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Evaluation of implant survival in atrophic jaws reconstructed with calvarial bone graft

Evaluación de la supervivencia de implantes en maxilares atróficos reconstruidos con injerto óseo calvarial

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ABSTRACT: The aim of this study was to analyze the survival rates of installed implants in atrophic maxillae reconstructed with calvarial bone graft. Was realized a retrospective study that evaluated the survival rate of implants, through the collection of data from medical records, including variables such as age and sex, type of reconstruction performed, number and platform of the installed implants, type of implant loss, the region of loss, as well as the time of clinical follow-up, through descriptive and exploratory data analysis. The sequence of removal, handling and stabilization of the calvarial bone graft, in addition to the installation of implants and prosthetic preparation followed routine standards and parameters established in the literature. The reconstruction of atrophic maxillae with autogenous calvarial bone graft provided high survival rates for dental implants, proving to be predictable. Of the 15 patients analyzed, 13 (86.7%) had survival of all implants, with only two cases of early loss of dental implants, showing that for a total of 95 dental implants installed in the reconstructed jaws, the survival rate was 97.9%. The calvarial bone as a donor area for reconstructions, prior to the installation of implants, therefore, represents a great alternative, allowing the correction of bone deficiencies and providing stability and maintenance of bone volume, with satisfactory results regarding implant survival and low failure rates.

KEY WORDS: Calvarial bone, atrophic jaws, implant.

INTRODUCCIÓN

The clinical consequence of tooth loss is continuous bone resorption (Quiles *et al*., 2015) Edentulous patients who have sufficient residual alveolar bone can be predictably rehabilitated with dental implants (Mertens *et al*., 2011), presenting stable and reliable long-term results for implant survival, however requiring techniques for maxillary bone reconstruction (Pereira *et al*., 2011).

In cases of severe atrophy of the jaws, poor quality and quantity of bone tissue may compromise osseointegration of the implant, especially in the posterior region, requiring more elaborate rehabilitation strategies (Gurler *et al*., 2017). Autogenous bone is considered the "gold standard" for reconstructive procedures (Klüppel *et al*., 2013), due to its better potential for revascularization (Hardesty *et al*., 1990).

For extensive bone reconstructions, the most common autogenous bone donor areas are the iliac crest (Chiapasco *et al*., 2004), tibia (Kirmeier *et al*., 2007), fibula (Chiapasco *et al*., 2004), and calvaria (Le Lorc'h-Bukiet *et al*., 2005), with a low rate of remodeling during the incorporation process (Orsini *et al*., 2003). The surgeon's choice of the donor area should consider the nature of the reconstruction requirements and volume (Movahed *et al*., 2013).

Calvarial bone grafts represent an alternative donor area, with a low incidence of complications, minimal postoperative morbidity at the donor site (Mertens *et al*., 2013) and relatively painless recovery (Movahed *et al*., 2013). They have high retention rates, attributed to factors such as embryology, early revascularization, and inherent architecture. They represent a reliable donor area for alveolar crest reconstruction (Smolka *et al*., 2014) and are associated with lower rates of resorption (Mertens *et al*., 2013).

Therefore, the present study aimed to analyze survival rates of implants installed in atrophic maxillae reconstructed with calvarial bone graft (associated or not with Le Fort I Osteotomy).

MATERIAL AND METHOD

A retrospective observational study was carried out by collecting data from medical records in accordance with the STROBE Declaration in totally edentulous atrophic maxillae of 15 patients who underwent maxillary alveolar reconstruction with the calvarial bone, in a follow-up period of 3 to 54 months after prosthetic loading of implants, between February 2014 and September 2018 by the same experienced oral and maxillofacial surgeon qualified to perform maxillary reconstruction and implant installation, and who received fixed prosthetic rehabilitation on upper implants until November 2019.

As criteria for inclusion of patients in the sample of this study, the following were obtained: complete and legible medical records, not giving up treatment at any stage, not having medical conditions that contraindicate surgical procedures, not having undergone head and neck radiotherapy, having total superior edentulism, having preoperative cone beam computed tomography, having bone atrophy of the maxillary alveolar ridge in the anterior and posterior regions classified as Class IV, V or VI by Cawood & Howell (1988). Patients excluded from the study were: patients with contraindications for the installation of dental implants, children, patients who did not agree to participate in the study and/or who did not sign the informed consent form.

Treatment protocols. Reconstruction with skullcap bone graft. Reconstruction with calvarial bone graft blocks (onlay), for thickness gain, associated or not with Le Fort I osteotomy, in addition to particulate graft (inlay) in maxillary sinuses for height gain, was performed to restore maxillary bone defects, in accordance with the classification of alveolar ridge atrophy. The chosen area for removal of the calvarial bone graft was the parietal bone on the right side with removal of partial-thickness blocks (external cortical bone only). All patients were treated following a similar protocol. Maxillary reconstruction surgeries were performed in a hospital environment, under general anesthesia and nasotracheal intubation, followed by standardized preparation of the selected donor area.

Installation of dental implants. Seven to twelve months after the reconstructive surgery, a new cone-beam computed tomography scan was requested to assess the post-reconstruction maxillary bone volume, its remodeling rate and the incorporation of the graft blocks in the recipient bed. We proceeded to the installation of dental implants. All grafts were checked for stability and incorporation into the recipient bed. The success of the grafts was evaluated using the criteria proposed by Barone & Covani 2007, evaluating: absence of block exposure, absence of postoperative infection, presence of the graft incorporation into the bed, absence of bone radiolucency, presence of bone graft bleeding after removal of stabilization screws and possibility of implant placement. The implants were inserted according to a cortical bone drilling protocol. Six to eight implants were installed in the reconstructed maxillae, from external or internal hexagon platforms, so that the implant platform was leveled with the alveolar crest. The installation torque varied between 25-50N, that is, all implants were inserted with satisfactory primary stability, the sutures remained in place for a minimum period of seven days and the patients did not use their prostheses during this period.

Prosthetic rehabilitation with fixed upper prostheses. Oral rehabilitation was based on fixed upper implant-supported prosthesis, in conventional or late prosthetic loading, with a minimum time of 3 months between the surgery to install the implants and the reopening, with a bar joining all the implants with the prosthetic system. Clinical follow-up consultations took place weekly in the first month and every three months during the first year, with half-yearly and annual radiographs in subsequent years. We considered surviving implants those that were functionally stable.

The data were analyzed in a descriptive and exploratory way, associating the survival or loss of the

implants with the other variables. All analyses were performed using the R program.

RESULTS

In the analyzed period of 4 years, 95 implants were installed in fifteen total edentulous patients with moderate to severe maxillary atrophy, 10 (66.7 %) females and 5 (33.3 %) males, with a mean age of 58.5 years, ranging from 40 to 73 years. As for anterior maxillary atrophy, 5 patients (33.3 % of the sample) had Class IV atrophy, 4 (26.7 %) Class V and 6 (40.0 %) Class VI. As for posterior maxillary atrophy, 1 patient (6.7%) had Class IV atrophy, 6 (40.0 %) Class V and 8 (53.3 %) Class VI (Table I).

Regarding the type of reconstruction, we observed that in 40.0 % of the patients, maxillary reconstruction was performed with bone from the cranial vault associated with Le Fort I osteotomy, in 53.3 %, maxillary reconstruction was used with calvarial bone associated with lifting of bilateral maxillary sinus and one patient (6.7 %) underwent reconstruction with unilateral lifting. Based on the criteria proposed by Barone and Covani for assessing bone graft success, all grafts presented successful incorporation and fulfilled the proposed criteria (Table II).

There was early loss of two implants in different patients, one in the right posterior region and the other in the left posterior region. All remaining implants were prosthetically loaded. The number of installed implants per patient ranged from 6 to 8 and the number of early losses per patient from 0 to 1 implant, with no late loss. Regarding the results of the crossovers of survival/loss of implants per patients, of the 15 patients analyzed, 13 (86.7 %) had survival of all implants. A case of early loss of an implant occurred in a 69-year-old male patient, with class IV anterior maxillary and class V posterior maxillary atrophy, who underwent reconstruction with calvarial bone graft and bilateral maxillary sinus lift. The other case of implant loss, also early, occurred in a female patient, 59 years old, with severe anterior and posterior maxillary atrophy (Class VI), who underwent reconstruction with calvarial bone graft and Le Fort I osteotomy.

Table I. Characteristics of patients who had implants installed between the years 2014 to 2018, in atrophic maxillae reconstructed through grafting with calvarial bone (n=15).

Variable	Category	Frequency	Percentage
Sex	Female	10	66.7 %
	Male	5	33.3 %
Anterior maxillary atrophy	Class IV	5	33.3 %
	Class V	4	26.7 %
	Class VI	6	40.0 %
Posterior maxillary atrophy	Class IV	1	6.7 %
	Class V	6	40.0 %
	Class VI	8	53.3 %
		Mean	Median (minimum and
Age (years)		58.5 (9.5)	59.0 (40.0-73.0)

Table II. Characteristics related to implant surgeries between the years 2014 to 2018, in atrophic maxillae reconstructed through grafting with skull bone (n=15).

Variable	Category	Frequency	Percentage
Type of reconstruction	Calvarial bone + Le Fort	6	40.0 %
	Calvarial bone + Bilateral lifting	8	53.3 %
	Calvarial bone + Unilateral lifting	1	6.7 %
		Mean (standard deviation)	Median (minimum and maximum value)
Time interval between reconstruction and implant (months)		8.1 (1.6)	7.0 (7.0-12.0)
Time interval between the implant and the healing cap (months)		6.4 (4.4)	5.0 (0.0-17.0)
Time interval between the healing cap and the prosthetic load (months)		2.7 (2.3)	2.0 (0.0-8.0)
Prosthetic load follow-up (months)		22.9 (18.2)	16.0 (3.0-54.0)

Regarding the results on the total number of installed implants in the period, there were 95 dental implants, and for the total number of installed implants in the reconstructed jaws, the survival rate was 97.9 % (Table III, IV, V).

Table III. Characteristics related to implants installed between the years 2014 to 2018, in atrophic maxillae reconstructed through grafting with bone from the cranial vault (n=15).

Variable	Category	Frequency	Percentage
Implant platform	EH	8	53.3 %
	IH	7	46.7 %
Implant platform	EH	52	54.7 %
	IH	43	45.3 %
Region of early loss	No loss	13	86.7 %
	Posterior R	1	6.7 %
	Posterior L	1	6.7 %
		Mean (standard deviation)	Median (minimum and maximum value)
Number of installed implants per patient		6.3 (0.7)	6.0 (6.0-8.0)
Early loss (n)		0.1 (0.4)	0.0 (0.0-1.0)
Early loss (%)		2.1% (5.5 %)	0.0 % (0.0 %-16.7 %)

Table IV. Survival and loss of dental implants installed between 2014 and 2018 in patients with totally edentulous atrophic maxillae who underwent alveolar reconstruction with calvarial bone (n=15).

Variable	Category	Number of patients	Patients with implant loss	Patients with implant loss	Patients with survival all implants	Patients with survival all implants
Total		15	2	13.0 %	13	86.7 %
Sex	Female	10	1	10.0 %	9	90.0 %
	Male	5	1	20.0 %	4	80.0 %
Anterior maxillary atrophy	Class IV	5	1	20.0 %	4	80.0 %
	Class V	4	0	0.0 %	4	100.0 %
	Class VI	6	1	16.7 %	5	83.3 %
Posterior maxillary atrophy	Class IV	1	0	0.0	1	100.0
	Class V	6	1	16.7 %	5	83.3 %
	Class VI	8	1	12.5 %	7	87.5 %
Age	≤ 59[&]	8	1	12.5 %	7	87.5 %
	> 59	7	1	14.3 %	6	85.7 %
Type of reconstruction	Calvarial bone + Le Fort	6	1	16.7 %	5	83.3 %
	Calvarial bone + Bilateral lifting	8	1	12.5 %	7	87.5 %
	Calvarial bone + Right unilateral lifting	1	0	0.0 %	1	100.0 %
Time interval between reconstruction and implant	≤ 7,0[&]	8	1	12.5 %	7	87.5 %
	> 7,0	7	1	14.3 %	6	85.7 %
Time interval between the implant and the healing cap	≤ 5,0[&]	9	1	11.1 %	8	88.9 %
	> 5,0	6	1	16.7 %	5	83.3 %
Time interval between the healing cap and the prosthetic load	≤ 2,0[&]	10	0	0.0 %	10	100.0 %
	> 2,0	5	2	40.0 %	3	60.0 %
Prosthetic load follow-up	≤ 16,0[&]	8	1	12.5 %	7	87.5 %
	> 16,0	7	1	14.3 %	6	85.7 %
Implant platform	EH	8	1	12.5 %	7	87.5 %
	IH	7	1	14.3 %	6	85.7 %
Number of implants installed	6	12	1	8.3 %	11	91.7 %
	7	1	1	100.0 %	0	0.0 %
	8	2	0	0.0 %	2	100.0 %

[&]Median of the sample

Table V. Survival and loss of dental implants installed between 2014 and 2018 in totally edentulous atrophic maxillae of 15 patients who underwent alveolar reconstruction with calvarial bone (n=95).

Variable	Category	Installed implants	Lost implants	Percentage of implant loss	Surviving implants	Percentage of implant survival
Total		95	2	2.1 %	93	97.9 %
Sex	Female	64	1	1.6 %	63	98.4 %
	Male	31	1	3.2 %	30	96.8 %
Anterior maxillary atrophy	Class IV	33	1	3.0 %	32	97.0 %
	Class V	24	0	0.0 %	24	100.0 %
	Class VI	38	1	2.6 %	37	97.4 %
Posterior maxillary atrophy	Class IV	8	0	0.0 %	8	100.0 %
	Class V	37	1	2.7 %	36	97.3 %
	Class VI	50	1	2.0 %	49	98.0 %
Age	≤ 59[&]	52	1	1.9 %	51	98.1 %
	> 59	43	1	2.3 %	42	97.7 %
Type of reconstruction	Calvarial bone + Le Fort	38	1	2.6 %	37	97.4 %
	Calvarial bone + Bilateral lifting	51	1	2.0 %	50	98.0 %
	Calvarial bone + R lifting	6	0	0.0 %	6	100.0 %
Time interval between reconstruction and implant	≤ 7,0[&]	52	1	1.9 %	51	98.1 %
	> 7,0	43	1	2.3 %	42	97.7 %
Time interval between the implant and the healing	≤ 5,0[&]	58	1	1.7 %	57	98.3 %
	> 5,0	37	1	2.7 %	36	97.3 %
Time interval between the healing cap and the prosthetic load	≤ 2,0[&]	64	0	0.0 %	64	100.0 %
	> 2,0	31	2	6.4 %	29	93.6 %
Prosthetic load follow-up	≤ 16,0[&]	48	1	2.1 %	47	97.9 %
	> 16,0	47	1	2.1%	46	97.9 %
Implant platform	EH	52	1	1.9 %	51	98.1 %
	IH	43	1	2.3 %	42	97.7 %

[&]Median of the sample

DISCUSSION

In the present sample, the majority of participants were female, consistent with findings from other studies on maxillary reconstructions using calvarial bone grafts (Moraes *et al*., 2015; Quiles *et al*., 2015; Restoy-Lozano *et al*., 2015; Gulinelli *et al*., 2017; Mertens *et al*., 2017; Carvalho *et al*., 2020). Only one study reported a higher prevalence of male participants (7 men and 4 women), although the literature does not provide a clear explanation for the predominance of women in these cases. In our study, no association was found between sex and implant failure rates.

As for the mean age of patients in their samples, Mertens *et al*. (2011) described a mean age of 54 years (30-71), Moraes *et al*. (2015) had a mean age of 59.8 years (40-71), Quiles *et al*. (2015) reported a mean age of 57 years (43-75), and Gulinelli *et al*. (2017) described a mean age of 45.9 years. Finally, Carvalho *et al*. (2020) had a sample with a mean age of 57 years (45-69). Our sample had a mean age close to that of these previously published studies, 58.5 years (40-73). These similarities are probably due to the age group of completely edentulous patients who most seek rehabilitation treatments on implants, with no relationship between implant loss and patient age.

Regarding the rate of initial bone remodeling of the grafts, the literature shows it as variable and difficult to predict. Thus, simultaneous bone grafting and implantation were not usually indicated; (Blomqvist *et al*., 1998) (Tong *et al*., 1998 although survival rates for late implants may be lower than for immediate implants (Tolamn, 1995). In a two-step procedure, the ideal implant site can be established more reliably after graft remodeling (Blomqvist *et al*., 1998). Corroborating with authors who defend the installation of implants in a second moment, we performed the placement

of implants after 7 to 12 months of maxillary reconstruction (mean of 8.1 months).

Regarding the period of implant failure, Donovan *et al*. (1994) described 7 failures before prosthetic loading and 6 failures in the first 4 months after loading. Mertens *et al*. (2011) reported 2 failures out of a total of 99 implants, both lost before prosthetic loading. Mertens *et al*. (2013) presented 1 pre-load failure and 6 post-load failures. Quiles *et al*. (2015) obtained 15 early failures, with 9 new implant placement surgeries in these sites and 6 were not reinstalled, as the absence would not interfere with the final prosthetic result. Moraes *et al*. (2015) obtained 13 pre-load failures (8 %) and 6 post-load failures (3.7 %), two in the first year and four in the next two years after loading. Carvalho *et al*. (2020) described a single loss after 12 months of implant installation. In our sample, we had two failures (2.1 % of the sample of 95 implants), both prior to prosthetic loading. In these two cases, the reason for the loss was the lack of osseointegration of the implants, diagnosed through complaints of local discomfort and mobility of the implants during the reopening phase. There was no relationship between the loss and the type of reconstruction performed, nor infection at the sites of implant loss or suture dehiscence, and there were no implant failures during the post-load follow-up period.

Regarding clinical implant survival, Mertens *et al*. (2011) reported survival and success rates of 97.85 % and 95.7 %, respectively. In a subsequent study, Mertens *et al*. (2013) found a survival rate of 98.64 %. Quiles *et al*. (2015) reported survival rates of 92.75 % for implants placed in the anterior maxilla and 91.34 % in the posterior region. Moraes *et al*. (2015) observed a survival rate of 95.97 % after prosthetic loading. Mertens *et al*. (2017) documented an overall survival rate of 98.51 % and a success rate of 86.7%. Gulinelli *et al*. (2017) found a survival rate of 94.1 %. Carvalho *et al*. (2020) reported a success rate of 97.73 %, which they attributed to high initial implant stability. In our study, implant survival was 97.9 %, consistent with the outcomes reported in the studies.

The limitations of the study are based on the retrospective design of the work and the limited sample size that may influence the quality of the data, considering the small sample of patients and the wide confidence interval that limited the external validity of the results. In addition, it was not possible to evaluate the correlation between implant survival and the variables, nor to perform survival analysis, considering the significance level of 5 %.

CONCLUSION

The calvarial bone represents an excellent donor area of autogenous bone for use in reconstructions of atrophic maxillae and allows the installation of implants with adequate survival, proving to be predictable and stable, with high survival rates of these implants, in a mean follow-up of 22.9 months.

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RESUMEN: El objetivo de este estudio fue analizar las tasas de supervivencia de los implantes instalados en maxilares atróficos reconstruidos con injerto óseo calvarial. Se realizó un estudio retrospectivo que evaluó la tasa de supervivencia de los implantes mediante la recopilación de datos de historias clínicas, incluyendo variables como edad y sexo, tipo de reconstrucción realizada, número y plataforma de los implantes instalados, tipo de pérdida del implante, región de la pérdida, así como el tiempo de seguimiento clínico, mediante análisis de datos descriptivos y exploratorios. La secuencia de extracción, manipulación y estabilización del injerto óseo calvarial, además de la instalación de los implantes y la preparación protésica, siguió los estándares rutinarios y parámetros establecidos en la literatura. La reconstrucción de maxilares atróficos con injerto óseo calvarial autógeno proporcionó altas tasas de supervivencia para los implantes dentales, demostrando ser un procedimiento predecible. De los 15 pacientes analizados, 13 (86,7%) presentaron supervivencia de todos los implantes, con solo dos casos de pérdida temprana de implantes dentales, lo que indica que, de un total de 95 implantes dentales instalados en los maxilares reconstruidos, la tasa de supervivencia fue del 97,9%. El hueso calvarial, como zona donante para reconstrucciones previas a la instalación de implantes, representa por tanto una excelente alternativa, permitiendo la corrección de deficiencias óseas y proporcionando estabilidad y mantenimiento del volumen óseo, con resultados satisfactorios en cuanto a supervivencia del implante y bajas tasas de fracaso.

PALABRAS CLAVE: Hueso calvarial, maxilares atróficos, implante

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