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Quality of life of patients receiving short dental implants in microvascular free flaps: a five year prospective study

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Placing dental implants in the microvascular bone free flaps used for reconstruction of mandible or maxilla is a technique that has been previously reported. However, there is a scarcity of data on the use of short dental implants in this situation, as well as on the performance of prosthetic restorations. Therefore, this prospective study enrolled 13 patients who have undergone jaw reconstruction using one of the four types of microvascular osseous flaps, who received a total of 44 implants. Patients who completed prosthetic rehabilitation answered questionnaires on their quality-of-life over the course of their treatment. The results revealed a high implant survival rate of 97.1% (95% CI: 80.9–99.6%), and a similarly high success rate of 88.2% (95% CI: 71.6–95.4%) at 63 months after implant surgery. Additionally, survey results revealed quality-of-life improvements after prosthetic rehabilitation, specifically in the areas of food and fluid intake, as well as articulating language. Overall, short implants in microvascular free flaps provide a robust solution for the functional rehabilitation of dentition in patients with head and neck malignancies.

Keywords Short dental implants, Microvascular free flap, Prosthetic rehabilitation, Quality of life

The gold standard treatment for head and neck malignancies is surgery followed by microvascular free flap reconstruction[1]. If, as a result of jaw tumor resection, the patient has no residual dentition suitable for denture retention, prosthetic reconstruction with dental, dentomucosal or mucosal transmission of masticatory pressure proves to be practically impossible. Patients lose the ability to accept food in solid form, masticate, or articulate properly. The lack of functional dentition, in combination with other consequences of oncological disease, significantly worsens patients' quality of life, even if the patient has undergone microvascular free flap reconstruction.

Defects in the head and neck area threaten patients' psychosocial well-being, and in extreme cases can lead to social isolation or suicidal tendencies. The success of reconstructive procedures, specifically the aesthetic and functional results of surgical treatment and prosthetic rehabilitation, is crucial for the social acceptance of the patient[2]. While it is possible to provide patients with functional dentition without involving jaw reconstruction by using zygomatic implants, said technique is associated with a high rate of medium to long term complications[3] and their use is subject to caution[4]. Hence, microvascular free flap reconstruction remains the method of choice, and can be further enhanced by utilizing CAD/CAM assistance[5].

Subsequently, the most appropriate method of rehabilitation for patients who have undergone free flap reconstruction is the introduction of dental implants into the bone of the microvascular free flaps (terminologically, the neomaxilla or neomandible), and subsequent laboratory fabrication of implant-supported prosthetic replacements. While this method of treating patients is the standard of care internationally, quality-of-life data for these patients is scarce.

To address this gap, our prospective study aims to evaluate dental implant survival, implant success, and patient quality-of-life, in a group of patients after reconstruction of the maxilla or mandible using osseous microvascular free flaps. Specifically, we evaluated short dental implants, which have previously demonstrated

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high survival and success rates in a variety of challenging clinical scenarios including severely atrophic mandibles and full-arch restorations[6–10], as well as oncologic patients[11].

Materials and methods

Our prospective study included patients who have undergone jaw reconstruction using one of the following types of microvascular osseous flaps: fibula free flaps (FFF); deep circumflex iliac artery (DCIA) flaps; thoracodorsal artery perforator (TDAP) scapular tip flaps; and medial femoral condyle (MFC) flaps. To qualify for inclusion both for reconstructive treatment and for this study, patients must have undergone healing times of at least 6 months after surgical reconstruction, and 12 months after the end of chemo/radiotherapy, before dental implant surgery was initiated. Additional inclusion criteria included having either the native dentition or a prosthetic replacement on the opposite jaw; satisfactory oral hygiene; a minimum neo-alveolar ridge height of 6 mm, and a minimum neo-alveolar ridge width of 5 mm.

Exclusion criteria, both for this study and for jaw reconstruction in general, included active or recurring oncological disease; smoking of more than 20 cigarettes a day[12]; ongoing treatment with bisphosphonates; and osteonecrosis in the area of the reconstructed alveolus. The study was approved by the Ethics Committee of the F.D. Roosevelt Hospital, 975 17 Banská Bystrica, with the approval number 2/2020. All authors confirm that the recognized standards of the Declaration of Helsinki; US Federal Policy for the Protection of Human Subjects; and the European Medicines Agency's guidelines for good clinical practice have been followed. All patients included in the study group provided their written informed consent prior to enrollment.

Since existing data on the quality of life outcomes of jaw reconstruction is scarce, we did not have sufficient data to conduct a power analysis. Therefore, we included in this study patients who were enrolled and received dental implant treatment between 01/02/2019 and 12/31/2023. Patients were examined by both the oral surgeon and the restorative dentist to determine the implant placement position and the prosthetic plan. The number of implants used was determined according to the size and extent of the microvascular bone flap. Osteosynthetic materials, namely, titanium plates and screws that were used to fixate microvascular flaps, were removed via surgery so as to not impede implant placement. Then, we placed dental implants in the osseous microvascular flaps on the same day. Given that microvascular reconstructions with osseous flaps often result in reduced bone volumes, we chose to place short dental implants (< 8 mm in length), which enabled insertion into neomandibles or neomaxillae with limited bone volumes, without requiring additional bone augmentation or osteodistraction.

Locking-taper implants with hydroxyapatite coatings (Integra-CP™, Bicon LLC, Boston, USA) were used. Implants were placed using the manufacturer's recommended two-stage protocol. After implant insertion, titanium temporary abutments with low profiles (Thin Crestal Temporary Abutments, Bicon LLC) were inserted into the locking-taper wells of the implants. The temporary abutments were then covered with soft tissue to achieve implant stability and allow for implant osseointegration.

After the osseointegration of the implants was confirmed by radiological examination, approximately 3–6 months after surgery, the implants were surgically exposed with the subsequent simultaneous introduction of temporary abutments. Any required soft tissue modification procedures, such as vestibular deepening, soft tissue augmentation, and epithelial or subepithelial mucosal grafts, were included in this step. Then, after a period of soft tissue healing, intraoral impressions and intraoral scans of the jaw were taken and used to fabricate definitive prostheses for the patient, which were then intraorally fixed onto the dental implants.

Data collection

Following implant and prosthesis insertion, patients were followed up using orthopantomogram and cone beam computed tomography imaging, which were used to monitor osseous changes around the implants. Additionally, the following study covariates were recorded: age at the time of implantation; sex; indication for jaw reconstruction with a microvascular bone flap; type of microvascular flap; the jaw being reconstructed; any postoperative complications; the number of implants; location of implant placement; and the material on the opposite jaw.

The primary outcome of this study was implant survival, defined as the presence of the implant in situ at the time of the most recent follow-up visit; and implant success, defined as less than 1 mm per-implant bone loss during the first year of function without signs of inflammation and subjective patient difficulties. Secondary outcomes were assessed using a quality-of-life questionnaire at three time points: after free flap reconstruction, after dental implant surgery and before prosthetic reconstruction; and after the patient was restored with the prosthesis. Of the 47 survey questions, 35 asked the patients to describe whether they encountered symptoms or problems (Table 1), 5 asked about patient experiences (Table 2), and 7 asked the patient to rate their satisfaction with different aspects of health using a Likert scale (Table 3). The survey was based upon the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ) for head and neck cancer patients. Questionnaire data was collected from all patients who have completed prosthetic rehabilitation.

Data analysis

Kaplan–Meier analyses were used to assess implant survival and success. Multivariate Cox regression was used to investigate the influence of patient covariates on implant outcomes. For quality-of-life survey results, two-sided t-tests were used to test for significant differences between two sets of survey results: after free flap surgery versus after prosthesis insertion; and after dental implant surgery versus after prosthesis insertion. Each survey question was tested individually, with the *P*-value significance threshold adjusted to account for multiple statistical tests being conducted.

Patients sometimes report that they have the following symptoms or problems. Please indicate the extent to which you have experienced these symptoms or problems during the past week. Please answer by circling the number that best applies to you					
Question	**During the past week:**	**Not at all**	**A little**	**Quite a bit**	**Very much**
1	Have you had pain in your mouth?	1	2	3	4
2	Have you had pain in your jaw?	1	2	3	4
3	Have you had soreness in your mouth?	1	2	3	4
4	Have you had a painful throat?	1	2	3	4
5	Have you had problems swallowing liquids?	1	2	3	4
6	Have you had problems swallowing pureed food?	1	2	3	4
7	Have you had problems swallowing solid food?	1	2	3	4
8	Have you choked when swallowing?	1	2	3	4
9	Have you had problems with your teeth?	1	2	3	4
10	Have you had problems opening your mouth wide?	1	2	3	4
11	Have you had a dry mouth?	1	2	3	4
12	Have you had sticky saliva?	1	2	3	4
13	Have you had problems with your sense of smell?	1	2	3	4
14	Have you had problems with your sense of taste?	1	2	3	4
15	Have you coughed?	1	2	3	4
16	Have you been hoarse?	1	2	3	4
17	Have you felt ill?	1	2	3	4
18	Has your appearance bothered you?	1	2	3	4
19	Have you had trouble eating?	1	2	3	4
20	Have you had trouble eating in front of your family?	1	2	3	4
21	Have you had trouble eating in front of other people?	1	2	3	4
22	Have you had trouble enjoying your meals?	1	2	3	4
23	Have you had trouble talking to other people?	1	2	3	4
24	Have you had trouble talking on the telephone?	1	2	3	4
25	Have you had trouble having social contact with your family?	1	2	3	4
26	Have you had trouble having social contact with friends?	1	2	3	4
27	Have you had trouble going out in public?	1	2	3	4
28	Have you had trouble having physical contact with family or friends?	1	2	3	4
29	Have you felt less interest in sex?	1	2	3	4
30	Have you felt less sexual enjoyment?	1	2	3	4

Table 1. Quality of life questionnaire assessing symptoms or problems.

Question	During the past week:	No	Yes
31	Have you used painkillers?	1	2
32	Have you taken any nutritional supplements (excluding vitamins)?	1	2
33	Have you used a feeding tube?	1	2
34	Have you lost weight?	1	2
35	Have you gained weight?	1	2

Table 2. Quality of life questionnaire assessing patient experiences.

Results

A total of 44 implants placed in 13 patients were included in the study. Patient characteristics are described in Table 4. Although the use of statins was not an exclusion criteria for this study, none of the patients include in this study were taking statins. In addition, one patient was a smoker, albeit under the exclusion criteria limit of 20 cigarettes a day. Patients with systemic conditions were included in the study—two patients had diabetes mellitus, and one other patient had osteoporosis and dyslipidemia. Kaplan–Meier survival analysis (Fig. 1) revealed that the 63-month implant survival probability was 97.1% (95% CI: 80.9–99.6%), while the 63-month implant success probability was 88.2% (95% CI: 71.6–95.4%). One implant failed 9 months after implant surgery due to non-integration. In the same patient, another implant experienced bone loss of greater than 1 mm one year after surgery. Another patient had two implants that also experienced similar bone loss without leading to implant failure. Additionally, two instances of biological postoperative complications were recorded: one patient had postoperative soft tissue inflammation, and another had hyperplastic soft tissue of his DCIA. Neither

Dear patients, using a Likert scale, we would like to record changes in your satisfaction with the given criteria during inclusion in our research. We ask you to fill it out accurately for each examination and record honest results. Thank you in advance For each question, choose one numeric percentage value, where 100% corresponds to excellent satisfaction and 0% corresponds to complete dissatisfaction. (Please circle the selected percentage of satisfaction) My satisfaction with:					
Taking food in solid form	100%	75%	50%	25%	0%
Biting food	100%	75%	50%	25%	0%
Swallowing	100%	75%	50%	25%	0%
Facial aesthetic	100%	75%	50%	25%	0%
Pronunciation	100%	75%	50%	25%	0%
Soft tissues in the oral cavity (gum, tongue, mucous membrane)	100%	75%	50%	25%	0%
The use and quality of prosthesis on implants	100%	75%	50%	25%	0%

Table 3. Likert scale assessing patient satisfaction.

Sex	Age	Indication for microvascular reconstruction	Number of bone segments	Microvascular free flap	Reconstructed jaw	Dentition on opposing jaw	Number of dental implants
M	65	Secondary reconstruction due to osteoradionecrosis	3	Fibula free flap	Mandible	Natural teeth	4
M	49	Reconstruction after resection due to ameloblastoma	3	Fibula free flap	Mandible	Natural teeth	3
F	68	Reconstruction after resection due to carcinoma	3	Fibula free flap	Mandible	Removable total prosthesis	4
F	54	Reconstruction after resection due to carcinoma	3	Fibula free flap	Maxilla	Natural teeth	4
M	23	Reconstruction after resection due to carcinoma	2	Fibula free flap	Maxilla	Natural teeth	4
M	26	Reconstruction after aseptic necrosis of the maxilla posttraumatic	1	DCIA	Maxilla	Natural teeth	3
F	20	Reconstruction after resection due to benign lesion	1	DCIA	Mandible	Natural teeth	2
M	47	Reconstruction after traumatic injury	2	Fibula free flap	Mandible	Removable total prosthesis	4
F	56	Reconstruction after resection due to carcinoma	1	Fibula free flap	Mandible	Natural teeth	3
F	51	Reconstruction after resection due to sarcoma	2	Fibula free flap	Maxilla	Natural teeth shortened dental arch	3
M	57	Reconstruction after resection due to carcinoma	1	Scapula free flap	Maxilla	Natural teeth	3
M	59	Reconstruction after resection due to carcinoma	3	Fibula free flap	Mandible	Removable total prosthesis	4
M	40	Secondary reconstruction due to osteoradionecrosis	1	Fibula free flap	Mandible	Natural teeth	3

Table 4. Patient characteristics.

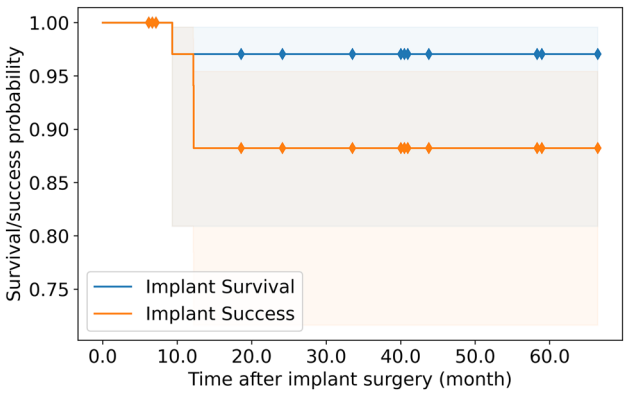

Fig. 1. Kaplan–Meier survival curve depicting implant survival and success. Shaded regions represent 95% confidence intervals.

complication led to bone loss or implant failure. When we separated the data by treating patients with different covariates as separate groups, we did not find significant differences between groups.From the point of view of the assessment of osseointegration of dental implants, we evaluated the presence of bone resorption one year after loading. From the total number of twenty-seven evaluated implants, according to the CBCT images, we evaluated four of them with resorption of the neo-alveolar bone, which is 14.8%.

Multivariate Cox regression using either implant survival or implant success failed to yield clinically meaningful results, since only one implant failed and few developed complications. Regression models using patient covariates either failed to converge or, when convergence was achieved, had large negative partial log-likelihood values.

Six patients received prostheses and completed quality-of-life surveys at all three time points during the course of the study. Two-sided t-tests revealed that of the questions that asked about problems with performing daily activities, two yielded significant results. Patients reported significantly fewer problems swallowing liquids ($P<0.001$) and less trouble talking to other people ($P<0.001$) after they received their prosthesis, compared to after free flap surgery (Fig. 2A,B). Similarly, for two questions on a Likert scale: satisfaction with biting food ($P<0.001$) and satisfaction with pronunciation ($P<0.001$), patients reported increased satisfaction after prosthesis insertion compared to after free flap surgery (Fig. 2C,D). There were no significant differences in the responses to those four questions between after the patients underwent implant surgery versus after the patients' prostheses were inserted. The patients' answers to the remaining questions were not significantly different over the course of treatment when assessed individually. Average survey responses are reported in Tables 5, 6, 7.

In addition to analyzing responses to each survey question individually, we combined patients' assessment scores of all symptoms and problems and compared bulk symptom scores ranging from 1 to 4 across the course of treatment. Patients' average self-reported symptom levels dropped from 1.8 after free flap surgery, to 1.3 after implant surgery, and stayed at 1.3 after prosthesis insertion (Fig. 3A). Similarly, patients' Likert scores of self-reported satisfaction increased over the course of treatment, from 59% after free flap surgery, to 64% after implant surgery, and eventually to 93% after prosthesis insertion (Fig. 3B). Similar to the analysis of patient outcomes, no significant differences in QoL or patient satisfaction between patients with different covariates were identified.

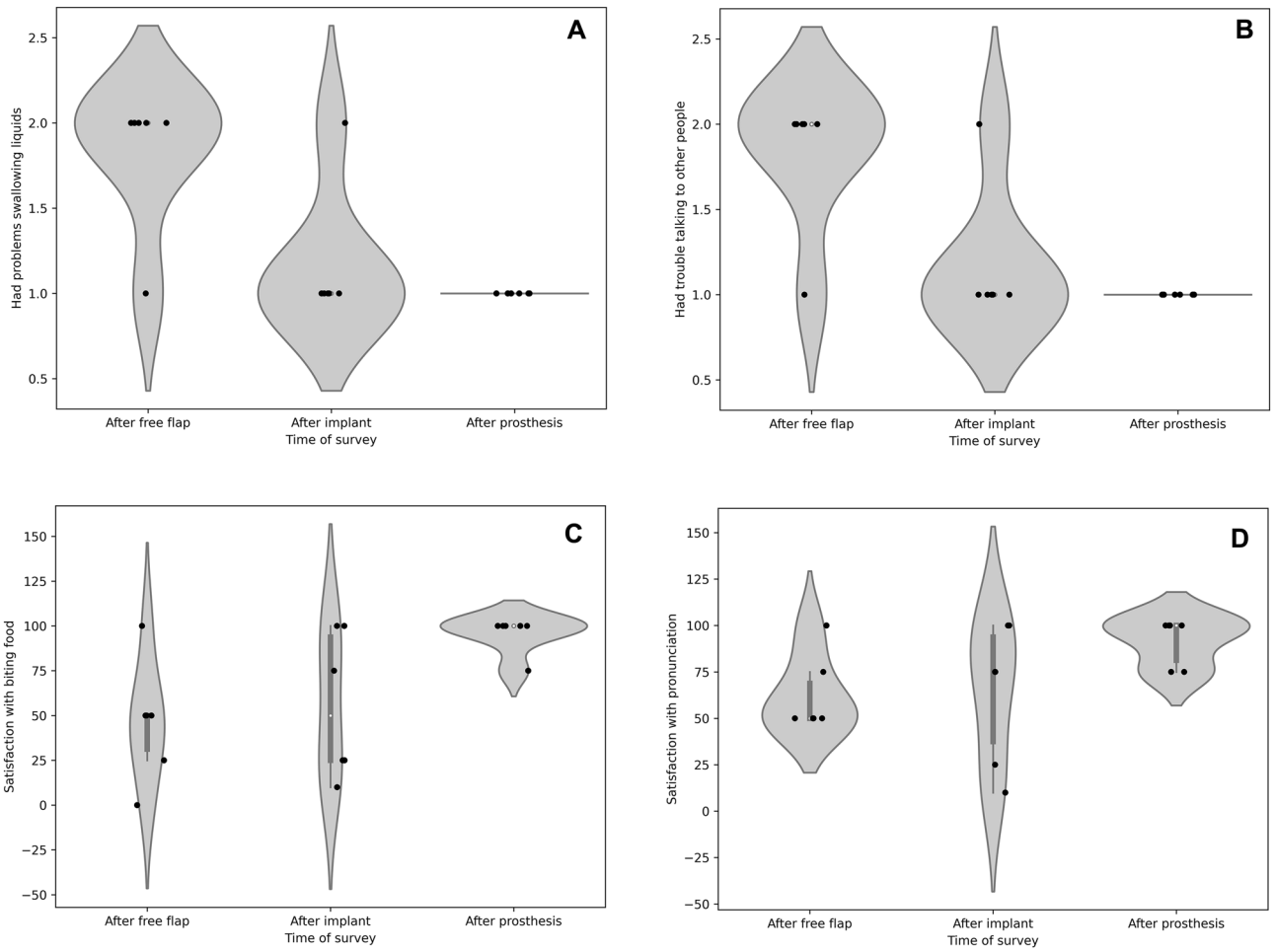

Fig. 2. Violin and strip plots representing survey responses that changed significantly over the course of treatment. Each dot represents one response, and the gray shaded areas represent the kernel density of data distribution. Each subplot corresponds to one survey question: (**A**) "Have you had problems swallowing liquids?" (**B**) "Have you had trouble talking to other people?"; (**C**) "Satisfaction with biting food."; (**D**) "Satisfaction with pronunciation."

After free flap		After implant surgery		After prosthesis insertion	
Question	Average symptom score	Question	Average symptom score	Question	Average symptom score
13	1.2	27	1.0	13	1.2
1	1.3	13	1.0	1	1.3
16	1.3	9	1.0	16	1.3
22	1.3	23	1.2	22	1.3
8	1.3	24	1.2	8	1.3
26	1.3	14	1.2	26	1.3
19	1.3	26	1.2	19	1.3
4	1.3	15	1.2	4	1.3
27	1.5	6	1.2	27	1.5
17	1.5	5	1.2	17	1.5
24	1.5	8	1.2	24	1.5
21	1.5	7	1.3	21	1.5
3	1.5	22	1.3	3	1.5
14	1.5	25	1.3	14	1.5
20	1.5	4	1.3	20	1.5
2	1.5	3	1.3	2	1.5
6	1.5	16	1.3	6	1.5
9	1.5	17	1.3	9	1.5
15	1.7	21	1.3	15	1.7
23	1.8	28	1.5	23	1.8
10	1.8	1	1.5	10	1.8
5	1.8	19	1.5	5	1.8
28	1.8	29	1.5	28	1.8
18	1.8	11	1.5	18	1.8
12	2.5	10	1.5	12	2.5
30	2.5	2	1.5	30	2.5
25	2.7	20	1.5	25	2.7
7	2.7	18	1.7	7	2.7
29	3.0	12	1.7	29	3.0
11	3.0	30	1.7	11	3.0

Table 5. Average patient symptom scores over the course of treatment.

After free flap		After implant surgery		After prosthesis insertion	
31	17%	31	0%	35	0%
34	33%	32	17%	31	17%
32	50%	33	17%	32	17%
35	50%	34	33%	33	17%
33	67%	35	33%	34	33%

Table 6. Results from quality-of-life questionnaire assessing patient experiences. For each time point at which the survey was administered, the survey questions were ranked by level of satisfaction to highlight the least and most common experiences at each stage.

Representative case

We present a case of a patient who underwent reconstruction of the mandible with the placement of four short dental implants following by prosthetic restoration. The patient's medical history dates back to 2013 when he was diagnosed with squamous cell carcinoma that has metastasized to the left cervical lymph nodes. Initially, the tumor was located on the floor of the mouth, slightly paramedian to the left side, with an ulceration measuring 2×1 cm. The tumor had infiltrated the floor of the anterior third of the tongue, which showed mild fixation, while the hypopharynx and larynx were unremarkable. In 2013, the patient declined primary surgical treatment at the initial institution and instead underwent concurrent chemotherapy and radiotherapy, completing the treatment in March 2013.

After free flap		After implant surgery		After prosthesis insertion	
The use and quality of prosthesis on implants	30%	The use and quality of prosthesis on implants	52%	Facial aesthetic	79%
Biting food	46%	Biting food	56%	Swallowing	85%
Taking food in solid form	58%	Taking food in solid form	64%	Pronunciation	92%
Pronunciation	63%	Pronunciation	64%	Biting food	96%
Soft tissues in the oral cavity (gum, tongue, mucous membrane)	67%	Swallowing	68%	Taking food in solid form	100%
Swallowing	75%	Facial aesthetic	73%	Soft tissues in the oral cavity (gum, tongue, mucous membrane)	100%
Facial aesthetic	75%	Soft tissues in the oral cavity (gum, tongue, mucous membrane)	73%	The use and quality of prosthesis on implants	100%

Table 7. Average patient satisfaction over the course of treatment. For each time point at which the survey was administered, the survey questions were ranked by level of satisfaction to highlight the least and most satisfying aspects of treatment at each stage.

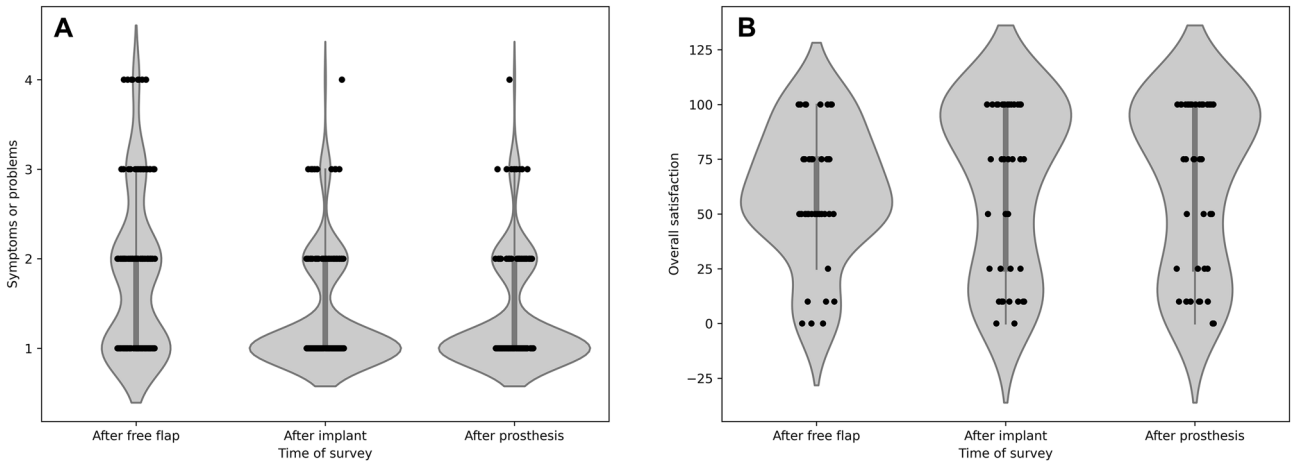

Fig. 3. Changes in average scores over the course of treatment for (**A**) patient self-reported symptoms, and (**B**) overall satisfaction.

In 2020, the patient was referred to our maxillofacial surgery clinic with a diagnosed carcinoma of the floor of the mouth and the alveolar ridge of the mandible on the left. In September 2020, the patient underwent surgery, including tracheostomy, neck dissection, resection of the mandible (from 38 to 45), and reconstruction of the defect using a fibular free microvascular osteocutaneous flap (Fig. 4A,B). Histopathological examination confirmed the resection with clear margins, and based on the oncological committee's recommendations, chemotherapy was initiated postoperatively. Regarding the healing of the donor site, VAC (vincristine sulfate, actinomycin-D, and cyclophosphamide) therapy was applied to the lower limb due to partial loss of the skin graft. The patient was regularly monitored in the oncological follow-up program, with both imaging and clinical assessments.

In December 2023, four short dental implants were placed in the fibular flap (Fig. 4C), and after successful osseointegration, healing abutments were placed in March 2023 (Fig. 4D,E). Currently, the patient is using a removable prosthesis made of TRINIA material with individually angulable abutments (Fig. 4F,G).

Discussion

Kaplan–Meier survival analysis revealed a high short implant survival rate of 97.1% at 63 months after implant surgery. Compared to previous studies of other implant systems in similar patient populations, our protocol using short implants showed an improved survival rate compared to 86.5% at 60 months as reported by Pellegrino et al.[13] Additionally, our results indicated a 63-month success rate of 88.2%, which also compares favorably to the 80% success rate reported by Bodard et al. (mean follow-up 27.5 months)[14]. Based on the authors' experience, we believe that peri-implant bone loss and other complications can be minimized by placing the implant deeper than 2 mm below the crestal bone. For this reason, we recommend modifying the standard surgical procedure to placing the implant 3–4 mm subcrestally, which in our experience still allows a functional prosthetic reconstruction and facilitates the long term maintenance of crestal bone[15]. On the other hand, the failure of Cox regression models to converge as well as the large negative log-likelihood values indicated that the data fit those models poorly. The poor fit was likely driven by the low number of implant failure and implant complication events.

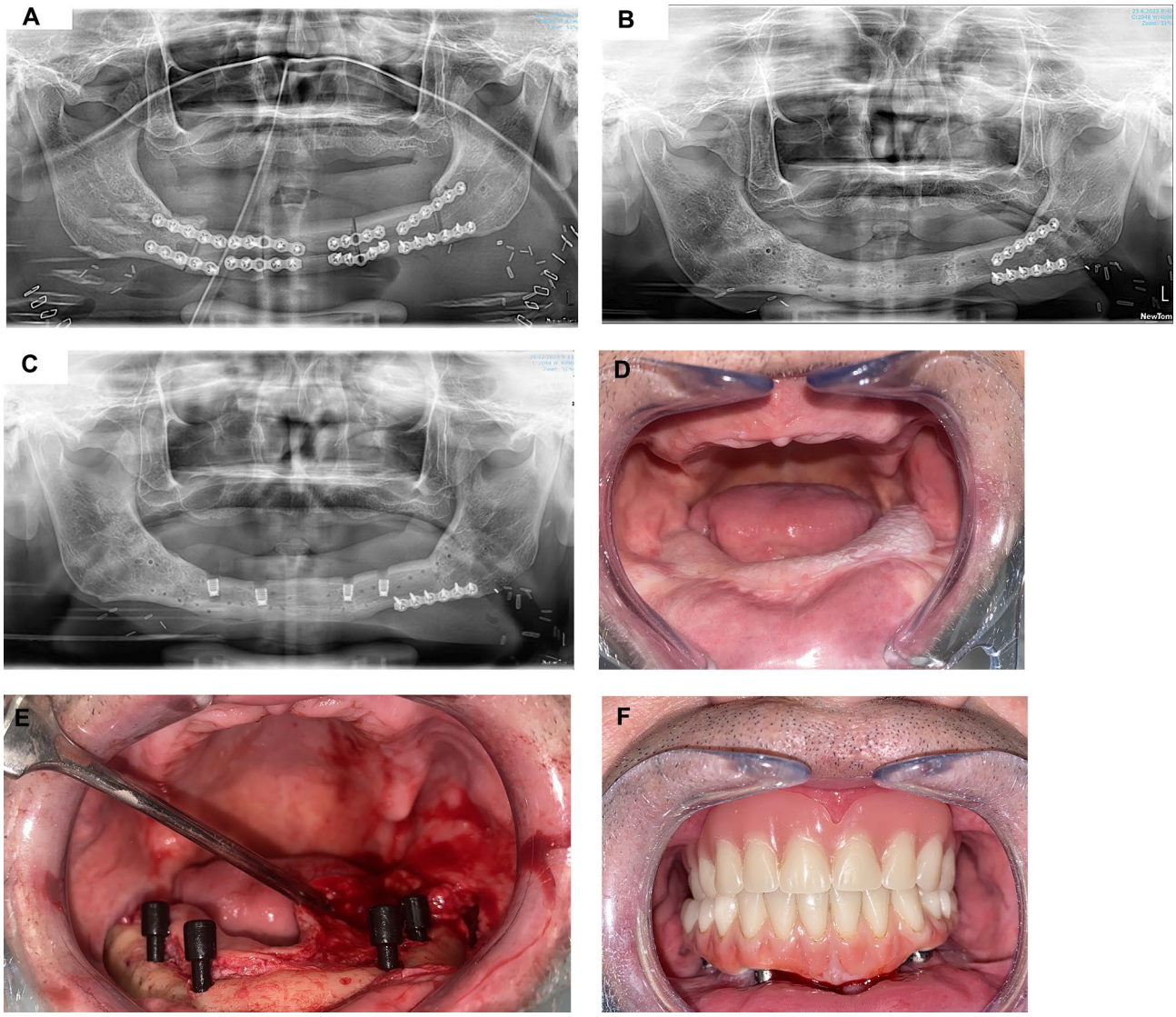

Fig. 4. Radiographs and clinical photographs of a mandibular reconstruction. (**A**–**C**) panoramic radiographs taken after free flap reconstruction of the mandible, removal of titanium plates, and placing four dental implants, respectively. (**D**, **F**) intraoral photographs taken after free flap healing, implant uncovering, and prosthesis delivery, respectively.

The results from patient quality-of-life surveys revealed that patients' self-reported symptoms, according to the EORTC questionnaire, generally decreased over the course of treatment. Specifically, significant improvements were identified with regards to fluid intake and communicating with others. Similarly, the results from the patient satisfaction Likert scale revealed overall improvements in patient satisfaction after prosthetic rehabilitation, with specific improvements in areas corresponding to the EORTC questionnaire results, namely, satisfaction with biting food and pronunciation. This suggests that implant surgery and subsequent prosthetic rehabilitation improves patient quality-of-life, especially in the areas of food and fluid intake, as well as language articulation.

Although there are few comparable analyses on the quality-of-life of patients who have underwent microvascular free flap surgery and subsequent rehabilitation, one recent study on patients with fibula flaps and implant-based rehabilitation, which used the same standardized EORTC questionnaire, reported no substantial change in the quality-of-life of patients after rehabilitation[16], while another similar study concluded that masticatory rehabilitation after bony reconstruction "might improve patient quality of life[17]. The results of this study compare favorably to those findings, which suggests that the implants or techniques used in this study may confer a benefit to patient satisfaction and quality of life. Another previous study using the same questionnaire evaluated the QoL of patients after free flap mandibular reconstruction but not after subsequent implant and restorative treatment, and found that patients reported persistent functional loss after free flap reconstruction[18]. This is consistent with the findings of this study, which do show low QoL scores immediately

after reconstruction, and emphasizes the importance of prosthetic reconstruction in improving patient quality of life.

Limitations of this study include the small sample size, which does not lend sufficient power to the comparison of implant and QoL outcomes between patients with different study covariates, as demonstrated by multivariate regression. Additionally, the fact that free flap reconstruction is the standard of care for this patient cohort means that all patients in the study were treated using this protocol. The absence of a control group meant that comparisons could only be made between pre- and post-treatment time points. Similarly, the limited set of covariates collected in this study prevent more robust adjustments for potential confounding factors. For example, the use of statins, similar to the use of bisphosphonates, has been shown to affect healing outcomes following dentoalveolar surgery[19], and should be analyzed in future research. Lastly, the limited set of outcome measures, such as the lack of marginal bone level or implant aesthetic score data prevents more robust analyses.

Conclusion

Short implants in microvascular free flaps provide a possible viable solution for the functional rehabilitation of dentition in patients with head and neck malignancies. This study revealed high implant survival and success rates over the course of five years after implant surgery. Additionally, patients reported improvements in quality-of-life after prosthetic rehabilitation, compared to immediately after free flap reconstruction or immediately after dental implant surgery. Specifically, QoL improvements were observed in the areas of fluid intake, biting food, pronunciation, and communicating with others.

Informed consent

We attest that we have obtained informed consent from all subjects and/or their legal guardian(s) for publication of identifying information/images in an online open-access publication.

Data availability

Raw data is available in a supplementary file.

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Author contributions

R.E. and B.H. provided ideation; B.H., R.S., D.P., and A.S. prepared data, Y.C. wrote the main manuscript text, and E.A.B. edited the manuscript. All authors reviewed the manuscript.

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Declarations

Competing interests
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Informed consent
We attest that we have obtained informed consent from all subjects and/or their legal guardian(s)for publication of identifying information/images in an online open-access publication.

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