Radiographic evaluation of autogenous bone sinus grafts after functional load

Anderson Tadashi Samejima[1], Eduardo Sanches Gonçales[2], Osny Ferreira Jr[2], Paulo Sérgio Perri de Carvalho[3]

1) MSc in Implantology, Dental Research Center São Leopoldo Mandic, Campinas, São Paulo, Brazil. 2) Associate professor, Universidade de São Paulo (USP), Department of Stomatology, Oral and Maxillofacial Surgery and Traumatology Subject, School of Dentistry, Bauru, São Paulo, Brazil. 3) Full professor, Universidade de São Paulo (USP), Department of Stomatology, Oral and Maxillofacial Surgery and Traumatology Subject, School of Dentistry, Bauru, São Paulo, Brazil.

Objective: *The aim of this study was to radiologically evaluate bone remodeling of sinus graft performed with autogenous bone harvested from the iliac crest or from the cranial vault.* ***Methods:*** *Radiographs of 24 individuals subjected to maxillary sinus lift were assessed at the following stages: preoperative (T_1), immediate postoperative (T_2) and late postoperative (T_3). Measurements were performed on panoramic radiographs to determine the remaining alveolar bone (T_1), from the alveolar ridge bone crest to the maxillary sinus floor, bone height (ridge + graft) after bone graft and implant surgery (T_2) and bone height (ridge + graft) one to five years with implants in function (T_3).* ***Results:*** *At T_2, the average increase of sinus on the right side was 12.60 mm (iliac crest bone graft) and 12.44 m (cranial vault bone graft), while on the left side, it was 11.83 mm (iliac crest bone graft) and 11.89 mm (cranial vault bone graft). At T_3, the average measurement of right maxillary sinus was 10.00 mm for the iliac crest bone graft, while for cranial vault bone graft, it was 8.56 mm. In the left maxillary sinus, the average was 8.83 mm for the iliac crest bone graft and 7.83 mm for cranial vault bone graft. It was concluded that there was no statistical difference between the values of bone height of sinus grafts with bone harvested from the iliac crest or from the cranial vault ($p < 0.05$) at the time of implant placement and after functional load.* ***Conclusion:*** *Therefore, it was concluded that there is no difference, from the point of view of maintenance of the amount of sinus lifting, between autogenous bone graft harvested from the iliac crest and from the cranial vault.* ***Keywords****: Maxillary sinus. Bone transplantation. Ilium. Skull.*

How to cite this article: Samejima AT, Gonçales ES, Ferreira Jr. O, Carvalho PSP. Radiographic evaluation of autogenous bone sinus grafts after functional load. J Clin Dent Res. 2016 jan-mar;13(1):39-48.

DOI: http://dx.doi.org/10.14436/2447-911x.13.1.039-048.oar

Submitted: 10/08/2015- **Revised and accepted:** 11/11/2015.

Contact address: Anderson Tadashi Samejima
FOB-USP - Al. Otávio Pinheiro Brizola 975. Bauru/SP - Brazil - E-mail: eduardogoncales@usp.br

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

Introduction

The maxillary sinus is a pyramid structure, approximately 15 ml in volume, occupying the posterior and medium region of the maxilla.[1] Atrophy of the alveolar ridges, associated with pneumatization, hinder the installation of dental implants in the posterior region of the maxilla[2] because the vertical and horizontal dimensions of the rim become insufficient to stabilize them.[3] This has led to the development of the maxillary sinus floor augmentation technique.[4,5]

The indication of the mediate or immediate technique of implant installation in cases in which maxillary sinus floor augmentation is necessary depends on the remaining bone[6] and the dimensions of the maxillary sinus.[7] In cases in which the remaining bone between the maxillary sinus floor and the alveolar ridge crest is equal to or less than 5 mm, the mediate technique is indicated (performing a bone graft followed by implant installation at a later stage) and the use of autogenous bone associated with or without inorganic bone substitutes.[6]

Among the donor sites of bone graft indicated for bilateral filling of pneumatized maxillary sinuses, the iliac crest and the cranial vault stand out, which have shown greater volume of vital bone after the period of incorporation of the graft.[8] Similarly to the bone remodeling tissue after receiving load from the prostheses on implants,[9] there is doubt regarding bone remodeling around implants placed in grafted maxillary sinus. The aim of the present study was to compare the process of bone remodeling of sinus grafts performed with bone obtained from the cranial vault and the iliac crest.

Material and Methods

The present study evaluated, radiographically and retrospectively, bone remodeling grafts used in maxillary sinus floor augmentation procedures when autogenous bone grafts were harvested from the cranial vault and iliac crest. The present research was approved by the Research Ethics Committee (CEP) of São Leopoldo Mandic School of Dentistry and Dental Research Center (Protocol #2011/0026).

The records of 89 individuals who underwent reconstructive surgery (maxillary sinus floor augmentation) with autogenous bone were evaluated. Of these, 22 were patients undergoing reconstructive surgery with autogenous bone harvested from the iliac crest, and 67 were patients undergoing reconstructive surgery with autogenous bone harvested from the cranial vault. However, only the records of 24 individuals were selected and used, since they met the following inclusion criteria: a) radiographs of individuals who have undergone autologous bone

> "Atrophy of the alveolar ridge resulting from tooth loss is not the only factor contributing negatively to the rehabilitation of the posterior region of the maxilla by means of dental implants."

reconstruction surgery and maxillary sinus floor augmentation with bone harvested from the iliac crest or cranial vault; b) radiographs of individuals who have been rehabilitated by a prosthetic implant for at least one year; c) panoramic radiographs (1) preoperative, (2) immediate postoperative and (3) late postoperative (one year or more); d) radiographs of individuals who have signed the consent form, authorizing their inclusion in the study.

For the development of the methodology, printed radiographic images were used in films, obtained by the Gendex Orthoralix 9000 conventional radiograph apparatus (with printed image on 15:30 film) and the Vatech PAX 400 radiographic digital device (with printed image on 20:25 film at a ratio of 1:1). The panoramic radiographs were evaluated with the aid of an illuminator (Cappe - Material Médico Hospitalar, Divinópolis-MG, Brazil) in a dark room. The sample of radiographic observations included 72 images with three radiographs of each one of the 24 patients, one preoperatively (T_1), another in the immediate postoperative period (T_2) and another in the late postoperative period (T_3), defined as follows:

1. T_1 (initial): measurement of remaining bone crest of the alveolar ridge to the maxillary sinus floor without graft.

2. T_2 (immediately after): measurement of bone graft height after implant surgery from the remaining bone crest of the alveolar ridge to the uppermost portion of the autogenous bone graft of the cranial vault or iliac crest in the maxillary sinus area.

3. T_3 (after one and five years of function): measurement of bone graft height from the remaining bone of the alveolar ridge crest to the uppermost portion of the autogenous bone graft from the cranial vault or iliac crest in the maxillary sinus area.

Measurements were obtained in millimeters with the aid of a triangular scale ruler. It is noteworthy that the measurements obtained in conventional panoramic radiographs are subtracted from the value of 30% due to image magnification inherent to the radiographic technique. Evaluations were performed by a single evaluator. For calibration, measurements of the same radiographs were obtained at two different times, with an interval of 30 days in between them, in order to assess the evaluator. The images of panoramic radiographs in the three periods studied measured the distance (mm) between the alveolar crest and the maxillary sinus floor or the distance between the alveolar crest and the highest point of sinus grafting, respecting the expansion and calculating the actual size of the images for the times studied (Fig 1). The data obtained from radiographic measurements were tabulated and analyzed by means of Student's t-test, with $p < 0.05$.

Results

According to the inclusion criteria described before, the radiographs of 24 subjects (both males and females), with a mean age of 43.54 years, who underwent maxillary sinus floor augmentation with autogenous bone graft harvested from the cranial vault (18 individuals) and maxillary sinus floor augmentation from the iliac crest (six individuals) were selected. Five individuals (two received iliac grafts while three received cranial vault

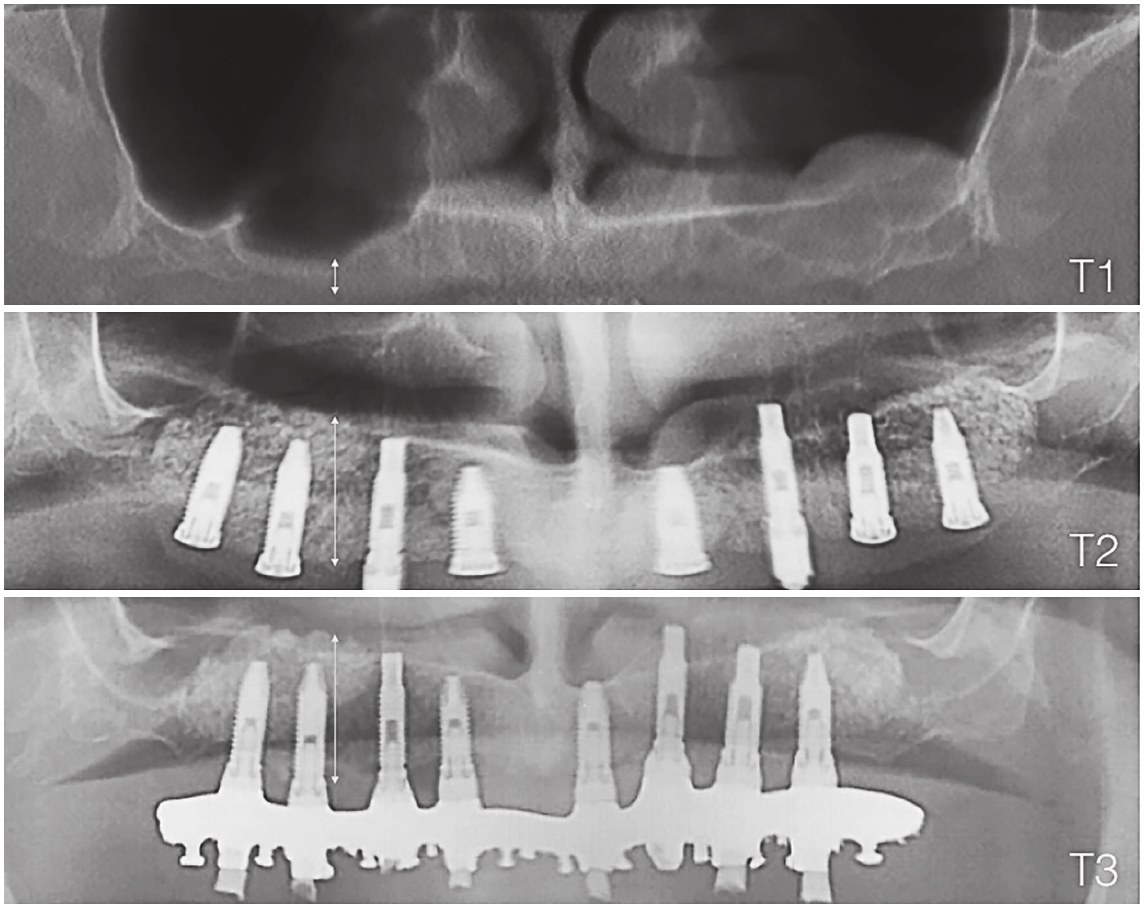

Figure 1: Arrows indicate where the distances were measured on panoramic radiographs for the three times studied.

grafts) were males, whereas 19 were females (four received iliac grafts while 15 received cranial vault grafts) (Table 1).

In three individuals, sinus floor augmentation was performed only on the left side. For the other individuals, grafts were performed both on the left and right sides, resulting in 45 units (sides) for the study. Cranial vault grafts were performed on 16 individuals on the right and left sides, and the left side in two individuals. The iliac crest grafts were performed on six individuals, wherein in one individual, it was performed only on the left side. Therefore, there were 45 grafts of two types (Table 1).

The mean measurements of the remaining bone crest of the alveolar ridge with extraoral

grafts in the area of maxillary sinus (in millimeters), according to the type of graft, side and times when they were measured, are shown in Table 2. The same table also shows the bone resorption of both types of bone grafts from the iliac crest and cranial vault, respectively, on both sides, in addition to the percentage of bone resorption. Measurements were higher when the iliac crest was used. Reduction (resorption) was higher when the

Table 1: Distribution of individuals according to sex, age, graft site, type of graft and measured distances (mm).

Chart	Sex	Age	Graft location	Graft type	T_1 right	T_1 left	T_2 right	T_2 left	T_3 right	T_3 left
1	M	50	SB	CI	2	6	14	15	11	11
2	M	59	SB	CI	2	2	15	15	13	13
3	F	47	E	CI	-	6	-	12	-	12
4	F	66	SB	CI	4	2	18	24	16	13
5	F	50	SB	CI	6	5	15	14	14	13
6	F	61	SB	CI	1	3	16	15	11	15
7	F	56	SB	CC	1	1	17	13	13	6
8	F	46	SB	CC	1	1	15	15	10	9
9	F	48	SB	CC	4	3	16	15	16	15
10	M	49	SB	CC	3	1	12	6	7	6
11	M	37	SB	CC	1	4	14	15	8	9
12	F	66	SB	CC	1	1	14	14	12	11
13	F	56	E	CC	-	1	-	20	-	18
14	F	57	SB	CC	5	5	21	17	13	13
15	F	63	SB	CC	1	1	13	16	8	10
16	F	41	SB	CC	1	1	11	10	11	10
17	M	54	SB	CC	1	5	12	11	9	8
18	F	70	SB	CC	1	2	11	11	9	8
19	F	53	SB	CC	7	1	18	15	15	9
20	F	65	SB	CC	2	1	16	16	10	10
21	F	42	E	CC	-	1	-	10	-	8
22	F	56	SB	CC	2	2	16	16	13	11
23	F	48	SB	CC	3	6	16	16	11	7
24	F	45	SB	CC	5	1	16	16	11	11

M = Male; F = Female; BS = Bilateral sinus; L = Left; R = Right; IC = Iliac crest; CC = Cranial vault; T_1 = Time 1 (initial - before bone graft); T_2 = Time 2 (after bone graft); T_3 = Time 3 (after functional stimulation); mm = Millimeters.

cranial vault was used on the left side, for both types of grafts.

In order to verify that the difference between measurements depends on the type of graft, the average, maximum and minimum values, as well as standard deviations were calculated for the left and right sides. Subsequently, Student's t-test was performed. Results are shown in Table 3 for differences between T_1 and T_2. Table 4 shows differences between T_1 and T_3 and Table 5 shows differences between T_2 and T_3. It is important to note that the average and minimum values of differences in measurements obtained between the two study times have negative values when expressing reduction in bone volume, possibly due to bone resorption. In other words, relative to the reduction (decrease) in measurements.

There was no statistical difference between the two types of grafts ($p < 0.05$). However, we must point out that in order to establish comparisons, we made the assumption that individuals' sex and age are not important factors of variation for the measurements performed.

Discussion

Atrophy of the alveolar ridge resulting from tooth loss is not the only factor contributing negatively to the rehabilitation of the posterior region of the maxilla by means of dental implants, since maxillary sinus pneumatization increases with the absence of teeth.[10] In the present study, radiographs of partially or fully

Table 2: Mean of remaining alveolar crest ridge bone measurements obtained, in millimeters, for the first, second and third time periods for each type of graft and side. Mean and relative differences are also presented.

Variable		Type			
		Iliac crest		Cranial vault	
		Right	Left	Right	Left
Time	T_1 (mm)	Left	4.00	2.44	2.11
	T_2 (mm)	15.60	15.83	14.88	14.00
	T_3 (mm)	13.00	12.83	11.00	9.94
Difference	$T_2 - T_1$ (mm)	12.60	11.83	12.44	11.89
	$T_3 - T_1$ (mm)	10.00	8.83	8.56	7.83
	$T_3 - T_2$ (mm)	-2.60	-3.00	-3.88	-4.06
Relative difference	Rel. $(T_2) - (T_1)$ (%)	420.00	295.75	510.26	563.16
	Rel. $(T_3) - (T_1)$ (%)	333.33	220.75	351.28	371.05
	Rel. $(T_3) - (T_2)$ (%)	-16.67	-18.95	-26.05	-28.97

mm = millimeters; % = percentage.

Table 3: Mean, maximum, minimum and standard deviation values of the difference between T_1 and T_2, according to the type of graft and side.

Statistics	Right		Left	
	Iliac crest	Cranial vault	Iliac crest	Cranial vault
Sample size	5	16	6	18
Average (mm)	12.60	12.44	11.83	11.89
Maximum (mm)	15	16	22	19
Minimum (mm)	9	9	6	5
Standard deviation	2.30	2.06	5.56	3.59
p-value	0.8825		0.9770	

Table 4: Mean, maximum, minimum and standard deviation values of the difference between T_1 and T_3, according to the type of graft and side.

Statistics	Right		Left	
	Iliac crest	Cranial vault	Iliac crest	Cranial vault
Sample size	5	16	6	18
Average (mm)	10.00	8.56	8.83	7.83
Maximum (mm)	12	12	12	17
Minimum (mm)	8	4	5	1
Standard deviation	1.58	2.19	2.93	3.59
p-value	0.1925		0.5415	

Table 5: Mean, maximum, minimum and standard deviation values of the difference between T_2 and T_3, according to the type of graft and side.

Statistics	Right		Left	
	Iliac crest	Cranial vault	Iliac crest	Cranial vault
Sample size	5	16	6	18
Average (mm)	-2.60	-3.88	-3.00	-4.06
Maximum (mm)	-5.00	-8.00	-11.00	-9.00
Minimum (mm)	-1.00	0.00	0.00	0.00
Standard deviation	1.52	2.19	4.20	2.60
p-value	0.2428		0.4688	

edentulous individuals were included, which presented remaining bone in the posterior region of the maxilla, ranging between 1 and 5 mm in height, with severe maxillary sinus or moderately pneumatized. According to Carvalho et al,[5] in these situations, the augmentation of the maxillary sinus floor with pure autogenous bone graft or associated with inorganic material is indicated.

Smiler et al[11] described the augmentation procedure of the maxillary sinus membrane, in which alveolar bone height is increased by placing bone graft in the lower third of the maxillary sinus. According to Prolo et al,[12] the autogenous bone is the second most commonly transplanted tissue in the human organism. Gordon et al[13] reported that autogenous bone graft is the standard of comparison to other methods for bone augmentation. They have also described that predictability achieved with autogenous bone graft is explained by the fact that even when providing the recipient site, cells with bone formation have the capacity and growth factors to be immunologically identical to the receptor site, as well as being able to restore original structural and mechanical stability. According to Carvalho et al,[5] the pelvic bone has been the favorite donor site for bone graft and reconstruction, depending on the amount of cortical and medullary bone.

Misch et al,[14] Triplett et al[15] and Rissolo et al[16] reported that autogenous bone block graft and of intraoral origin are indicated for cases of inadequate bone of the alveolar process in total or partially edentulous areas. It may be performed to increase the height and/or thickness of sinus graft (maxillary sinus floor augmentation). When the area to be grafted is increased, it becomes necessary to increase bone volume, thus indicating extraoral donor sites, such as the iliac crest bone and cranial vault.[5]

Prolo et al[12] and Goldberg et al[17] reported that incorporation of autogenous bone graft refers to the donor tissue integration process with new bone produced by the receptor site, and may be obtained by three biological mechanisms of bone formation: osteogenesis, osteoconduction and osteoinduction. Anitua[18] reported that growth factors stimulate, accelerate or neoform damaged or lost structures, thus speeding the repair process up.

According to Aghaloo and Moy,[19] the survival rates of implants installed in sinus augmentation sites varied according to the grafting material used, being 92% for implants placed in autogenous bone grafts, with or without biomaterial. When only the iliac crest was used as graft in maxillary sinus floor augmentations, the survival rates of fixations have been around 88%.

Crespi et al[7] compared, microscopically and histomorphometrically, the use of autogenous bone graft obtained from the iliac crest or cranial vault for sinus grafting procedures (maxillary sinus floor augmentation). Their results showed that bone graft from the cranial vault showed higher vital bone volume compared to the iliac crest. These findings seem justified by the calvaria bone structure which should be more cortical than the iliac crest and resorbs more slowly than cancellous bone from the iliac crest.

Since Crespi et al[7] demonstrated the advantage of autogenous bone grafts, of which degree of vital new bone formation depends on

the donor site and the speed of revascularization and remodeling, including osteoclastic resorption and bone formation. For this remodeling process of autogenous bone graft to be balanced, there is a need for functional stimuli, and osseointegrated implants and function (subject to load) seem to generate such stimuli.[20] The results obtained in the present study in the cranial vault or iliac crest groups showed no statistically significant difference between bone volume maintained after the implants were subjected to functional load, which contradicts previous results[20,21,22,23] showing that iliac graft resulted in lower total bone volume. It is believed that the results obtained in the present study should be the methodology used, particularly related to the function of implants. That is, functional stimulus transmits to the bone graft, resulting in lower rates of resorption, regardless of the grafted bone.

As regards the methods employed in the present study, the use of panoramic radiographs, which provide two-dimensional images, made it possible to observe the maintenance of height obtained by sinus bone graft. However, it was considered ideal that the evaluation be conducted by means of cone-beam computed tomography, which would allow us to evaluate images in three dimensions. Nevertheless, as our interest was to assess the vertical dimensions of the remaining bone graft, it was considered that the methods employed were appropriate. In addition, it is emphasized that the cases studied were taken from the archives of the researchers, and some had no postoperative CT images, depending on the time period when the procedures were performed, making it impossible to compare radiographs and CT scans.

On the other hand, the results obtained in the present study demonstrated that there was reduced intrasinus vertical bone dimension at the time of implant installation (T_2) and in the later reviews (T_3). This finding may be related to the air pressure present in the sinus nasal cavity.[10] The presence of implants may be considered a limiting factor for such pressure and the subsequent remodeling/resorption of the graft, especially when this is predominantly cortical or associated with inorganic material,[4,20] thereby suggesting no correlation with the origin of the donor site.

Thus, autogenous bone graft from the iliac crest and the cranial vault showed adequate quality conditions and bone quantity. Additionally, it presents the same degree of resorption in the periods analyzed. Since there was no statistically significant difference between bone height values of the sinus grafts performed at the time of implant placement and after functional stimulus, it was concluded that there is no difference from the point of view of maintaining the amount of performed sinus augmentation between the autogenous bone graft from the iliac crest and the cranial vault.

References:

1. Garg AK. Augmentation grafting of the maxillary sinus for placement of dental implants: anatomy, physiology, and procedures. Implant Dent. 1999;8(1):36-46.
2. Batista RWC, Passeri LA. Elevação do seio maxilar e enxerto para colocação de implante dentam. ROBRAC. 2000;9(27):54-7.
3. Moy PK, Lundgren S, Holmes RE. Maxillary sinus augmentation: histomorphometric analysis of graft materials for maxillary sinus floor augmentation. J Oral Maxillofac Surg. 1993 Aug;51(8):857-62.
4. Jensen OT. The sinus bone graft. Quintessence: Illinois; 1999.
5. Carvalho PSP, Pellizer E. Fundamentos em Implantodontia: uma visão contemporânea. São Paulo: Quintessence; 2015. p. 125-40.
6. Jang HY, Kim HC, Lee SC, Lee JY. Choice of graft material in relation to maxillary sinus width in internal sinus floor augmentation. J Oral Maxillofac Surg. 2010 Aug;68(8):1859-68.
7. Crespi R, Vinci R, Capparè P, Gherlone E, Romanos GE. Calvarial versus iliac crest for autologous bone graft material for a sinus lift procedure: a histomorphometric study. Int J Oral Maxillofac Implants. 2007 Jul-Aug;22(4):527-32.
8. Frost HM. Bone "mass" and the "mechanostat": a proposal. Anat Rec. 1987 Sept;219(1):1-9.
9. Arasawa M, Oda Y, Kobayashi T, Uoshima K, Nishiyama H, Hoshina H, et al. Evaluation of bone volume changes after sinus floor augmentation with autogenous bone grafts. Int J Oral Maxillofac Surg. 2012 Jul;41(7):853-7.
10. Khoury F, Hanser Th, Khoury Ch, Neugebauer J, Terpelle T, tunkel J, et al. Aumento ósseo em Implantodontia. São Paulo: Quintessence; 2011.
11. Smiler DG, Johnson PW, Lozada JL, Misch C, Rosenlicht JL, Tatum OH Jr, Wagner JR. Sinus lift grafts and endosseous implants. Treatment of the atrophic posterior maxilla. Dent Clin North Am. 1992 Jan;36(1):151-86; discussion 187-8.
12. Prolo DJ, Rodrigo JJ. Contemporary bone graft physiology and surgery. Clin Orthop Relat Res. 1985 Nov;(200):322-42.
13. Gordh M, Alberius P. Some basic factors essential to autogenic nonvascularized onlay bone grafting to the craniofacial skeleton. Scand J Plast Reconstr Hand Surg. 1999;33:129-46.
14. Misch CM, Misch CE, Resnik RR, Ismail YH. Reconstruction of maxillary alveolar defects with mandibular symphysis grafts for dental implants: a preliminary procedural report. Int J Oral Maxillofac Implants. 1992 Fall;7(3):360-6.
15. Triplett RG, Schow SR. Osseous regeneration with bone harvested from the anterior mandible. In: Nevins M, Mellonig JT. Implant therapy-clinical approaches and evidence of successes. Illinois: Quintessence; 1998. v. 2, p. 209-17.
16. Rissolo AR, Bennett J. Bone grafting and its essential role in implant dentistry. Dent Clin North Am. 1998 Jan;42(1):91-116.
17. Goldberg V, Stevenson S. Natural history of autografts and allografts. Clin Orthop Relat Res. 1987 Dec;(225):7-16.
18. Anitua E. Plasma rich in growth factors: preliminary results of use in the preparation of future sites for implants. Int J Oral Maxillofac Implants. 1999 Jul-Aug;14(4):529-35.
19. Aghaloo TL, Moy PK. Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement? Int J Oral Maxillofac Implants. 2007;22 Suppl:49-70.
20. Schlegel KA, Fichtner G, Schultze-Mosgau S, Wiltfang J. Histologic findings in sinus augmentation with autogenous bone chips versus a bovine bone substitute. Int J Oral Maxillofac Implants. 2003 Jan-Feb;18(1):53-8.
21. Klijn RJ, Meijer GJ, Bronkhorst EM, Jansen JA. Sinus floor augmentation surgery using autologous bone grafts from various donor sites: a meta-analysis of the total bone volume. Tissue Eng Part B Rev. 2010 Jun;16(3):295-303.
22. Sbordone C, Sbordone L, Toti P, Martuscelli R, Califano L, Guidetti F. Volume changes of grafted autogenous bone in sinus augmentation procedure. J Oral Maxillofac Surg. 2011 Jun;69(6):1633-41.
23. Sbordone C, Toti P, Guidetti F, Califano L, Pannone G, Sbordone L. Volumetric changes after sinus augmentation using blocks of autogenous iliac bone or freeze-dried allogeneic bone. A non-randomized study. J Craniomaxillofac Surg. 2014 Mar;42(2):113-8.