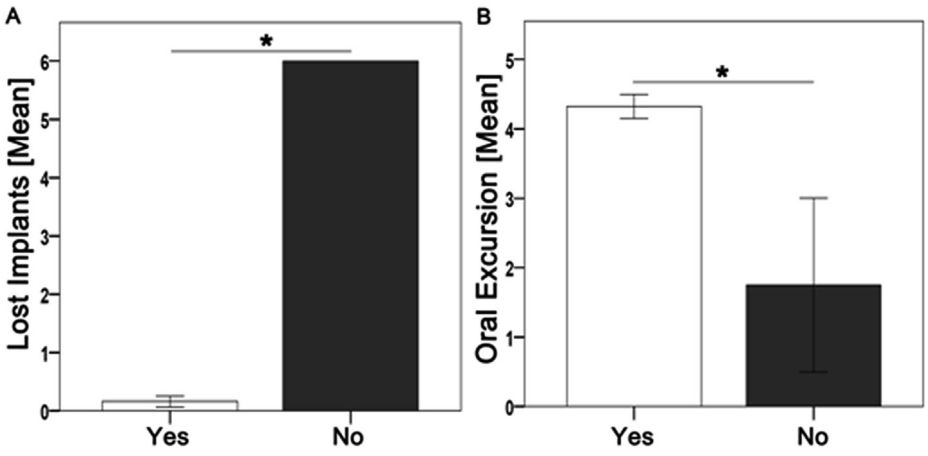

Fig. 5. Overall patient assessment of functional treatment. (A) More lost implants were associated with more loss of function. (B) Lower oral excursions were associated with lower functional assessments.

the functional capacity, satisfaction, or aesthetic. Despite 50% of the upper jaw augmentation showing lack of function, the sample size of 2 is not representative. Furthermore, the lower jaw showed only 3% lack of function in 32 patients. Therefore, no relevance to the localization or classification of the augmentation is seen in the current study.

Excellent aesthetic results in this study were found in 8 patients (23.5%), but 23 patients (67.7%) rated the results as good. By contrast, other authors reported higher patient ratings of aesthetic results: excellent in 78.6% and acceptable in 2 patients (14.3%) (Shpitzer et al., 2000). Hidalgo and Pusic (2002) found that 55% of patients reported an excellent aesthetic outcome and 20% reported a good aesthetic outcome (Hidalgo and Pusic, 2002).

5. Conclusion

Oral rehabilitation of oral tumour patients with regard to dentures, speech intelligibility, and deglutition as well as in terms of the aesthetic outcome after free flap transplantation can be challenging. Immediate reconstruction by fibula transfer and application of endosseous implants has significantly increased the possibilities of jaw reconstruction. This study found reasonably good functional and aesthetic results after the free fibula flap procedure and dental implantation in terms of the subjective well-being of tumour patients.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2018.12.017.

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