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ASSESSMENT OF CRESTAL BONE LOSS AND SURVIVABILITY OF DENTAL IMPLANTS PLACED IN FREE FIBULAR GRAFT VERSUS NON-VASCULARIZED ILIAC CREST GRAFT IN MANDIBULAR RECONSTRUCTION

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Abstract

Objective: The objective of this study is to evaluate the crestal bone loss and survivability of dental implants in non-vascularized iliac crest grafts and free vascularized fibular flap in mandibular reconstruction.

Materials and Methods: This study included eighteen patients which were divided into two groups. The first group (n=9) underwent non-vascularized iliac crest graft while the second group (n=9) underwent vascularized free fibular flap with delayed implant insertion in both groups. A total of 48 dental implants were placed and after 3 months, a second-stage surgery for implant loading with the planned prosthesis was performed. All succeeded implants were loaded with fixed implant supported prothesis. Radiographic assessment of crestal bone loss was recorded along with the percentages of the survived implants and statistically analyzed. The data was explored for normality using Shapiro-Wilk tests and were analyzed with independent t-test and Fisher's exact test with a significance level of 0.05.

Results: Crestal bone loss was significantly higher in the iliac graft group than in fibular graft group. Regarding the survivability results, 25 implants placed in the vascularized fibular graft group were successful in function. While for non vascularized iliac graft group 18 implants were successful. However, there was no significant difference between both groups.

Conclusions: The crestal bone loss around the dental implants placed in vascularized free fibular grafts were less compared to those placed in non-vascularized iliac crest grafts. The survivability of the dental implants placed in both grafts were comparable.

KEYWORDS: Crestal bone loss, Survival rate, Dental implants, Mandibular reconstruction, Iliac crest graft, Vascularized free fibular graft.

INTRODUCTION

Dental rehabilitation is one of the most important goals in mandibular reconstruction and plays a key role in functional aspects as chewing, deglutition, speech, respiration, and aesthetic outcomes thus improving the quality of life of these patients. (1) Furthermore, the use of dental implants often helps reduce the risk of graft resorption. (2)

Implants can be placed either in a non-vascularized iliac crest graft or a vascularized free fibular graft. The decision as to which donor site would be chosen for reconstruction depends on defect size, location, and the patient's current dental status. The defect classification by Jewer et al., (3) was used to quantify the defects treated in this study.

Because of vascularization of the fibular grafts, bone volume is expected to achieve higher stability and a lower resorption rate. (2) Furthermore, vascularized bone shows higher graft survival rates (4) and lower infection rates compared with non-vascularized bone. One major disadvantage of this kind of bone transplant is the small diameter of the graft. In dentate patients there are usually height discrepancies between the teeth bearing mandible and the grafted fibula. Furthermore, retention and angulation of dental implants can be difficult because of the limited graft height and abnormal occlusal relationships after mandibular reconstruction. (5)

Another alternative is the non-vascularized anterior iliac crest graft. Its vertical bone volume is much greater, allowing for reconstruction having the original bone height of the dentate mandible. Additionally, a subsequent implant placement can be performed without creating unfavorable implant-to-crown ratios or requiring further surgical intervention. The capability of bridging larger segmental gaps, in comparison, is inferior to that of fibular grafts. Reconstructing large, continuous mandibular defects after ablative surgery with free non-vascularized bone grafts usually results in high graft failure (6) and resorption rates. (2)

Implants may be placed either at the time of reconstructive surgery (immediate implants) or later (delayed implants) (7). Although immediate implantation reduces rehabilitation time in oncologic patients, immediate placement of the implants may compromise bone viability, lengthen the operative procedure, or result in implant malposition. (8).

However, delayed implant placement, which is done 6 months after the graft, when bone remodeling and muscle healing are complete (9) makes implant placement safer, helps to prevent implant failure resulting from inadequate placement (10), allows time for acquiring a good knowledge of the vascularization of the flap, evaluating the prosthetic need and motivation of the patient. (11). Other studies have shown that most of the bone remodeling and resorption on the graft takes place during the few months following the surgery. (12,13).

The selection of the appropriate type of dental prothesis depends on several factors as excessive thickness and mobility of the overlying skin and soft tissues and obliteration of the vestibule may limit oral rehabilitation. (14). Acrylic resin prosthesis placed on implants surrounded by mobile soft tissues might cause inflammation and pocket formation. (15).

Therefore, to avoid persistent hyperplasia, resin reconstruction should be prohibited, and metal-ceramic restorations should be favored. (10)

Cone Beam Computed Tomography (CBCT) measurements for crestal bone loss around dental implants have been found to be applicable and repeatable, however, concerning its accuracy according to the previous studies by Martina Schriber et al., (16) to investigate the diagnostic accuracy of CBCT, the results showed high diagnostic accuracy for peri-implant bone defect detection regardless of the device, imaging setting or implant material used.

No standardized definition of implant success has been established for this group of patients and local situations. Buch RS et al., (17) discussed the difficulty of standardizing the definition of implant success, even in non-reconstructed, healthy patients. They evaluated 508 inserted implants using five different internationally accepted classifications and obtained different success rates for the same sample: 88% (Albrektsson criteria), 89% (Naert), 88% (Buser), 85% (NIH conference), and 75% (Jahn-d'Hoedt). (18) Moreover, Foster RD et al., (19) reported an implant success rate of 99 % in vascularized bone flaps versus 82 % in non-vascularized bone grafts over a mean follow-up period of 3 years. The aim of this in-vivo study is to evaluate the crestal bone loss and survivability of dental implants in non-vascularized iliac crest grafts and free vascularized fibular flap in mandibular reconstruction.

Materials & Methods

Patient inclusion criteria were traumatic injuries, gunshot injuries, tumor ablative surgeries, osteomyelitis, and osteonecrosis at the Oral and Maxillofacial Surgery Faculty of Dentistry, Ain Shams University, Egypt.

Patients with any cardiovascular or pulmonary disease or general medical condition hindering the fitness for general anesthesia or receiving radiotherapy after mandibular reconstruction or incomplete medical records were excluded. This prospective clinical study was approved by the Research Ethics Committee of Faculty of Dentistry, Ain Shams University (FDASU-RecD061814), confirming that the recognized standards have been followed (Declaration of Helsinki). Following the human rights put by Research Ethical Committee, Faculty of Dentistry, Ain Shams University who approved for this research, all patients signed an informed consent prior to inclusion in the study after explaining thoroughly the full treatment trial including all the benefits and the possible complications and risks, any patient who desired to leave the study or discontinue the treatment for any or no reason had all the right to do that. This study included 18 patients which were divided into two groups. The first group (n=9) underwent non-vascularized anterior iliac crest grafting while the second group (n=9) underwent vascularized free fibular flap with delayed implant insertion in both groups. Preoperative clinical and radiographic examination (Computed Tomography) (C.T) were done for all patients for measurements of the defect and virtual planning for resection. For patients undergoing reconstruction with iliac crest graft a routine C.T was done on the pelvis for the reconstruction planning. While, for patients undergoing reconstruction with free vascular fibular flap a routine C.T angiography and normal C.T on both lower limbs were done. The partial mandibular en bloc resection was classified according to Jewer et al., (3) depending on

the extent of the pathology and the planned resection, the partial mandibular resection included surrounding tissues such as mucosa, muscle, skin, and salivary glands. The resection was followed by an immediate mandibular reconstruction with either a vascularized free fibula graft or a non-vascularized iliac crest graft using the virtual surgical planning software Pro-Plan CMF (Materialise, Leuven, Belgium).

After healing of the grafts, the prosthetic rehabilitation as well as the number and locations of implant placement for each case were assessed. A total of 48 implants (Ritter, GmbH & Co. KG, Biberach, Germany) were positioned. All the patients were selected as implant candidates based on the following criteria (20, 21): favorable prognosis after tumor resection based on grade and stage; good residual tongue function; absence of coexisting systemic diseases that could compromise osseointegration; sufficient bone quality and quantity; absence of untreatable soft tissue abnormalities and lack of trismus; good oral hygiene and high level of dental awareness with realistic expectations of the patient; favorable relationship between the mandible and the maxilla. After 3 months of implant insertion, a second-stage surgery for implant loading with the planned prosthesis was performed and the fibrous and keratinized soft tissue was revaluated. When required and applicable, additional soft tissue surgery was executed in terms of vestibuloplasty with free gingival grafts from the palate. All succeeded implants were loaded with fixed metal-ceramic implant supported prothesis. (Figure 1). Also, the clinical data are shown in Table 1.

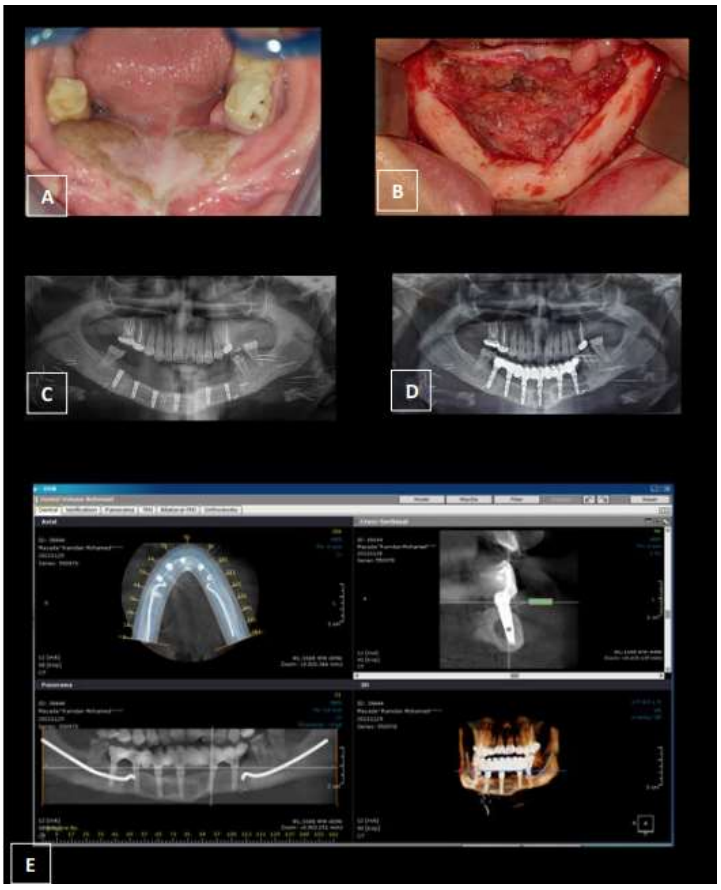

Figure 1: (A) Preoperative view after reconstruction with a free fibula graft (B) Intraoperative view prior to implant placement. (C) Postoperative radiograph after implant placement. (D, E) Follow-up radiograph at one-year post-prosthetic loading.

Table 1. Surgical defects, type of flap and rehabilitation characteristics.

Patient	Site of defect	Bone Defect	Type of flap	Prosthesis
M, 35	Anteroposterior	LCL	FFF	Fixed
M, 38	Anteroposterior	LC	FFF	Fixed
M, 40	Anteroposterior	LC	FFF	Fixed
M, 42	Anteroposterior	LCL	FFF	Fixed
M, 45	Anteroposterior	LCL	FFF	Fixed
F, 41	Anteroposterior	LCL	FFF	Fixed
F, 37	Anteroposterior	LCL	FFF	Fixed
F, 40	Anteroposterior	LC	FFF	Fixed
F, 38	Anteroposterior	LCL	FFF	Fixed
M, 38	Posterior	L	NV iliac crest	Fixed
M, 30	Posterior	L	NV iliac crest	Fixed
M, 45	Posterior	L	NV iliac crest	Fixed
M, 35	Posterior	L	NV iliac crest	Fixed
F, 33	Posterior	L	NV iliac crest	Fixed
F, 42	Posterior	L	NV iliac crest	Fixed
F, 39	Posterior	L	NV iliac crest	Fixed
F, 41	Posterior	L	NV iliac crest	Fixed
F, 37	Posterior	L	NV iliac crest	Fixed

*FFF: Free Fibular Flap

*NV: Non-Vascularized

Radiographic assessment of crestal bone loss was recorded by CBCT (Planmeca Romexis, Helsinki, Finland.) radiographs taken immediately after implant insertion, at 3

months after the implant insertion for both groups and at 1, 2-, 3-, 4- and 5-years postoperatively. Measurements were made mesiodistal and buccolingual to each implant by means of a digital millimeter ruler, measuring the distance between the top of implant head shoulder and the most coronal level of direct bone-to-implant contact. The bone level measured on radiographs taken immediately after implant insertion were considered the "baseline" for further measurements, two blinded independent observers measured the bone loss & analyzed the outcome in a standardized manner.

We adopted the Albrektsson's criteria (22) to define the implant survival: absence of persistent pain; absence of mobility; absence of infection; absence of continuous peri-implant radiolucency. Implant failure was defined as implant removal. The follow-up examination was performed according to a standardized protocol, including clinical examination, radiological evaluation and patient interview. Routine radiographic documentation was obtained with CBCT radiographs taken preoperatively, immediately after implant insertion, at the time of prosthetic rehabilitation and annually thereafter. Questions were posed to the patients covering five general groups of problems: nutrition, speech, salivary production, oral competence and esthetic. To evaluate the outcome, we adopted the categorization proposed by Iizuka T et al., (23); deglutition: normal diet, soft diet, feeding tube diet; speech: intelligible, intelligible with effort or unintelligible; oral competence: normal competence, drooling. Patients were also asked whether they had problems with their facial appearance.

Results

Categorical data were presented as frequency and percentage values and were analyzed using Fisher's exact test. Numerical data were presented as mean and standard deviation values. They were explored for normality by checking the data distribution using Shapiro-Wilk test. Data showed parametric distribution and were analyzed using independent t-test. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

Independent t-test showed that the crestal bone loss was significantly higher in the iliac graft group (0.92±0.07 mm) in comparison to fibular graft group (0.89±0.02 mm) ($p=0.032$) (Figure 2).

Figure 2 - Bar chart showing average crestal bone loss (mm) for both groups.

Regarding the survival rate results, Fisher's exact test showed that out of the 27 implants placed in the vascularized free fibular graft group, 25 (92.5%) were successful in function and 2 (7.5%) failed. While for non vascularized iliac graft group, out of the 21 implants, 18 (85.7%) were successful and 3 (14.3%) failed. There was no significant difference between both groups (p=0.6413) (Figure 3).

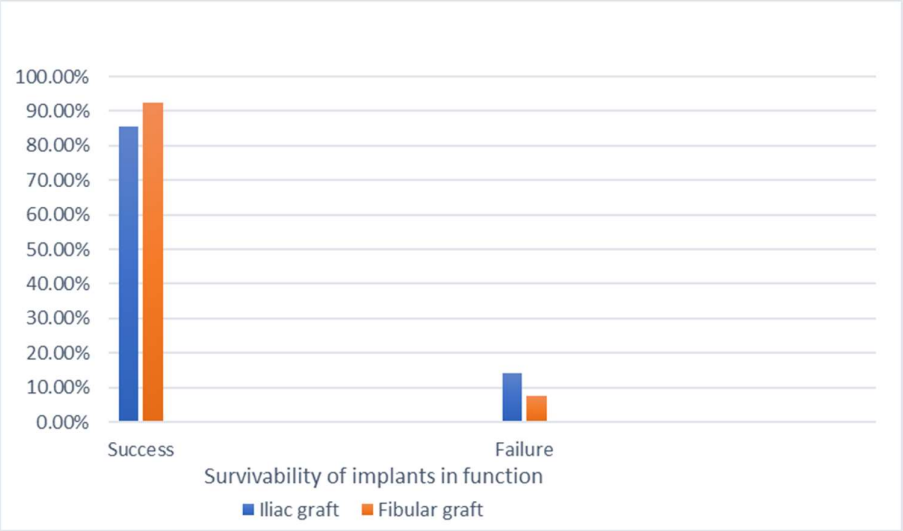

Figure 3 - Bar chart showing survivability of the implants in function.

Also, functional and aesthetic results are presented in Table 2.

Table 2. Functional and aesthetic results.

	Characteristics	No. of patients	%
Diet	Normal	12	66.7
	Soft	6	33.3
	Feeding tube	0	0
Speech	Intelligible	14	77.8
	Intelligible with effort	4	22.2
	Unintelligible	0	0
Oral competence	Normal	17	94.4
	Drooling	1	5.6
Aesthetical perception	Good	15	83.3

Moderate	2	11.1
Poor	1	5.6

Discussion

The present study aimed to evaluate crestal bone loss and survivability of dental implants in non-vascularized iliac crest grafts and free vascularized fibular flaps in mandibular reconstruction. Partial mandibular resection and reconstruction with either vascularized fibular grafts or with non-vascularized iliac crest grafts proved to be an efficient and safe treatment. The results of this study regarding crestal bone loss demonstrated that vascularized free fibular graft had lower bone resorption in contrast with non-vascularized iliac crest graft. The higher bone resorption rate in the iliac crest graft group may be attributed to its endochondral origin (24, 25), and cortico-cancellous morphology. (26, 27). The findings of this study are in accordance with a study reporting 16.7% resorption for iliac crest graft and 9.1% for free fibular graft 1-year postoperatively. (4)

Concerning the radiographic evaluation of the crestal bone loss around dental implants placed in both grafts which was done using CBCT, it was found that CBCT was more accurate and with higher applicability & repeatability. As using a paralleling technique RVG with customised bite block in patients reconstructed with vascularized free fibular graft was difficult due to excessive thickness, mobility of the overlying skin and soft tissues and obliteration of the lingual vestibule which limited the use of this technique. (14), which is consistent with previous studies by Martina Schriber et al., (16).

Regarding the results of the survival rate of the implants in the present study, 25 (92.5%) implants placed in the free fibular graft group were successful and in function which was statistically non-significant compared with those placed in the iliac crest graft group, where 18 (85.7%) were successful. Following Albrektsson's criteria (22) in addition to radiographic evaluation of crestal bone loss around dental implants placed in both vascularized free fibular graft and non-vascularized iliac crest graft. These results were consistent with the overall dental implant success rate of previous studies. (19, 28)

Conclusion

Within the limitations of this study, the crestal bone loss around the dental implants placed in vascularized free fibular grafts was less compared to the implants placed in non-vascularized iliac crest graft. The survival rate of the dental implants placed in both vascularized free fibular grafts and those placed in non-vascularized iliac crest graft were comparable. Therefore, the following study recommends submerging the dental implants placed in iliac crest grafting by at least 2mm to compensate for the crestal bone loss that will occur around the dental implants. Using under sized drilling or the use of osseo-densification technique (Densah burs, Versah UK Ltd.) in iliac crest grafts in implant placement technique accommodates for higher success rates. Using bicortical implant placement technique with low-speed drilling and high torque in free fibular grafts is recommended to decrease crestal bone loss.

Conflict of Interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

Ethical Approval

This study was approved by the Research Ethics Committee of Faculty of Dentistry, Ain Shams University (FDASU-RecD061814), confirming that the recognized standards have been followed Declaration of Helsinki.

References

1- Zheng, G. S., Su, Y. X., Liao, G. Q., Chen, Z. F., Wang, L., Jiao, P. F., Liu, H. C., Zhong, Y. Q., Zhang, T. H., & Liang, Y. J. (2012). Mandible reconstruction assisted by preoperative virtual surgical simulation. *Oral surgery, oral medicine, oral pathology and oral radiology*, *113*(5), 604–611. https://doi.org/10.1016/j.tripleo.2011.05.016.

2- Li, L., Blake, F., Heiland, M., Schmelzle, R., & Pohlenz, P. (2007). Long-term evaluation after mandibular reconstruction with fibular grafts versus microsurgical fibular flaps. *Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons*, *65*(2), 281–286. https://doi.org/10.1016/j.joms.2006.08.009.

3- Jewer, D. D., Boyd, J. B., Manktelow, R. T., Zuker, R. M., Rosen, I. B., Gullane, P. J., Rotstein, L. E., & Freeman, J. E. (1989). Orofacial and mandibular reconstruction with the iliac crest free flap: a review of 60 cases and a new method of classification. *Plastic and reconstructive surgery*, *84*(3), 391–405.

4- Rana, M., Warraich, R., Kokemüller, H., Lemound, J., Essig, H., Tavassol, F., Eckardt, A., & Gellrich, N. C. (2011). Reconstruction of mandibular defects - clinical retrospective research over a 10-year period -. *Head & neck oncology*, *3*, 23. https://doi.org/10.1186/1758-3284-3-23.

5- Lee, J. H., Kim, M. J., Choi, W. S., Yoon, P. Y., Ahn, K. M., Myung, H., Hwang, S. J., Seo, B. M., Choi, J. Y., Choung, P. H., & Kim, S. M. (2004). Concomitant reconstruction of mandibular basal and alveolar bone with a free fibular flap. *International journal of oral and maxillofacial surgery*, *33*(2), 150–156. https://doi.org/10.1054/ijom.2003.0487.

6- Adamo, A. K., & Szal, R. L. (1979). Timing, results, and complications of mandibular reconstructive surgery: report of 32 cases. *Journal of oral surgery (American Dental Association : 1965*, *37*(10), 755–763.

7- Sclaroff, A., Haughey, B., Gay, W. D., & Paniello, R. (1994). Immediate mandibular reconstruction and placement of dental implants. At the time of ablative surgery. *Oral surgery, oral medicine, and oral pathology*, *78*(6), 711–717. https://doi.org/10.1016/0030-4220(94)90085-x.

8- Disa, J. J., Hidalgo, D. A., Cordeiro, P. G., Winters, R. M., & Thaler, H. (1999). Evaluation of bone height in osseous free flap mandible reconstruction: an indirect measure of bone mass. *Plastic and reconstructive surgery*, *103*(5), 1371–1377. https://doi.org/10.1097/00006534-199904050-00005

9- Chiapasco, M., Abati, S., Ramundo, G., Rossi, A., Romeo, E., & Vogel, G. (2000). Behavior of implants in bone grafts or free flaps after tumor resection. *Clinical oral implants research*, *11*(1), 66–75. https://doi.org/10.1034/j.1600-0501.2000.011001066.x.

10- De Santis, G., Nocini, P. F., Chiarini, L., & Bedogni, A. (2004). Functional rehabilitation of the atrophic mandible and maxilla with fibula flaps and implant-supported prosthesis. *Plastic and reconstructive surgery*, *113*(1), 88–100. https://doi.org/10.1097/01.PRS.0000090723.98704.36.

11- Roumanas, E. D., Markowitz, B. L., Lorant, J. A., Calcaterra, T. C., Jones, N. F., & Beumer, J., 3rd (1997). Reconstructed mandibular defects: fibula free flaps and osseointegrated implants. *Plastic and reconstructive surgery*, *99*(2), 356–365. https://doi.org/10.1097/00006534-199702000-00008.

12- Nelson, K., Glatzer, C., Hildebrand, D., Hell, B., & Klein, M. (2006). Clinical evaluation of endosseous implants in nonvascularized fibula bone grafts for reconstruction of the severely atrophied mandibular bone. *Journal of oral and maxillofacial surgery : official journal of the American Association of Oral and Maxillofacial Surgeons*, *64*(9), 1427–1432. https://doi.org/10.1016/j.joms.2006.05.035.

13- Altundal, H., Celebiler, O., & Capa, N. (2009). The rehabilitation of facial shotgun wound with free fibula flap and retained overdenture: case report. *The Journal of trauma*, *66*(6), 1718–1723. https://doi.org/10.1097/TA.0b013e31804856fa.

14- Chang, Y. M., Chan, C. P., Shen, Y. F., & Wei, F. C. (1999). Soft tissue management using palatal mucosa around endosteal implants in vascularized composite grafts in the mandible. *International journal of oral and maxillofacial surgery*, *28*(5), 341–343.

15- Ciocca, L., Corinaldesi, G., Marchetti, C., & Scotti, R. (2008). Gingival hyperplasia around implants in the maxilla and jaw reconstructed by fibula free flap. *International journal of oral and maxillofacial surgery*, *37*(5), 478–480. https://doi.org/10.1016/j.ijom.2007.12.010.

16- Schriber, M., Yeung, A. W. K., Suter, V. G. A., Buser, D., Leung, Y. Y., & Bornstein, M. M. (2020). Cone beam computed tomography artefacts around dental implants with different materials influencing the detection of peri-implant bone defects. *Clinical oral implants research*, *31*(7), 595–606. https://doi.org/10.1111/clr.13596.

17- Buch, R. S., Weibrich, G., & Wagner, W. (2003). Erfolgskriterien in der Implantologie [Criteria of success in implantology]. *Mund-, Kiefer- und Gesichtschirurgie : MKG*, *7*(1), 42–46. https://doi.org/10.1007/s10006-002-0432-1.

18- Naert, I., Quirynen, M., van Steenberghe, D., & Darius, P. (1992). A six-year prosthodontic study of 509 consecutively inserted implants for the treatment of partial edentulism. *The Journal of prosthetic dentistry*, *67*(2), 236–245. https://doi.org/10.1016/0022-3913(92)90461-i.

19- Foster, R. D., Anthony, J. P., Sharma, A., & Pogrel, M. A. (1999). Vascularized bone flaps versus nonvascularized bone grafts for mandibular reconstruction: an outcome analysis of primary bony union and endosseous implant success. *Head & neck*, *21*(1), 66–71. https://doi.org/10.1002/(sici)1097-0347(199901)21:1<66::aid-hed9>3.0.co;2-z.

20- Wu, Y. Q., Huang, W., Zhang, Z. Y., Zhang, Z. Y., Zhang, C. P., & Sun, J. (2008). Clinical outcome of dental implants placed in fibula-free flaps for orofacial reconstruction. *Chinese medical journal*, *121*(19), 1861–1865.

21- Teoh, K. H., Huryn, J. M., Patel, S., Halpern, J., Tunick, S., Wong, H. B., & Zlotolow, I. M. (2005). Implant prosthodontic rehabilitation of fibula free-flap reconstructed mandibles: a Memorial Sloan-Kettering Cancer Center review of prognostic factors and implant outcomes. *The International journal of oral & maxillofacial implants*, *20*(5), 738–746.

22- Albrektsson, T., Zarb, G., Worthington, P., & Eriksson, A. R. (1986). The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *The International journal of oral & maxillofacial implants*, *1*(1), 11–25.

23- Iizuka, T., Häfliger, J., Seto, I., Rahal, A., Mericske-Stern, R., & Smolka, K. (2005). Oral rehabilitation after mandibular reconstruction using an osteocutaneous fibula free flap with endosseous implants. Factors affecting the functional outcome in patients with oral cancer. *Clinical oral implants research*, *16*(1), 69–79. https://doi.org/10.1111/j.1600-0501.2004.01076.x

24- Zins, J. E., & Whitaker, L. A. (1983). Membranous versus endochondral bone: implications for craniofacial reconstruction. *Plastic and reconstructive surgery*, *72*(6), 778–785. https://doi.org/10.1097/00006534-198312000-00005.

25- Kusiak, J. F., Zins, J. E., & Whitaker, L. A. (1985). The early revascularization of membranous bone. *Plastic and reconstructive surgery*, *76*(4), 510–516. https://doi.org/10.1097/00006534-198510000-00003.

26- Hardesty, R. A., & Marsh, J. L. (1990). Craniofacial onlay bone grafting: a prospective evaluation of graft morphology, orientation, and embryonic origin. *Plastic and reconstructive surgery*, *85*(1), 5–15.

27- Sullivan, W. G., & Szwajkun, P. R. (1991). Revascularization of cranial versus iliac crest bone grafts in the rat. *Plastic and reconstructive surgery*, *87*(6), 1105–1109. https://doi.org/10.1097/00006534-199106000-00013.

28- Christian Mertens, Christian Decker, Michael Engel, Anja Sander, Jürgen Hoffmann, Kolja

Freier. (2014). Early bone resorption of free microvascular reanastomized bone grafts for mandibular reconstruction – A comparison of iliac crest and fibula grafts, Journal of Cranio-Maxillofacial Surgery, 42(5). e217-e223, https://doi.org/10.1016/j.jcms.2013.08.010.