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Assessing the survival rate of implants placed in vascularized and nonvascularized bone grafts for extensive jaw reconstructions in 2010 to 2021 articles: A review

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ABSTRACT

Introduction: Restoring oral function with dental implants after maxillofacial defects improves aesthetics and provides adequate nutrition to improve patients' quality of life significantly. One of the essential methods of repairing jawbone defects is bone grafting. Graft sources may be vascularized or nonsecularized. The present study aimed to review the survival rate of implants placed in vascularized and nonvascularized bone grafts for extensive jaw reconstructions in 2010 to 2021 articles.

Materials and Methods: This study is a narrative review study. In this study, research published in PubMed, Google Scholar, and Scapus databases has been reviewed by a review method and with a keyword search strategy.

Results: 2815 articles were found from the mentioned databases that after removing unrelated research (2713 cases) and duplicate researches (63 cases), 39 articles remained for final review. Then, those research that were presented in the scientific conference and were in the form of abstracts or did not have a correct statistical population, were excluded from the study (18 cases) and finally 21 articles were reviewed.

Conclusion: Bone jaw defects are a severe complication that affects many aspects of a person's life. Our results showed that vascularized and nonvascularized grafts are used for mandibular and maxillary bone regeneration. Also, after maxillary reconstruction, implant survival in vascularized and nonvascularized grafts was more than 90% in the 17 cases of 21 studied articles. Also, the duration of follow-ups was from 3 months to 14 years. Interestingly, in patients with head and neck cancer whose jaws were reconstructed with bone grafts and implants were placed in them, the survival rate of implants under radiotherapy was lower than in patients without radiotherapy.

Keywords: Mandibular atrophy; Atrophic maxilla; Vascularized graft; Nonvascularized graft; Implant survival.

Introduction

Asymmetrical defects in the maxilla or mandible caused by removing tumors, injuries inflicted by impact, severe atrophy, or congenital disorders can result in a substantial deformation. Changes in oral function affect chewing, speaking, swallowing, or retaining oral moisture, as well as other psychological problems

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[1,2]. The oral function and beauty can be reconstructed using bone flaps by inserting implants [3]. In the past decade, dental implants (DI) have been employed as a common treatment to rehabilitate partially toothless or edentulous patients [4,5]. Inserting implants in the reconstructed jaws provides the opportunity to create more stable and durable DIs. Sufficient bone quantity must be maintained to retain the implants and obtain desirable results. In some cases, undesirable conditions of the area such as the atrophic jaw, bone defects caused by various types of osteomyelitis, tumor removal surgery, and posttraumatic outcomes due to defects in one or several dimensions might fail to provide sufficient bone quantity to insert the implants [4].

The atrophic alveolar crest might be treated using a short dental implant (SDI), with a length of 8mm [6]. Currently, several techniques are used to treat the lack of sufficient bone in the cases that SDI cannot be used on account of a severe bone defect. These techniques include bone reconstruction, autogenous bone graft (ABG), alveolar distraction osteogenesis (DO), and bone reconstruction using nonvascularized flaps [7]. There are various types of ABGs, vascularized, or nonvascularized flaps depending on the type of defect to be reconstructed. ABGs are regarded as the golden standard for the reconstruction of such defects. There are several intraoral and extraoral donation resources for ABGs. Intraoral bones can be procured from mandibular symphysis and parasymphysis (chin region), mandibular ramus, and maxillary tuberosity [8]. An extraoral donation region is required in cases with large bone defects. The extraoral bone can be procured from the iliac crown, calvarium, or tibia bone. In recent years, iliac bone grafting (IBG) has become one of the most prevalent ABG methods [9]. The survival and function of implants inserted in bone flaps for jaw rehabilitation are hardly discussed or mentioned in most journals. The researchers reported a broad spectrum of the success rate of osseointegration ranging from 86 to 99%, which can be influenced by factors such as radiation therapy, implant properties, the thickness of soft tissue, lack of cooperation of the patient, and poor oral hygiene [3,10-12]. This study sought to review the studies carried out from 2010 to 2021 on the survival rate of implants placed on the vascularized, or nonvascularized bone grafts for extensive jaw reconstruction.

Materials and Methods

In this literature review the data were collected through searching the scientific websites. The electronic review of articles from 2010 to 2021 comprised DIs, vascular graft, bone graft, and bone defect from the accredited databases such as PubMed, GoogleScholar, Scopus, and Science direct. In addition, the electronic databanks such as MEDLINE (via Ovid and PubMed, Appendix, from 2000 up to 2021), Embase (via Ovid), the Cochrane Oral Health Group's Trials Register, and Central were searched.

Inclusion Criteria

- Studies were carried out on humans.
- Studies with a systematic review, plus case-cohort and case-control studies.

Exclusion Criteria

- Studies carried out on animals.

After examining and eliminating the contradicting cases, 12 articles remained and were investigated.

Results

A review was conducted in the aforesaid databases from 2010 to 2021 regarding the survival rate of implants in vascularized and nonvascularized grafts placed in the jaws. According to figure 1, 2815 articles were found in the aforesaid databases. After examining and eliminating the studies that were not related or were less related to implant survival rate in the vascularized and nonvascularized grafts, as well as the repetitive studies (2713 cases), 102 cases remained. Afterward, the titles and abstracts of these articles were investigated and the non-related or less related studies were eliminated (63 cases). Accordingly, 63 articles remained to be studied. Then, the studies that were not accessible, did not meet the inclusion criteria, or matched the exclusion criteria were eliminated from the study (18 cases). In light of that, 21 cases were finalized and examined (Fig.1).

Table 1 shows the methods and results of the studies from 2010 to 2021 on the implant survival rate in the vascularized and nonvascularized grafts placed in jaws. The results of the investigation were reported on the basis of the type of complication, type of graft, follow-up duration, number of implants used in the study, and the implant survival rate. Per the results from 17 articles (from 21 articles), i.e., 81% of the total studies, the implant survival rate exceeds 90%. Furthermore, the duration of follow-up ranged from a minimum of 3 months up to a maximum of 14.3 years. In addition, 9 out of 21 examined articles used vascularized grafts and reported the implant survival rate to be 93.1%. On

the other hand, 12 other studies used nonvascularized grafts and their implant survival rate was reported to be 94.13%. Thus, it can be concluded that there is no considerable difference between the vascularized and nonvascularized grafts concerning implant survival rate.

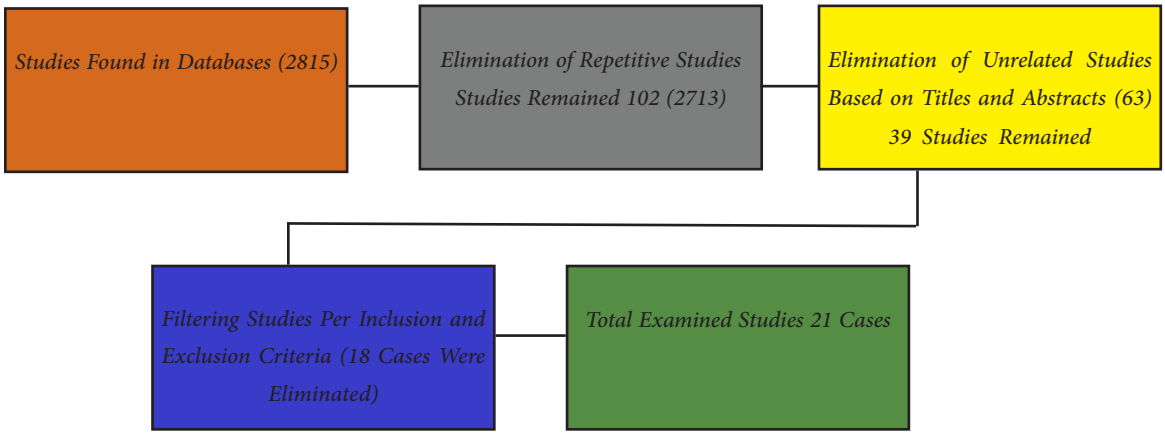

Figure 1. Research selection stages (diagram of course of study).

Table 1. Results of Implant Survival Rate in the Vascularized and Nonvascularized Grafts Inserted in Jaws.

First Author (Year)	Implant Type	Graft Type	Jaw Resorption	Reconstructed Jaw	Number of Implants	Results
Acocella A (2010)[13]	-	Autologous Mono-Cortical Bone Blocks	13.1±8.19%	Maxilla	30	The results of this research suggested that a larger part of osteocytes in mono-cortical bone incur damage after the graft surgery. Neo-vascularization of non-vital grafted bone into the new vital form is difficult on account of the slow process of reconstruction.
Pelo S (2010)[14]	Biomet 3i Osseotite1	Autogenous Bone Graft (ABG)	-	Mandible	141	The survival rate of implants was 91%. The interposition of 2-stage osteotomy with iliac crest bone graft with secondary implant placement is a predictable method to rehabilitate patients suffering from severe atrophic edentulous mandible with implant-supported prosthesis.
Chiapasco M (2011)[15]	Titanium	Revascularized Fibula Free Flaps	1-7mm(maxilla), 1-4.5mm (mandible)	Maxilla and Mandible	75	Despite the high survival rate of dental implants (95.8%), some of them manifested peri-implant bone-level loss.
Parbo N (2013)[16]	-	Fibula Graft	-	Mandible	67	The survival rate of the fibula was 97%. Half of the patients experienced non-severe complications; loosening of osteosynthesis material, fistula, and graft exposure. The survival rate of implants was 96%. Three implants out of 67 implants were lost due to infection.

First Author (Year)	Implant Type	Graft Type	Jaw Resorption	Reconstructed Jaw	Number of Implants	Results
Dottore AM (2014)[17]	-	Autogenous Graft of Oral Bone	-	Mandible	44	The total implant survival rate was 95.45%. The implant success rate was 90.90%. DIB for ncHA grafts and autogenous bone was 0.71±0.71 and 0.84±0.72mm ($p<0.05$). Measurement of implant stability was the same during the 12-months follow-up ($p<0.05$).
Fenlon MR (2012)[18]	-	Vascularized Graft	-	Maxilla and Mandible	145	The implant failure was increased in the immediately placed mandibular implants. Radiation therapy was associated with a considerable increase in failure. It appears that the modern implant surfaces operate better than the machined surfaces. Donor sites had no impact on implant survival.
Kim A(2013)[19]	-	Non-vasculari Iliac Crest Graft	0.09mm	Mandible	10	All implants survived and were successful in the course of 44-105 months of follow-up.
Jacobsen C (2014)[20]	Screw-Retained Implants	Vascularized Fibula Flap	-	Mandible	140	The total survival rate of 1-year and 5-year implants were 94% and 83%, respectively. The survival rate of implants was 86 % in the mandible bone, 86% in the non-radiated grafted fibula bone, 82% in the radiated mandible bone, and 38% in grafted fibula bone with radiation therapy.
de Moraes PH (2015) [21]	Conexao	Autogenous Bone Graft (ABG)	-	Maxilla	306	There were 162 implants in the bone graft group, among which 8.0% of implants were lost in the pre-loading stage, 3.7% in the post-loading stage, and 88.7% of them survived. In the non-bone graft group, 6.17% were lost in the pre-loading stage and 85.1 % in the post-loading stage, and 90.97 % fully survived. There was no significant difference between the two groups concerning the implant survival ($P=0.082$).

First Author (Year)	Implant Type	Graft Type	Jaw Resorption	Reconstructed Jaw	Number of Implants	Results
Hakim SG (2015)[22]	Straumann Standard Implants SLA®, Replace Select®, tioLogic©, Conelog®	Non-Fibula Free Flaps	Slight Resorption of Onlay	Maxilla, and Mandible	119	Iliac bone onlay graft was used in six patients to obtain suitable vertical height in mono-barrel grafts. In total, 10 implants in eight patients could not be loaded (five cases underwent radiation). All implants demonstrated stable osseous integrity and satisfactory peri-implant soft tissue conditions.
Rahim I (2015)[23]	Synthes®, USA	Vascularized Graft	-	Mandible	1	Successful
Kang Y-H (2015)[24]	BioHorizon™	Iliac Crest or Jaw Bone	Jaw Bone Graft Group Manifested a Slower Vertical Bone Resorption	Alveolar Ridge	386	Both autologous bone graft groups demonstrated desirable clinical results, long-term implant stability, and overall implant survival rates. However, the grafted iliac bone showed a more prompt vertical loss than the jaw bone, especially, since the maximum vertical bone reduction occurred within 6 months after the bone graft. On the other hand, the jawbone graft group manifested a lower incidence of peri-implantitis during long-term follow-up than the iliac bone graft group.
Bllaca F (2016)[25]	-	Iliac Crest	-	Maxilla, and Mandible	37	The most common intervention site was maxilla (71.4%). Dental implants were placed six months after augmentation. All of them were fixed on an augmented alveolar ridge. On average between 20% to 30% of bone grafts were resorbed. Among settled implants 97.3% of them survived.
Schwartz-Arad D (2016)[26]	-	Onlay Bone Grafting (OBG)	-	Maxilla, and Mandible	663	A total of 216 OBG were successful (96.4%), and most of the augmentations were uneventful (88.4%). The healing period after implant placement was 4-6 months. Most of the implants survived (93.4%). The cumulative survival rate of the implants was 83%.

First Author (Year)	Implant Type	Graft Type	Jaw Resorption	Reconstructed Jaw	Number of Implants	Results
Sozzi D (2017)[27]	-	Vascularized Fibula Free Flaps	-	Maxilla, and Mandible	100	The survival rate of implants was 98%. There was no statistically significant difference in implant success between maxillary and mandibular implants, or between radiated and non-radiated bone. The prostheses success rate, was 100%
Gurler G (2017)[28]	-	Alveolar Ridge Splitting (ARS) and Autogenous Onlay Bone Grafting (AOBG)	1.62mm	Maxilla, and Mandible	77	The implant survival rate was 93.9% in the ARS group and 93.1% in the AOGB group. Peri-implant bone resorption at one year was higher in the AOBG group than in the ARS group (p=0.032). There were minor surgical complications such as a bad split and wound dehiscence.
Doimi JR (2017)[29]	-	Bone Graft	-	Maxilla	6	In the course 18 months of follow-up, no complication was observed. Satisfactory results were obtained concerning the function and esthetic of the patients. The success rate of implants was 100%.
Khachatryan L (2018)[30]	-	Vascularized Fibula Graft	-	Mandible	134	The coefficient of osteointegration of implants within 3 years after bone grafting was 97%. Using a vascularized autograft of the fibula to reconstruct the defects of the lower jaw provides the conditions for full rehabilitation of patients. The success rate of implants was 97%.
Attia S (2018)[31]	-	Vascularized Fibula Free Flaps	-	Maxilla, and Mandible	134	The cumulative implant survival rate was 81%. The survival rate of the 34 fibula flaps transplanted after surgical reconstruction was 97%.
Nguyen TTH (2019)[4]	Straumann® Dental Implant	Iliac Bone graft	42.5%	Maxilla, and Mandible	29	In the course 50 months of follow-up 100% of IBG's were successful. The total implant survival rate was100%.
Karimi A (2019)[32]	-	Non-vascularized Iliac Crest Graft	0.96 mm (the length of the failed implant), 0.64mm (in survived implants)	Mandible	36	The mean survival rate of implants was 97.2%. One implant was failed. There was no sign of peri-implantitis.

Discussion

In the cases of jaw defects, the DIs restore oral function and boost the beauty, plus they considerably improve the quality of life of patients by helping to supply adequate nutrition. There are numerous options to reconstruct jaw defects ranging from distraction osteogenesis to multiple autogenous resources [33-35]. Among the autogenous donor sites, the iliac crest supplies large amounts of bones that enjoy compressed cortical bone and are rich in blood cells, which maximize the chance of tooth reconstruction using implants [36]. Numerous studies investigated the implant survival rate in the regions reconstructed using vascularized and nonvascularized bone grafts. This research examined these studies and it found that implant success and survival rate differ depending on the type of jaw defect, location of complication, type of implant, and type of graft [19,37,38]. The recent advancement in the field of dentistry revolutionized the use of DIs. Thus, it helps perfectly manage the lost teeth. Today, DIs are in great demand. However, implant failure is also prevalent. The failure rate includes the early failure and late failure. The early implant refers to the inability to establish an intimate bone-to-implant contact within several weeks up to several months.

Avascular necrosis, bacterial infection, surgical trauma, lack of primary stability, and early loading of obstruction can lead to initial failure. Late failure occurs while later after functional loading and due to extreme load and infection. The results of the investigation were reported on the basis of the type of complication, type of graft, follow-up duration, number of implants used in the study, and the implant survival rate. Per the results from 17 articles (from 21 articles), i.e., 81% of the total studies, the implant survival rate exceeds 90%. Furthermore, the duration of follow-up ranged from a minimum of 3 months up to a maximum of 14.3 years. In addition, 9 out of 21 examined articles used vascularized grafts and reported an implant survival rate of 93.1%. On the other hand, 12 other studies used nonvascularized grafts and their implant survival rate was reported to be 94.13%. Thus, it can be concluded that there is no considerable difference between the vascularized and nonvascularized grafts concerning implant survival rate. Bleeding from implant location, infection, and pain are among the first side effects of implant failure. DI failure is quite common. Lack of bone-to-implant contact in the course of initial recovery, infection of the tissues surrounding the implant, and fracture are among other causes of implant failure. There are hardly any symptoms and contraindications regarding placing implants. The implant contraindications are recommended for patients with epilepsy, children and adolescents, patients with endocarditis, patients with a history of osteoradionecrosis (ORN), smokers, and diabetic patients. Absolute implant contraindications are recommended for patients with a history of heart attack, cerebrovascular accident (CVA), patients with records of bleeding, heart transplant, immunosuppression, active cancer treatment, drug abusers, and patients with psychiatric disorders [39]. A variety of factors affect implant failure. First, factors related to the host, second, factors related to the position of an implant, third, factors related to surgery, fourth, related to implant devices, and fifth, factors related to implant prosthesis. Host-related factors comprise patients' sex and age, smoking habits, systematic diseases, as well as oral and dental hygiene. Implant position-related factors consist of position at the arch, and bone quality and quantity. The primary stability, implant direction and angles, and proficiency of the operator are among the surgery-related factors. Surface roughness, DI length and diameter, and coarse and refined structure of implant devices are among the factors related to implant devices. Factors related to implant prosthesis include maintenance and occlusion design [40]. Albrektsson et al. concluded that factors such as design and implant surface, the position of an implant, the technique of surgery, and occlusal loading affect jawbones [41]. Renouard et al. found that the increase in implant failure due to the weak bone density and proficiency of the operator is associated with the shorter and wider implant. However, short or wide implants might be considered for undesirable regions such as low bone density [42]. Borie et al. argued that the length, diameter, and connection of each implant can affect bone biomechanics. In addition, they stated that despite the impact of implant length and diameter, bone stress and strain around the implant must be maintained within physiological boundaries to prevent excessive pathological load, bone resorption, and as a result, the risk of lack of prolonged success of implant prosthesis [43]. Arsalanloo et al. expressed that in the case of bone grafting shorter implants can be used along with the longer implants, as well as wider implants in the grafter bones [44]. According to Busenlechner et al., smoking and periodontal conditions can double the implant failure rate [45]. Bataineh and Al-Dakes advised that increasing the length of implants can enhance their stability, even despite low bone quality [46]. YeŞildal et al. recommended increasing the length and diameter of implants to increase implant survival [47]. Ebrahim et al. reported that when compared to the NP

model, the PR model indicated less strain and pressure stress in the bone surrounding an implant [48]. Topkaya et al. concluded that the length and diameter of the implant are quite crucial in its success rate. They stated that loss of alveolar bone reduced the success and survival rate of implant [49]. Wang et al. stated that sufficient soft and hard tissues are required for implant restoration [50]. The narrow diameter of the implant has higher stress and faces greater failure than the larger diameter of the implant [51]. In their study, Shigehara et al. assessed the long-term result of the full arch, fixed, and one-piece prosthesis placed immediately after Dis. They recommended immediate implant for edentulous patients [52]. French et al. demonstrated a higher survival rate in implants inserted into soft tissue and bone compared to conical implants [53]. Removal surgery with and without the current standard radiation therapy is used for oral cancer.

Removing tumors by surgery might cause various problems such as deformation of face lines, disruption in speaking, chewing, swallowing, and saliva retention. loss of teeth or jaw bone can cause considerable disruption in chewing. Rehabilitation of cancer patients using full and partial prostheses might be difficult or impossible, even in the case of ideal reconstruction of the mandible or maxilla. The denture will be unstable in the damaged area of the mouth [31]. Hämmerle et al. concluded that the survival rate of implants inserted into the augmented sites ranged from 79 to 100% [54]. The majority of studies manifested a more than 90% success rate after at least one year, which matches the results of this study. That study concluded that this survival rate is similar to the cases in which implants are placed in regions that do not require bone augmentation. In their research, Zou et al. found that the total five-year survival of DIs placed in vascularized iliac grafts amounted to 91.8%, plus DIs placed in iliac autogenous grafts are regarded as an effective method to reconstruct mandibles [38].

One of the rare studies that assessed the success rate of implants in the nonvascularized iliac grafts [37] argued that the cumulative success rate of the implant was 100% after five years and 60.3% after 10 years. In addition, it was demonstrated that both types of vascularized and nonvascularized iliac crest grafts enable satisfactory contour restoration in the reconstruction of a part of the jaws, and it operates as a proper host for DIs. Aside from iliac crest grafts, other autogenic resources are used to reconstruct jaws and place implants such as vascularized fibula [55,56,57] and shoulder [58]. In their study, Chiapasco et al. placed 71 implants in 16 patients with vascularized fibula grafts, bearing the mean follow-up period of 50.2 months [56]. In that study, the success and survival rate of implants at the end of the followup period amounted to 98.6% and 93.1%, respectively, which can be compared to the total survival rate of implants in this study (more than 90%). In the study by Wu et al., the total survival rate of implants placed in the nonvascularized at one-year and five-year were 96% and 91%, respectively.

This study found that the main causes of DI failure were infection, tumor recurrence, and proliferation of soft tissue [55]. Li et al., investigated the possibility of inserting implants into the nonvascularized bone flaps of the shoulder. They found that despite the survival of nonvascularized flaps in all 10 patients undergoing reconstruction with the nonvascularized bone flaps of the shoulder, the implants were successful merely in 50% of patients. Furthermore, they discovered a considerable loss of bone height and width within one year after the examination. In addition, bone height was reduced more rapidly than bone width. However, no data were provided regarding bone resorption around the implants [59]. In future studies, it is recommended to conduct a clinical trial on larger sample size and investigate the success rate of implants in the bone grafts of patients who undergo radiation therapy in comparison to patients who didn't undergo radiation therapy.

Conclusion

There are numerous options for the reconstruction of jaw defects ranging from distraction osteogenesis to multiple autogenous resources. Among the autogenous donor sites, the iliac crest supplies large amounts of bones that enjoy compressed cortical bone and are rich in blood cells, which maximize the chance of tooth reconstruction using implants. This study manifested that the iliac crest bone is the largest bone source used for jaw reconstruction. The success and survival rate of implants differ depending on the type of jaw defect, site of complication, type of implant, and type of graft. No difference was found in the conducted studies concerning the survival rate of implants in the vascularized and nonvascularized grafts. In addition, the articles reported that the survival rate of implants in the maxilla and mandible had no significant difference. Patients suffering from head and neck cancer with jaw resorption who underwent bone grafting and implants inserted into them demonstrated extreme sensitivity to radiation therapy. In light of that, the survival rate of implants in the patients receiving radiation therapy considerably decreased. Per the results, among 81%

of the total studies, the implant survival rate exceeded 90%. Furthermore, the duration of follow-up ranged from a minimum of 3 months up to a maximum of 14.3 years. In addition, 9 out of 21 examined articles used vascularized grafts and reported an implant survival rate of 93.1%. On the other hand, 12 other studies used nonvascularized grafts and their implant survival rate was reported to be 94.13%. Thus, it can be concluded that there is no considerable difference between the vascularized and nonvascularized grafts concerning implant survival rate.

Conflict of Interest

There is no conflict of interest to declare.

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