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Survival, Function, and Complications of Oral Implants Placed in Bone Flaps in Jaw Rehabilitation: A Systematic Review

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Purpose: This systematic review attempted to determine the survival rate of implants placed in bone flaps in jaw rehabilitation and the functional gains and the most common complications related to these implants. **Materials and Methods:** An electronic search was undertaken of PubMed, EMBASE, and CNKI records from 1990 through July 2014. Two independent examiners read the titles and abstracts of the results to identify studies that met the inclusion criteria. Subsequently, the reference lists of the selected publications were hand searched. Descriptive statistics were used to report all data related to the survival rate of implants placed in bone flaps in jaw rehabilitation, the functional gains, and complications. **Results:** A total of 20 studies were included for systematic review without repetition. The mean follow-up time after implant placement ranged from 1.75 to 9.5 years. Within the limitations of available studies, the survival rate of implants placed in bone flaps in jaw rehabilitation ranged from 82.4% to 100%. Of the 20 included studies, 15 reported a survival rate higher than 90%. The cumulative survival rate was 93.2%, with the longest follow-up time being 12.9 years. The most common complications related to these implants were peri-implant bone resorption or peri-implant inflammation, and peri-implant soft tissue proliferation. The main factors associated with the survival rate of implants in bone flaps were reported as time of implant placement and radiotherapy. Despite some persistent soft tissue problems and implant loss, most patients reached a satisfactory functional and esthetic outcome, as evaluated by clinical examination and subjectively by the patients at interview. Implant-supported dental prosthetic rehabilitation in reconstructed jaws improved the quality of life in terms of speech, nutrition, oral competence, and facial appearance. **Conclusion:** Placement of implants in bone flaps in jaw rehabilitation was demonstrated to be a reliable technique with a high survival rate. Multicentered randomized controlled clinical trials and longer clinical studies should be undertaken in this area. *Int J Prosthodont* 2016;29:115–125. doi: 10.11607/ijp.4402

Mandibular or maxillary continuity defects due to tumor resection, traumatic injuries, severe atrophy, or congenital anomalies can lead to significant facial deformity; altered oral function affecting mastication, speech, swallowing, and/or saliva retention; and subsequent psychologic problems. Aimed to achieve restoration of

function and esthetics, oral rehabilitation of patients with bony defects of the jaws remains an important and challenging problem.^{1,2}

Free vascularized bone flaps have become a reliable procedure in the reconstruction of jaws and the adjacent soft tissue during the last few decades, especially for cases with large and complex defects.^{3,4} Survival rates of 92% or higher for free vascularized bone flaps for the reconstruction of the jaws have been reported.^{3–5} On the other hand, dental restoration is most important for function and esthetics after jaw resection.⁶ Conventional prostheses are often difficult or unsuitable for rehabilitation of masticatory function because of the abnormal condition of hard and soft tissues postreconstruction.

Placement of implants in reconstructed jaws permits fabrication of dental prostheses with improved stability and retention,^{7–9} which facilitates the support of soft tissues and provides a stable platform for mastication and speech.¹ Rehabilitation of oral function and esthetics has been shown to be achievable by use of vascularized free flaps with the placement of endosseous implants.^{2,3}

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The survival and function of implants placed in bone flaps in jaw rehabilitation has not been discussed or mentioned in many publications.⁴⁻⁷ One review⁴ discussed the technique for implantation in free fibula flaps in mandibular reconstruction. The authors reported a range of success rates for osseointegration from 86% to 99%, which might be compromised by factors such as radiotherapy, specific peri-implant conditions, thickness and mobility of soft tissues, lack of patient cooperation, or poor oral hygiene.

However, to the best of the authors' knowledge, comprehensive systematic reviews regarding implant therapy placed in bone flaps are still missing. Therefore, the focus questions for this systematic review are: what is the survival rate for implants placed in bone flaps in jaw rehabilitation? and what are the functional gains and the most common complications related to these implants?

Materials and Methods

Inclusion Criteria

Studies that met the following criteria were included:

1. The study was a clinical study reporting outcomes of dental implants placed in bone flaps in jaw rehabilitation. *Bone flap* is defined as vascularized bone-containing free flap, including the fibula flap, iliac flap, rib flap, and scapula flap, used as an osteomuscular flap, osteocutaneous flap, or osteomyocutaneous flap.
2. The study was performed on humans.
3. The language was English or Chinese.
4. The study design was a randomized controlled clinical trial, cohort study, case-control study, cross-sectional study, case series, or case report.
5. For case series and case reports, at least 5 cases were included or 20 implants were placed in bone flaps, independent of the type of prosthetic restoration applied.
6. The mean follow-up was at least 12 months (or a range exceeding 12 months) after implant loading.
7. To calculate the survival rate of implants in bone flaps, the number of implants located in bone flaps and the number of implant failures in bone flaps were clearly reported.

Exclusion Criteria

The following studies were excluded:

1. Simple case report articles including fewer than five cases
2. Review articles

3. Studies that only reported dental implants placed in nonvascularized bone grafts in jaw rehabilitation

Data Source and Search Strategies

An electronic search was undertaken in PubMed, EMBASE, and CNKI covering articles published between 1990 and July 2014. The following terms were used in the search strategy: (Implant OR implants [Title/Abstract]) AND ((bone flap OR bone flaps [Title/Abstract]) OR (fibula flap OR fibula flaps [Title/Abstract]) OR (free flap OR free flaps [Title/Abstract])).

The search resulted in a great number of published studies, so a screening process was performed independently and in duplicate by two reviewers (QD and CRL). Titles and abstracts (when available) from the results were read by two reviewers to identify studies that met the inclusion criteria. When studies met the inclusion criteria or when data in the title and abstract were insufficient to determine eligibility, the full article was obtained and assessed. All reference lists of the selected studies were hand searched for additional papers that might meet the eligibility criteria for inclusion in this study. Disagreement between the two reviewers was resolved after additional discussion.

Quality Assessment

Assessment of methodologic study quality was performed using the criteria proposed by Clementini et al⁸ and Quaranta et al.⁹ When random selection in the population, defined inclusion/exclusion criteria, report of losses to follow-up, validated measurements, and statistical analysis were reported, the study was classified as having a low risk of bias. Studies missing one of these five criteria were classified as having a moderate risk of bias. Risk of bias was high if the study was missing two or more of these criteria.

Data Abstracted from Each Study

For each of the identified studies included, the following data were extracted on a standard form by two independent reviewers and compared:

- Year of publication
- Study design
- Number of patients who received jaw rehabilitation by use of bone flaps with the placement of endosseous implants
- Follow-up period from implant placement, including range and means
- Total number of implants placed in bone flaps
- Time of implant placement after reconstruction

- Time of implant loading after implantation
- Number of implants failed in bone flaps, with time of failure and reason for failure
- Survival rate of implants placed in bone flaps
- Complications related to the implants
- Cause of jaw defect and defect location (mandible or maxilla)
- Type of prosthetic reconstruction
- Donor site of bone flap used for jaw reconstruction
- Factors reported to have influenced the survival rate of implants placed in bone flaps
- Time and dose of radiation therapy, and whether hyperbaric oxygen (HBO) therapy was administered

Data Analysis

Agreement between the two reviewers was achieved by discussion. Due to the absence of controlled studies and the heterogeneity of the included studies concerning patient selection, surgical method, follow-up time, loading protocol, type of prosthesis, and other factors, meta-analysis was not performed and analytic statistics were not used. Descriptive statistics were used to report all the data. To standardize and clarify ambiguous data, survival rates of implants placed in bone flaps (percentage of implants that remained osseointegrated in bone flaps at the end of the observation period, ie, percentage of implants that were not removed) were reported or calculated for all included publications. Quantitative data extracted from the included studies that provided data on the time to failure of implants placed in bone flaps were used to calculate interval survival rate during follow-up periods of 6 months and 1 year and cumulative survival rate over a 12-year period.

Results

The study selection flow chart is illustrated in Fig 1. The search strategies resulted in 2,171 records. After the titles were screened, 1,782 articles were excluded because they did not relate to dental implants placed in bone flaps in jaw rehabilitation. Therefore, 389 titles and abstracts were screened by two reviewers. The reviewers agreed on 47 of these for full-text review. The reference lists of the relevant publications were searched. A total of 20 articles fulfilled the inclusion criteria for further analysis. These included 2 cross-sectional studies, 1 cohort study, and 17 case series or case reports with low levels of evidence. No published randomized controlled trials or controlled clinical trials were identified. The estimated risk of bias was considered to be moderate for 10 studies and high for 10. Because this systematic review focused

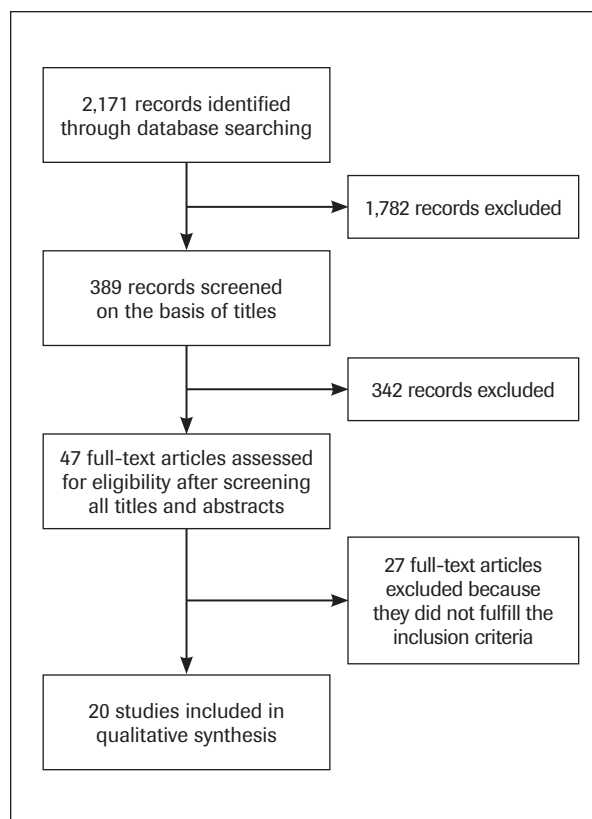


Fig 1 Flow of studies through the review.

on the survival, function, and complications of oral implants placed in bone flaps, if the number of implants located in the bone flaps and the number of implant failures in bone flaps were not clearly reported the study was excluded. Descriptive data extracted from the included studies are presented in Table 1. The included 20 articles were published over a range of 20 years (1992 to 2012) and provide data relative to 372 patients and 1,348 implants placed in bone flaps, including 1,247 implants placed in fibula flaps, 79 implants in iliac flaps, 13 implants in scapula flaps, 6 implants in tibia flaps, and 3 implants in rib flaps. The mean follow-up time after implant placement ranged from 1.75 to 9.5 years. A total of 13 studies reported mean follow-up values of 3 years or longer. Most cases in included studies used fibula free flaps in jaw reconstruction. Iliac flaps were employed in 3 studies. Rib flaps, tibia flaps, and scapula flaps were each employed in one study with several cases. The number for iliac flaps, rib flaps, tibia flaps, or scapula flaps used is too small to make a meaningful assessment as to which offers better outcomes.

Table 1 Summary of Included Studies Evaluating the Survival Rate of Implants in Bone Flaps

Authors	Publication year	Study design	Quality assessment	Patients (n)	Follow-up period range after implant placement (mo) (average)	Implants	Implantation time after reconstruction (no. of cases)	Loading time after implant placement	Implant failure	Failure time after implant placement (no. of implants)	Failure before or after implant loading (no. of implants)
Zlotolow et al ²⁵	1992	Case series	Low	7	4.3–20.7	23	5.7–36 mo	4–6 mo	0		
Barber et al ¹¹	1995	Case series	Low	9	18–24	35	Not mentioned	Not mentioned	0		
Roumanas et al ¹²	1997	Case series	Low	20	1–49	71	Immediately (4) or delayed (16): 2–19 mo	> 6 mo	3	6 wk (1); 6 mo (1); 19 mo (1)	Before loading
Gurlek et al ¹³	1998	Case series	Low	20	18–84 (47)	60	3.5–60.7 mo	2.5–8.2 mo (4.5 mo)	5	Not mentioned	Not mentioned
Chang et al ¹⁴	1998	Case series	Low	12	1–43 (25)	34	Immediately	6 mo (4 mo waiting for stage 2)	0		
Foster et al ¹⁵	1999	Case series	Moderate	14	36	71	Immediately (44%) or delayed: 4–6 mo	4–5 mo	1	Not mentioned	Not mentioned
Chiapasco et al ¹⁶	2000	Case series	Moderate	8	14–34 (22.1)	31	4–6 mo	4–6 mo	1	< 4–6 mo	Before loading (1)
Nakai et al ³	2000	Case series	Low	13	24–91	58	Immediately (9); delayed (4–6 mo, 8 mo, 9 mo, 14 mo)	4–15 mo (8 mo)	0		
De Santis et al ¹⁷	2004	Case series	Low	12	14–86 (41)	73	6 mo	9 mo	0		
Rohner et al ¹⁸	2003	Case series	Low	24	2–48 (21)	90	Prefabrication	Immediate function after flap transfer	14	Not mentioned	Not mentioned
Kramer et al ¹⁹	2005	Cohort studies	Moderate	16	24–46.8 (30)	51	3 mo or 6 mo	3 mo	1	11 d (1)	Before prosthetic load
Chana et al ²⁰	2004	Case reports	Low	13	14–60 (40.1)	43	Immediately	7–12 mo	0		
Teoh et al ⁷	2005	Retrospective study	Moderate	24	1.3–138 (51.7)	81	5.6–48.6 mo	> 6 mo	5	1.3 mo (1); 7.8 mo (1); 8 y (3)	Before loading (2); 96.8 Mo after loading (3)
Chiapasco et al ⁶	2006	Case series	Low	16	24–96 (50.2)	71	3–12 mo	3–6 mo (14)/immediately (2)	1	< 3–6 mo	Before loading

Failure reason (no. of implants)	Survival rate (%)	Complications	Defect location	Cause of bone defect (no. of cases)	Donor site of bone flap (no. of implants)	Prosthesis type	Radiotherapy (dose)
	100.0	Peri-implantitis	Mandibular	Cancer	Fibula	Removable clip-bar prostheses or fixed appliances	2 cases (dose not mentioned) at least 2 y prior to the flap reconstruction.
	100.0	Not mentioned	Mandibular	Malignant tumors	Fibula	Not mentioned	9 cases (5,000 rads for 6–8 w) 2 w after reconstruction; 2–6 mo after this, HBO therapy was received
Failed to osseointegrate (1); radiation-related complication (1); tumor recurrence (1)	95.8	Loose healing cap; peri-implant bone loss and radiolucency and a fistula around 1 implant	Mandibular	Tumor (16); trauma (2); osteoradionecrosis (2)	Fibula	Implant-retained overlay denture (11); hybrid bar-supported removable denture (2); fixed prosthesis (1); fixed partial denture (1)	1 case (5940cGy) 6 wk following reconstruction and immediate implantation
Failed to osseointegrate	91.7	Not mentioned	Mandibular	Osteoradionecrosis, tumor	Fibula (16); iliac crest (4)	Implant-assisted dental prosthesis/implant-borne device	None
	100.0	Peri-implant bone loss	Mandibular	Osteoradionecrosis; tumors; osteonecrosis; osteomyelitis	Fibula	Fixed partial dentures, overdentures	Not mentioned
Failed to osseointegrate	99.0	Not mentioned	Mandibular	Malignant disease; osteoradionecrosis; trauma	Fibula	Not mentioned	22 cases (dose not mentioned): 9 preoperative; 6 pre- and intraoperative; 7 postoperative
Failed to osseointegrate	96.8	Peri-implant bone resorption	Mandibular	Tumor	Fibula (14); ilium (17)	Not mentioned	3 cases (50–60 Gy) before the reconstruction
	100.0	Not mentioned	Mandibular	Tumor, fibrous dysplasia, osteomyelitis	Fibula (39); scapula (13); tibia(6)	Fixed prosthesis	5 cases (40 Gy) before tumor surgery; 3 cases had HBO before and after implantation
	100.0	Superficial peri-implant mucositis	7 maxillary, 4 mandibular; 1 both arches	Extreme jaw atrophy	Fibula	Overdenture; fixed partial denture; hybrid prosthesis	Not mentioned
In conjunction with total or partial flap loss (10); peri-implant infection (4)	84.4	Peri-implant infection	14 maxillary; 10 mandibular	Atrophy (5); gunshot (5); traffic accident (2); fibrous dysplasia (1); tumor (11)	Fibula (83); iliac crest (7)	Bar-supported overdenture	5 cases (dose not mentioned) 6 mo before prefabrication and reconstruction
Located at the interface of the local bone and the fibula graft, had to be removed due to dehiscence and regional infection	98.0	Dehiscence and regional infection	12 mandibular; 4 maxillary	Tumor (15); osteomyelitis (1)	Fibula	Bar-based removable dentures	Not mentioned
	100.0	Not mentioned	Mandibular	Ameloblastomas	Fibula	Implant-supported prostheses	None
Lack of osseointegration (2); dehiscence of the buccal bone and exposure of the implant threads (3)	93.8	Peri-implant bone loss; peri-implant soft tissue proliferation	Mandibular	Osteoradionecrosis, tumor	Fibula	11 overdentures (8 bar-retained, 3 O-ring-retained), 9 hybrid (fixed-detachable), 5 metal-ceramic prostheses	6 cases (60–79 Gy for 6–8 wk) before implant placement (IP), 1 case (60–79 Gy for 6–8 wk) after IP; 3 cases had HBO before IP
Failed to osseointegrate	98.6	Peri-implant bone resorption; peri-implant soft tissue proliferation; early exposure of implant cover screws and superficial part of bone transplant	5 maxillary; 11 mandibular	Osteoradionecrosis, tumor	Fibula	Fixed (14)/overdenture (2)	Not mentioned

Table 1 (cont'd) Summary of Included Studies Evaluating the Survival Rate of Implants in Bone Flaps

Authors	Publication year	Study design	Quality assessment	Patients (n)	Follow-up period range after implant placement (mo) (average)	Implants	Implantation time after reconstruction (no. of cases)	Loading time after implant placement	Implant failure	Failure time after implant placement (no. of implants)	Failure before or after implant loading (no. of implants)
Wu et al ⁵	2008	Case series	Moderate	29	24–84 (47.8)	100	Immediately (19) or delayed (10)	> 3 mo	9	< 12 mo (4); > 12 mo (5)	Before loading
Fenlon et al ²¹	2012	Cross-sectional study	Moderate	41	36	145	Immediately (22) or delayed (3 mo)	6 mo	18	6 mo (18)	Before loading
Raoul et al ²²	2009	Case series	Moderate	30	7–155 (76)	105	5–51 Mo	5–18 mo (8 mo)	4	Not mentioned	Not mentioned
Lizio et al ¹⁰	2009	Case series	Moderate	6	17–81	35	Reconstruction 11–38 mo (19); distraction osteogenesis 2–11 mo (5); implantation	6–12 mo	4	19 mo (2); > 6 mo (2)	Before loading (2); 1 mo after loading (2)
Salinas et al ²³	2010	Case series	Moderate	44	4–108 (41.1)	114	> 24 Mo	> 6 mo	20	< 6 mo (18); > 6 mo (2)	Before loading (18); after loading (2)
Ferrari et al ²⁴	2013	Case series	Moderate	14	12–120 (114)	57	Immediately (2) or delayed (28 mo)	2–23 mo (9.5 mo)	5	Not mentioned	
Total				372		1,348	Immediately, 79 mo	Immediately, 23 mo	91		

Implants were inserted immediately or 2 to 79 months after reconstruction procedures. Seven studies^{3,5,7,10,12,22,25} reported that implants were allowed to integrate for at least 3 months before stage 2 surgery. Most cases in 19 of the included studies were delayed loading at 3 to 6 months or longer after implantation. Only two patients were prosthetically rehabilitated at the time of implant placement (immediate loading). One study¹⁸ used the following technique for prefabrication of vascularized free flaps: Preoperative prosthetic planning, placement of dental implants in the donor sites, transfer of the flaps with placed implants, followed by reconstruction of jaws 4 to 6 weeks later in a second procedure. In 14 studies, 119 patients received radiotherapy. Among them, 33 patients in seven studies had radiotherapy before reconstruction; 23 patients in four studies received it after reconstruction; 44 patients in five studies received it before implant placement; and 19 patients in five studies received it after implant placement. In

addition, four studies employed HBO before or after implant placement in 59 patients. However, only four studies suggested the influence of radiotherapy on implant failure. Prosthesis type mainly included implant-supported overdentures, implant-supported fixed prostheses, and hybrid prostheses.

Survival Rate of Implants Placed in Bone Flaps and Influencing Factors

The lowest reported survival rate of implants placed in bone flaps was 82.4% for a mean follow-up time of 41.1 months. The highest implant survival rate was recorded as 100% in 6 studies. In these studies, immediate loading was avoided and the implants were left unloaded or healing abutments were placed on the implants for at least 4 months. Of the included 20 studies, 15 reported a survival rate higher than 90%. A total of 91 implants placed in bone flaps were reported as failures over varying periods. Of these failures,

Failure reason (no. of implants)	Survival rate (%)	Complications	Defect location	Cause of bone defect (no. of cases)	Donor site of bone flap (no. of implants)	Prosthesis type	Radiotherapy (dose)
Failed to osseointegrate	91.0	Peri-implant bone loss; peri-implant soft tissue proliferation	Implants: 29 maxillary; 88 mandibular	Tumor	Fibula	Fixed bridges retained by implants (21); bar-supported overdentures (4); o-ring-retained overdentures (3)	3 cases (40–65 Gy) before implant placement
Osseointegration failure (15 of 18 had radiotherapy and all were immediately placed)	87.6	Not mentioned	Mandibular	Cancer	Fibula (10)/rib (3)/ilium (79)	Bar-based removable dentures	12 cases (66 Gy) after immediate implantation
Peri-implantitis (2); lack of primary stability (1); spontaneous fibula fracture around the implant (1)	96.2	Peri-implantitis	6 maxillary; 25 mandibular	Cleft palate (1); gun blast (4); fracture (1); tumor	Fibula	Removable partial prosthesis (5), fixed partial prosthesis (2), implant-borne denture (19), implant-stabilized denture (5)	8 cases (dose not mentioned) before reconstruction; 6 cases (dose not mentioned) after reconstruction
Failed to osseointegrate (2); peri-implantitis (2)	89.0	Peri-implant bone resorption; peri-implant soft tissue proliferation	5 mandibular; 1 maxillary	Malignant tumors; osteomyelitis	Fibula	Implant-supported fixed prosthesis	1 case (dose not mentioned) after implantation; 1 case (dose not mentioned) before reconstruction
Not mentioned	82.4	Not mentioned	Mandibular	Tumor	Fibula	Not mentioned	22 cases (6,000 cGy) before implantation; 4 after; all patients had HBO before and after implantation
Overgrowth of granulomatous soft tissue in one patient	91.2	Peri-implant soft tissue proliferation	Mandibular	Osteoradionecrosis (2); malignant tumors (5); biphosphonates osteonecrosis (2); traumas (2); ossifying fibroma (1); chronic osteomyelitis (1); atrophy (1)	Fibula	Implant-supported overdenture (6); implant-retained fixed partial dental prostheses (3); implant-retained fixed dental prostheses, toronto bridge type (5)	7 cases (45–65 Gy) before implant placement
93.2							

58 were detected before the prosthetic procedure (6 months after implant placement in most studies). The accumulated descriptive data in different time frames (without considering different levels of evidence of the studies) produced a 6-month survival rate of 95.3% (865 implants in 14 studies) and a 1-year survival rate of 94.9% (930 implants in 14 studies). Five studies were not included because the time when implant failures occurred was not reported and the authors could not extract the total number of implants followed up to the time of failure. The cumulative survival rate of implants placed in bone flaps is 93.2%, with the longest follow-up being 12.9 years.

Main factors associated with the survival rate of implants in bone flaps were reported as time of implant placement (immediate or delayed) and radiotherapy. Other possible influencing factors mentioned in one or two studies were types of bone defect and bone flap, specific peri-implant conditions, poor oral hygiene, and patient's age.

Complications

A total of 14 studies reported complications following implant placement in bone flaps. The most common complications reported were peri-implant bone loss or peri-implant inflammation (11 studies) and peri-implant soft tissue proliferation (34 cases in 5 studies). In 5 studies, 31 implants were not integrated into the prosthodontic treatment (implants without function) due to unfavourable local soft tissue configuration or suboptimal position for prosthetic rehabilitation.

One patient⁶ was reported to have early exposure of the implant cover screws, and the superficial part of the bone transplant occurred 1 month after implant placement. This healed spontaneously within 1 month, and implants integrated normally. Loss of implants was reported to be the result of the following complications: total or partial flap loss,¹⁸ spontaneous fibula fracture around the implant,²² dehiscence of the buccal bone and exposure of the implant threads,⁷

peri-implant inflammation or peri-implant infection,^{10,18,22} overgrowth of peri-implant granulosomatous soft tissue,²⁷ unfavorable position,¹⁹ radiation-related complication, or tumor recurrence.¹²

Functional and Esthetic Outcome

In all studies, most patients reached a satisfactory functional and esthetic outcome as evaluated by clinical examination or by patient interviews with questionnaires. However, in situations where there was massive soft tissue loss, such as tongue resection and neural deficit, functional outcomes were poor even with implant-supported prostheses.^{5,28} Implant-supported dental prosthetic rehabilitation in reconstructed jaws improved quality of life in terms of speech, nutrition, oral competence, and facial appearance.

Discussion

The aim of this review was to provide an overview of the survival rate, complications, and functions of implants placed in bone flaps in jaw rehabilitation. The outcomes of the present systematic review showed implants placed in bone flaps are a safe and reliable technique in oral rehabilitation. Implant-based dental restorations in patients reconstructed with bone flaps have been shown to present sufficient stabilization for prostheses even in patients with severe irregularities of hard and soft tissue anatomy. An additional benefit is improved esthetics as a result of supporting the lip profile.^{8,21} Functions such as chewing, swallowing, and speech ability could be preserved much better than with conventional dentures. However, major disadvantages of implant-based prostheses may be the need for additional operations and the extended amount of time until completion of the prostheses.

Kramer et al¹⁹ observed no significant reduction in the success rate of implants inserted into fibula flaps when compared with implants that were inserted into regional bone in otherwise healthy individuals. This observation confirms the necessary biologic capability of vascularized fibula grafts regarding the potential of implant osseointegration, which seems to be comparable with regional mandibular or maxillary bone. Furthermore, survival rates of implants in vascularized grafts harvested from different donor sites were not significantly different.^{7,21} The high survival rates of implants in bone flaps could be attributed to advanced surgical techniques in most studies and to the stringent criteria used in selecting patients for implant rehabilitation, such as a good prognosis after tumor resection, absence of recurrence signs, favorable relationship between the mandible and the maxilla, good oral hygiene, absence of periodontal disease to

the residual dentition, good residual tongue function, absence of systemic diseases, and request to be prosthetically rehabilitated.

Due to the large jaw defects caused by tumor resection and other reasons mentioned above, most cases in included studies employed vascularized bone flaps in jaw reconstruction. Nonvascularized bone grafts should be avoided if there are associated soft-tissue defects or if the bony defect is larger than 4 to 6 cm.^{15,20} Two of the included studies compared bone graft and bone flap healing and success of implant placement in patients reconstructed with vascularized bone flap (VBF) versus nonvascularized bone graft (NVBG). One study concluded that patients reconstructed with VBFs had a significantly greater implant success rate than NVBG patients.¹⁵ The other found no significant difference between VBF and NVBG in bone resorption or implant survival,¹⁶ which was consistent with another study.²⁹

The fibula free flap was used in all included studies in orofacial reconstructive surgery. This type of flap has the advantages of a consistent shape; great total thickness of cortical bone; sufficient length; a distant location from the head and neck, which permits a two-team approach, decreasing operative time; and low donor-site morbidity. The flap can be easily shaped with osteotomies, according to the defect size. However, a limitation of the fibula flap can be insufficient bone height for the reconstruction of the alveolar ridge.^{8,29} It presents some problems from a prosthetic point of view, particularly in cases of partial mandibular resection with a residual dentition on the healthy side. The distance between the implant shoulder and the occlusal plane is large, leading to an unfavorable crown-to-implant ratio, which may produce bending moments with possibility of implant fracture, damage to prosthetic components, and esthetic problems.³⁰ The solution to this problem may be the use of double-barrel fibula bone, which compensates for the height of the transplant.^{30,31} Another alternative may be the use of vertical distraction osteogenesis to increase the alveolar height of the fibula bone.²⁶

One included study^{18,26} applied the technique for prefabrication of vascularized free flaps in reconstructive surgery, which could provide attached gingiva-like soft tissue, promoting successful insertion of implants with stable long-term peri-implant conditions. Patients with prefabricated bone flaps were able to wear prostheses immediately after the surgical procedure, and good function could be achieved. But the indication to use a prefabricated fibular flap has to be considered carefully.²⁶

Peri-implant bone resorption or peri-implant inflammation is the most commonly reported complication

in this review, which could ultimately predispose to implant failure.^{5,6,19} Tissue movement, plaque accumulation, and ineffective oral hygiene efforts may affect peri-implant health and, possibly, the long-term retention of implants. But most cases showed a low degree of peri-implant bone loss. Raoul et al²² found an average of 3 mm of peri-implant bone loss in 14 patients, while in the other 16 patients no bone resorption was seen. Lizio et al¹⁰ reported a low success rate (52%) of implants placed in vertically distracted fibular free flaps after a mean follow-up of 39 months, which resulted from the high rate of peri-implant vertical bony resorption (mean value of 2.5 mm [0–10.6 mm]). Lack of keratinized oral mucosa was considered the main reason for the remarkable degree of peri-implant bony resorption observed.

Peri-implant soft tissue proliferation is a common phenomenon around implants placed in a bone flap. This hyperplastic or inflammatory response of the skin and subcutaneous tissues around implant abutments, with the formation of a granulomatous tissue, may cause pain and bleeding during brushing as well as esthetic problems.^{9,33} A reliable solution to this problem may be skin removal around implants and substitution with oral mucosa grafts harvested from the palate, with the objective of obtaining an adequate zone of firmly attached keratinized mucosa around implants.³² Firmly attached gingiva-like soft tissue could prevent peri-implant soft tissue inflammation and facilitate oral hygiene.²⁶

The time between mandibular reconstruction and implant placement ranged from 0 to 79 months in the included studies, except for one that used prefabrication of vascularized free flaps. Immediate implant placement during reconstruction has the advantages of better access to the bone, greater ease in determining the occlusal relationship, and the need for a shorter time to attain oral rehabilitation.²⁴ However, implant placement is less precise, which leads to difficulty in subsequent prostheses.²⁷ Fenlon et al²¹ reported a high failure rate of 18.9% for implants placed immediately at the time of reconstructive surgery, and 26.3% of implants that osseointegrated were unusable or suboptimally placed. In addition, in case of a malignant tumor, resection may be insufficient and may involve part of the reconstructed jaw. The success rate of bone flaps is not 100%, so if implants are inserted immediately there is a chance of losing them with failure of the bone flap.²² Patient treatment protocols in most studies chose delayed implantation to select fit, well-motivated, and overtly disease-free patients and to plan procedures in consolidated jaws. In addition, the shorter reconstruction surgery time allows for reduced anesthesia duration and morbidity and avoids the exposure of implants to radiotherapy.²⁴

Radiotherapy has been shown to adversely influence survival of implants by some researchers^{7,21,33} but not others.^{29,34} Radiotherapy may compromise implant prognosis due to its effects on hard and soft tissues that result in mucositis, xerostomia, reduced vascularity of soft tissues with impaired resistance to infection, and reparative fibrosis and production of hypocellular, hypovascular, and hypoxaemic tissue on bone, with diminished osteogenetic capacity of the irradiated bone and potential development of osteoradionecrosis.^{24,27,35} A systematic review by Jegoux et al³⁶ showed that osseointegration in irradiated bone is often possible but remains more uncertain with higher failure rates. The sooner implantation takes place after the end of radiation therapy, the higher the likelihood of failure. Some authors demonstrated that radiation therapy is not a risk factor for dental implant failure in the radiated fibula flap.^{3,18,35} Smolka et al³⁷ reported a 92% osseointegration rate with 85% of the patients who underwent radiation therapy. Salinas et al²³ also showed no significant difference in survival rate between implants in the radiated fibula flap and those in the nonradiated group. The reason for the acceptable survival rate of implants in the radiated bone in these studies may be that radiotherapy was finished before implant placement, the radiation dose was limited, and supportive HBO therapy was used.

Other possible factors influencing implant survival in bone flaps were reported as follows:

1. A higher failure rate was reported in presence of Class III and IV bone defects (two or more osteotomies for fibula) and of soft tissue involvement when an osteocutaneous flap was used.²⁴
2. Implants with modern microroughened surfaces possibly survived better than those implants machined or macroroughened when placed in grafted bone.²¹
3. Older patients had a significantly higher risk of implant failure. These patients may have potentially longer healing times, more systemic health concerns, and decreased ability to maintain hygiene.⁷
4. Implants supporting hybrid prostheses had a lower survival rate than implants supporting overdentures or metal-ceramic prostheses.⁷
5. One study reported a reduced implant survival rate in patients reconstructed after tumor resection (82.6%) or chronic osteomyelitis (66.7%).²⁴

However, considering most of the included studies were case series or case reports, most of the results included had low levels of evidence. Evidence for the effects of age and gender of patients, cause of the

jaw defects (eg, tumor resection, traumatic injuries, severe atrophy, congenital anomalies), smoking, opposing dentition, implant design and dimensions, implant surgery, type of prosthesis, occlusal loading, and parafunctional habits on the survival rate of implants and incidence of complications is still scarce because of missing data.

This systematic review has several limitations. One is the small number of studies and patients involved. Most included studies did not follow each patient for a sufficient duration to allow definitive conclusions to be made about clinical outcomes. Second, the numbers of patients included in each follow-up evaluation were not the same. Third, data of patients who were lost to follow-up, suffered from a pathologic fracture, or died of tumor progression were missing, resulting in selective reporting bias. Fourth, among published studies, those with preferable results such as better survival rate and functional gains or more advanced surgical techniques are published sooner than those without preferable results or advanced techniques. When studies are missing for these reasons, the available results will be biased toward exaggerating the positive results of implants in bone flaps. Therefore, the clinical outcomes could be biased by these issues. Last, the heterogeneity of the case series, especially regarding surgery procedures and patient selection, did not allow for meta-analysis and comparison of different subgroups. Therefore, the evidence on influencing factors is insufficient.

In the present systematic review, most of the included studies did not have internal comparison groups in the form of patients who received implants in a natural mandible or maxilla. Moreover, more studies with longer follow-up periods, involving adequate numbers of implants and patients, are needed. This will provide a better understanding of the survival of implants placed in bone flaps over the long term.

Conclusion

Within the limitations of this study, placement of implants in bone flaps in jaw rehabilitation was demonstrated to be a reliable technique with a high survival rate. Peri-implant inflammation and peri-implant soft tissue proliferation were reported to be the most common complications related to these implants. The main factors associated with the survival rate of implants in bone flaps were reported as time of implant placement and radiotherapy (albeit with limited evidence). Information that would permit more meaningful determinations is still lacking. Consequently, assertions in this manuscript are themselves suspect and open to criticism. Multicentered, randomized controlled clinical trials and longer-duration clinical studies should

be undertaken in this area before recommending clinical guidelines for implant therapy protocols during oral rehabilitation with bone flaps.

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References

1. Cuesta-Gil M, Ochandiano Caicoya S, Riba-García F, Duarte Ruiz B, Navarro Cuellar C, Navarro Vila C. Oral rehabilitation with osseointegrated implants in oncologic patients. *J Oral Maxillofac Surg* 2009;67:2485-2496.
2. González-García R, Naval-Gías L, Rodríguez-Campo FJ, Muñoz-Guerra MF, Sastre-Pérez J. Vascularized free fibular flap for the reconstruction of mandibular defects: Clinical experience in 42 cases. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008;106:191-202.
3. Nakai H, Okazaki Y, Ueda M. Clinical evaluation of vascularized bone grafts and osseointegrated implants. *J Oral Implantol* 2000;26:304-308.
4. Anne-Gaëlle B, Samuel S, Julie B, Renaud L, Pierre B. Dental implant placement after mandibular reconstruction by microvascular free fibula flap: Current knowledge and remaining questions. *Oral Oncol* 2011;47:1099-1104.
5. Wu YQ, Huang W, Zhang ZY, Zhang ZY, Zhang CP, Sun JO. Clinical outcome of dental implants placed in fibula-free flaps for orofacial reconstruction. *Chin Med J (Engl)* 2008;121:1861-1865.
6. Chiapasco M, Biglioli F, Autelitano L, Romeo E, Brusati R. Clinical outcome of dental implants placed in fibula-free flaps used for the reconstruction of maxillo-mandibular defects following ablation for tumors or osteoradionecrosis. *Clin Oral Implants Res* 2006;17:220-228.
7. Teoh KH, Huryn JM, Patel S, et al. Implant prosthodontic rehabilitation of fibula free-flap reconstructed mandibles: A Memorial Sloan-Kettering Cancer Center review of prognostic factors and implant outcomes. *Int J Oral Maxillofac Implants* 2005;20:738-746.
8. Clementini M, Morlupi A, Canullo L, Agrestini C, Barlattani A. Success rate of dental implants inserted in horizontal and vertical guided bone regenerated areas: A systematic review. *Int J Oral Maxillofac Surg* 2012;41:847-852.
9. Quaranta A, Perrotti V, Piattelli A, Piemontese M, Procaccini M. Implants placed in sites of previously failed implants: A systematic review. *Implant Dent* 2014;23:311-318.
10. Lizio G, Corinaldesi G, Pieri F, Marchetti C. Problems with dental implants that were placed on vertically distracted fibular free flaps after resection: A report of six cases. *Br J Oral Maxillofac Surg* 2009;47:455-460.
11. Barber HD, Seckinger RJ, Hayden RE. Reconstruction of the head and neck cancer patient with a vascularized fibula flap and dental implants: Preliminary clinical report. *Implant Dent* 1995;4:111-114.

12. Roumanas ED, Markowitz BL, Lorant JA, Calcaterra TC, Jones NF, Beumer JR. Reconstructed mandibular defects: Fibula free flaps and osseointegrated implants. *Plast Reconstr Surg* 1997;99:356–365.
13. Gurlek A, Miller MJ, Jacob RF, Lively JA, Schusterman MA. Functional results of dental restoration with osseointegrated implants after mandible reconstruction. *Plast Reconstr Surg* 1998;101:650–655.
14. Chang YM, Santamaria E, Wei FC, et al. Primary insertion of osseointegrated dental implants into fibula osteoseptocutaneous free flap for mandible reconstruction. *Plast Reconstr Surg* 1998;102:680–688.
15. Foster RD, Anthony JP, Sharma A, Pogrel MA. Vascularized bone flaps versus nonvascularized bone grafts for mandibular reconstruction: An outcome analysis of primary bony union and endosseous implant success. *Head Neck* 1999;21:66–71.
16. Chiapasco M, Abati S, Ramundo G, et al. Behavior of implants in bone grafts or free flaps after tumor resection. *Clin Oral Implants Res* 2000;11:66–75.
17. De Santis G, Nocini PF, Chiarini L, Bedogni A. Functional rehabilitation of the atrophic mandible and maxilla with fibula flaps and implant-supported prosthesis. *Plast Reconstr Surg* 2004;113:88–98.
18. Rohner D, Jaquiéry C, Kunz C, et al. Maxillofacial reconstruction with prefabricated osseous free flaps: A 3-year experience with 24 patients. *Plast Reconstr Surg* 2003;112:748–757.
19. Kramer FJ, Dempf R, Bremer B. Efficacy of dental implants placed into fibula-free flaps for orofacial reconstruction. *Clin Oral Implants Res* 2005;16:80–88.
20. Chana JS, Chang YM, Wei FC, et al. Segmental mandibulectomy and immediate free fibula osteoseptocutaneous flap reconstruction with endosteal implants: An ideal treatment method for mandibular ameloblastoma. *Plast Reconstr Surg* 2004;113:80–87.
21. Fenlon MR, Lyons A, Farrell S, et al. Factors affecting survival and usefulness of implants placed in vascularized free composite grafts used in post-head and neck cancer reconstruction. *Clin Implant Dent Relat Res* 2012;14:266–272.
22. Raoul G, Ruhin B, Briki S, et al. Microsurgical reconstruction of the jaw with fibular grafts and implants. *J Craniofac Surg* 2009;20:2105–2117.
23. Salinas TJ, Desa VP, Katsnelson A, Miloro M. Clinical evaluation of implants in radiated fibula flaps. *J Oral Maxillofac Surg* 2010;68:524–529.
24. Ferrari S, Copelli C, Bianchi B, et al. Rehabilitation with endosseous implants in fibula free-flap mandibular reconstruction: A case series of up to 10 years. *J Craniomaxillofac Surg* 2013;41:172–178.
25. Zlotolow IM, Huryn JM, Piro JD, Lenchewski E, Hidalgo DA. Osseointegrated implants and functional prosthetic rehabilitation in microvascular fibula free flap reconstructed mandibles. *Am J Surg* 1992;164:677–681.
26. Jaquiéry C, Rohner D, Kunz C, et al. Reconstruction of maxillary and mandibular defects using prefabricated microvascular fibular grafts and osseointegrated dental implants -- a prospective study. *Clin Oral Implants Res* 2004;15:598–606.
27. Hundepool AC, Dumans AG, Hofer SO, et al. Rehabilitation after mandibular reconstruction with fibula free-flap: Clinical outcome and quality of life assessment. *Int J Oral Maxillofac Surg* 2008;37:1009–1013.
28. Teoh KH, Patel S, Hwang F, Huryn JM, Verbel D, Ziatolow IM. Prosthetic intervention in the era of microvascular reconstruction of the mandible--a retrospective analysis of functional outcome. *Int J Prosthodont* 2005;18:42–54.
29. Schliephake H, Schmelzeisen R, Husstedt H, Schmidt-Wondera LU. Comparison of the late results of mandibular reconstruction using nonvascularized or vascularized grafts and dental implants. *J Oral Maxillofac Surg* 1999;57:944–951.
30. He Y, Zhang ZY, Zhu HG, Wu YQ, Fu HH. Double-barrel fibula vascularized free flap with dental rehabilitation for mandibular reconstruction. *J Oral Maxillofac Surg* 2011;69:2663–2669.
31. Bähr W, Stoll P, Wächter R. Use of the "double barrel" free vascularized fibula in mandibular reconstruction. *J Oral Maxillofac Surg* 1998;56:38–44.
32. Ciocca L, Corinaldesi G, Marchetti C, Scotti R. Gingival hyperplasia around implants in the maxilla and jaw reconstructed by fibula free flap. *Int J Oral Maxillofac Surg* 2008;37:478–480.
33. Yerit KC, Posch M, Seemann M, et al. Implant survival in mandibles of irradiated oral cancer patients. *Clin Oral Implants Res* 2006;17:337–344.
34. Schepers RH, Slagter AP, Kaanders JH, van den Hoogen FJ, Merks MA. Effect of postoperative radiotherapy on the functional result of implants placed during ablative surgery for oral cancer. *Int J Oral Maxillofac Surg* 2006;35:803–808.
35. Iizuka T, Häfliger J, Seto I, Rahal A, Mericske-Sterm R, Smolka K. Oral rehabilitation after mandibular reconstruction using an osteocutaneous fibula free flap with endosseous implants. Factors affecting the functional outcome in patients with oral cancer. *Clin Oral Implants Res* 2005;16:69–79.
36. Jegoux F, Malard O, Goyenville E, Aguado E, Daculsi G. Radiation effects on bone healing and reconstruction: Interpretation of the literature. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;109:173–184.
37. Smolka K, Kraehenbuehl M, Eggensperger N, et al. Fibula free flap reconstruction of the mandible in cancer patients: Evaluation of a combined surgical and prosthodontic treatment concept. *Oral Oncol* 2008;44:571–581.