LONG-TERM OUTCOMES OF DIFFERENT RECONSTRUCTION OPTIONS USING AUTOGENOUS BONE GRAFT FOR MANDIBULAR RECONSTRUCTION: A RETROSPECTIVE COMPARATIVE STUDY

Surgery

Zakariaou Garba Habibou*

MD, PhD resident of Department of Head and Neck Surgery, Oral and Maxillofacial Oncology, West China Hospital of Stomatology, Sichuan University, Chengdu, China. *Corresponding Author

Wang Xiao Yi

PhD, Pr, State Key Laboratory of Oral Diseases & National Clinical Research Center for Oral Diseases, and Department of Head and Neck Surgery, Oral and Maxillofacial Oncology, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

Gao Pan

DDS, PhD, State Key Laboratory of Oral Diseases, National Clinical Research Center for Oral Diseases, and Department of Head and Neck Surgery, Oral and Maxillofacial Oncology, West China Hospital of Stomatology, Sichuan University, Chengdu, China.

ABSTRACT

Background: Several recent studies have attempted to document VBG and NVBG following mandibular reconstruction, mainly the advantages and disadvantages, but very few have specifically evaluated the differences in large parameters including both radiographic and functional aspects for long-term follow-up. However, the object of this study is to compare between two different methods of reconstruction in mandibular defects and to determine the outcomes of different reconstruction options using autogenous vascularized and nonvascularized bone grafts for mandibular reconstruction.

Patients and Methods: a total of 39 patients, 22 (56.4%) females and 17 (43.6%) males, with a mean age of 36.41 years at the time of presentation (age ranged for 48 years). Study was performed in two stages at the Department of Head and Neck Surgery - Oral and Maxillofacial oncology. In the First stage (N=39), bone-density, bone resorption, and bone graft failure were examined radiographically on panorex and CBCT. The second stage included functional evaluation (physical examination and questionnaire) based on pain, infection, speech and recurrence. Both groups were followed-up for at least 1 month, 6 months and 1 year.

Results: the results show significant difference in Pain after one month ($p=0.032$), radiodensity ($p=0.05$), bone graft resorption ($p=0.03$) for 1 year follow-up in favor of the VBG group compared to the NVBG group, there was no statistical difference in bone graft failure, infection, speech and recurrence between the two groups.

Conclusion: Vascularized bone graft is the method of choice, especially in extensive malignant defects. On the other hand, nonvascularized bone graft (81.2% success rate) is a suitable complementary flap for mandible reconstruction mainly in benign and healthy patients. For future studies, large sample size with long-term follow-up more than 1 year will be required to validate our study.

KEYWORDS

Vascularized fibular bone graft, none vascularized bone graft, Iliac crest bone graft, Rib bone graft.

Patients and Methods

Two patients groups were evaluated similarly by physical examination, CBCT radiographs, and questionnaire. The inclusion criteria were as follow: patients with systemic mandibular bone pathology, the oromandibular defect had to be a primary tumor, and the patients had to be followed-up for at least one year after surgery. Patients who had post-traumatic defects were excluded. There were a total of 39 patients, 22 (56.4%) patients were females and 17 (43.6%) were males, with a mean age of 36.41 years at the time of presentation (age ranged for 48 years). Study was performed in two stages at the Department of Head and Neck Surgery - Oral and Maxillofacial oncology. In the First stage (N=39), bone-density, bone resorption, and bone graft failure were examined radiographically on panorex and CBCT. The second stage included functional evaluation (physical examination and questionnaire) based on pain, infection, speech and recurrence. Both groups were followed-up for at least 1 month, 6 months and 1 year. The research was approved by the West China Hospital of Stomatology Institutional Review Board (WCSHIRB).

Density and bone graft failure were examined postoperatively on panorex radiographs. Bone density was evaluated and classified as Good (no change of bone density), Partial (slightly decreased) and lucent (significantly decreased). Bone resorption was assessed based on Coronal CBCT radiography which was used to measure the height and thickness of the neomandible bone at the same distance from the opposing maxillary tooth for 1, 6 and 12 months follow up. All images were visualized in bone algorithm using settings of: Zoom:210.37%; level: 2069 and window:5405 (Fig3). We quantified osseous changes using the bone resorption index (BRI) to calculate the percentage of atrophy at different intervals, no bone hypertrophy was indicated in our cases. However, bone resorption percentage was rated as follows: Differences in height decreased after 1, 6 and 12 months were rated as Unchange (= 0%), Moderate ($\leq 10\%$) and Severe ($> 10\%$). Bone graft failure was rated based on infection, fracture of plate or loosening of screw. Plate Failure was rated as either occurred or not.

Bone was measured with Assisted Surgical Report Design by (PTY Med Tech, shenzhen China) at standardized locations on the body, ramus, and symphysis before surgery. The templates for defect resection, Flap resection, and graft shaping were designed and fabricated, and used in surgery. With the help of templates, the defect can be removed with high accuracy, and an ideal graft can be implanted to restore function and appearance to the patient in addition to the decrease in surgical time and high degree of efficiency and quality (Fig2).

The pain was evaluated based on presence (present, moderate or severe). Speech assessment was based on Intelligibility, as either (intelligible or unintelligible), whether the patient could be readily understood, Intelligible if it required concentration on the part of the listener, who constantly had to ask the patient to repeat phrases, patients were qualified as Unintelligible if speech could not be understood even with concentration. Infection and recurrence were checked by physical examination.

Success was defined as: maintenance of bone continuity and complete consolidation with absence of graft failure and infection on radiographic and physical examinations.

Statistic analysis was performed using the statistical package for the social sciences (IBM SPSS statistics version 20). Data were compared using the Pearson chi-square test. $P < 0.05$ were considered statistically significant.

RESULTS

There were a total 39(100%) patients in both groups, among those 18 (46.2%) patients were reconstructed with vascularized bone graft (VBG) and 21 (53.8%) with nonvascularized bone graft (NVBG) (Table 1). VBG constitutes of fibula (46.2%) and NVBG with iliac crest 23 (29.8%) and rib 18 (23.4%) bone flap. Table1 shows the Distribution of Cases by Etiology of Defects. Mean length of mandibular resection was 9.8 cm (range, 6 to 20 cm) defect types were

as follow (Jewers' classification) 19 L, 9 H, 7 C, 3 LC and 1 HC (Fig1).

Table1: Distribution of Cases by Etiology of Defects

Etiology of Defect	Donor graft site		Total
	VBG	NVBG	
Ameloblastoma	8(20.5%)	13(33.3%)	21(53.8%)
SCC	5(12.8%)	4(10.3%)	9(23.1%)
Ossifying fibroma	1(2.6%)	1(2.6%)	2(5.1%)
osteomyelitis	1(2.6%)	0(0%)	1(2.6%)
Odontogenic myxoma	1(2.6%)	0(0%)	1(2.6%)
Mucoepidermoid carcinoma	0(0%)	1(2.6%)	1(2.6%)
Keratocyst Odontogenic tumor	1(2.6%)	1(0%)	2(2.6%)
Sarcoma	0(0%)	1(2.6%)	1(2.6%)
Spindle cell tumor	1(2.6%)	0(0%)	1(2.6%)
TOTAL	18(46.2%)	21(53.8%)	39(100%)

VBG: vascularized bone graft; **NVBG:** non vascularized bone graft

Radio-density, Bone resorption, and bone graft failure were assessed

Table2: Results of radiographic evaluation up to 1 Year after Mandible Reconstruction (N = 39)

Radiodensity	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Good	18(46.2)	19(48.7)	17(43.6)	14(35.9)	15(42.9)	11(39)
Partial	00	2(5.1)	1(2.6)	4(10.3)	3(7.7)	5(12.8)
Lucent	00	00	00	3(3.9)	00	5(12.8)
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.2)
<i>P value</i>	.179		.087		.05	
Resorption of bone grafts	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Unchange	18(46.2)	20(51.2)	18(46.2)	14(35.9)	16(41)	11(28.2)
Moderate	00	1(2.6)	00	5(12.8)	2(5.1)	5(12.8)
Severe	00	00	00	2(5.1)	00	5(12.8)
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
<i>P value</i>	.348		.026		.030	
Bone graft failure	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Yes	00	2(5.1)	1(2.6)	3(7.7)	1(2.6)	4(10.3)
No	18(46.2)	19(48.7)	17(43.6)	18(46.2)	17(43.6)	17(43.6)
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
<i>P value</i>	.179		.370		.209	

Functional follow-up was assessed based on pain, infection, speech, and recurrence (Table3). Pain was statistically significant, less pain was reported in the VBG group than the NVBG after one month follow-up ($p < 0.05$). An important rate of moderate pain in both groups VBG 5(12.8%) and 11(28.2) in NVBG, however, pain was reported after one year only in NVBG in 4 patients with moderate pain ($p = 0.5$). Infection was assessed as absent or present, after 1 month and after one year postoperatively, we observed the same rate in the both groups, 2 and 1 patient respectively had infection. For Speech after one year follow-up it was 1(2.6.3%) in VBG and 2(5.1%) in NVBG ($p = 0.643$). in total of 39 patients, after one year follow-up we observed two

by panorex and CBCT radiograph (Table2). Only 2 (5.1%) partial bone density was observed in the NVBG after one month follow-up, on 6 month follow-up its' was 1(2.6%) partial in VBG and 4(10.3%) in NVBG, out of 39 patients, only one moderate bone resorption is observed in the NVBG group after 1 and 6 month follow-up. The highest bone resorption detected after 1 year was noted in NVBG group with 25.45% of height decrease. On the other hand, there were only 2(5.1%) with moderate resorption in VBG ($p = 0.03$). On the 1st month of follow up, failure of 2 bone grafts were noted in the NVBG, at the 6 month follow-up, failure of 1(2.6%) graft was noticed in VBG and 3(7.7%) in NVBG, on one year follow up 2(5.1%) in VBG and 5(12.8%) in NVBG graft failure were noted ($p < 0.05$), table2.

As summarized in Table2 bone graft failure there was no statistically significant difference between the VBG and NVBG groups. On the other hand, bone density and bone resorption was statistically significantly better in the VBG group than the NVBG group for 1 year follow-up ($p < 0.05$).

recurrence in VBG and 4(10.6%) in NVBG ($p = 0.493$), table3.

As summarized in Tables3 for functional outcome there was no statistically significant difference between the VBG and NVBG groups for infection, speech and recurrence, on the other hand, pain after one month follow-up was statistically significantly better in VBG than NVBG group ($p = 0.03$).

Similarly, there was no statistically significant difference for hospital stay and length of surgery duration ($p > 0.05$) but statistically significant in length of bone harvest ($p = 0.02$).

Table3: Results of functional evaluation up to 1 Year after Mandible Reconstruction (N = 39)

Pain	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Absent	13(33.3)	7(17.9)	17(43.6)	13(33.3)	18(46.2)	17(43.6)
Moderate	5(12.8)	11(28.2)	1(2.6)	7(17.9)	00	4(10.3)
Severe	00	3(7.7)	00	1(2.6)	00	00
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
<i>P value</i>	.032		.054		.051	
Infection	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Absent	16(41)	19(48.7)	18(46.2)	19(48.7)	17(43.6)	20(51.3)
Present	2(5.1)	2(5.1)	00	2(5.1)	1(2.6)	1(2.6)
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
<i>P value</i>	.871		.179		.911	
Speech	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Normal	15(38.5)	13(33.3)	17(43.6)	18(46.2)	17(43.6)	19(48.7)
Intelligible	2(5.1.2)	7(17.9)	1(2.6)	2(5.1)	1(2.6)	2(5.1)
Unintelligible	1(2.6)	1(2.6)	00	1(2.6)	00	00
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
<i>P value</i>	.258		.566		.643	

Recurrence	At 1 month follow-up		At 6 months follow-up		At 1 year follow-up	
	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)	VBG (%)	NVBG (%)
Yes	00	00	1(2.6)	1(2.6)	2(5.1)	4(10.3)
No	18(46.2)	21(53.8)	17(43.6)	20(51.3)	16(41)	17(43.6)
Total	18(46.2)	21(53.8)	18(46.2)	21(53.8)	18(46.2)	21(53.8)
P value	/		.911		.493	

DISCUSSION

Jewer's classification is one of the most used international classifications which provides a good distribution to classify mandibular defects¹ (Figure1).

Figure1: distribution of the mandibular defect according to the HCLclassification.

Representative area of mandible resection was indicated with blue light shade in each HCL classification.

There were a total 39(100%) patients in both groups, among those 18 (46.2%) patients were reconstructed with vascularized bone graft (VBG) and 21 (53.8%) with nonvascularized bone graft (NVBG) (Figure2; Table1).

Figure2: A. measurement with assisted surgical report design; B.reconstruction with vascularized fibula bone flap; C. nonvascularized rib bone flap D. nonvascularized iliac crest bone flap.

The fundamental objectives of mandibular reconstruction are primary wound closure and to restore both appearance and function. Bone density is routinely taken for initial diagnosis of bone quality, its' also an important factor when one is choosing a more favorable donor bone because it may be responsible for the biologic response and mechanical support of the implant fixture. In particular, the quality of the bone-implant interface may affect the initial stability that is crucial for obtaining osseointegration.² it is necessary to evaluate the possibility of recognizing decreased bone density on panoramic radiographs. On one year follow up, bone density was 'good' for 15(42.9%) in VBG and 11(39%) in NVBG. According to these results, the vascularized bone flap seems to be superior over the nonvascularized flap. In their study Myoung et al showed that bone-implant interface density of iliac bone is lower than the fibular bone, on the other hand in the same study, the iliac bone showed high cancellous bone density than fibula bone³.

However, we evaluated bone resorption based on Coronal CBCT radiography which was used to measure the height and thickness of the

neomandible bone at the same distance from the opposing maxillary tooth for 1, 6 and 12 months follow up (Figure3), resorption was statistically significant for one year follow up ($p = .030$). For more accurate result we used CBCT to define and to monitor the severity of bone resorption in mandibular reconstruction. We noted the highest bone resorption 5% after 1 year follow up in NVBG group with 5(12.8%) moderate and 5(12.8%) severe resorption (Table2). Makiguchi et al reported higher resorption rates of greater than 20%, with a fibular bone resorption index (FBRI) of 38%. They attributed these higher rates to segmental osteotomies that disrupted the direct nutrient artery to the fibular bone marrow. They noted lower resorption rates when this artery was preserved. They concluded that preservation of the nutrient artery to the bone marrow, avoidance of multiple osteotomies, and placement of osseointegrated implants inhibited rapid bone resorption and maintained flap height.⁴ Marcello et al found a significant correlation between mandibular length and masticatory function.⁵ Additionally, Factors that correlate with increased risk of atrophy include nicotine abuse, peripheral vascular disease, and alcoholism.^{4,6}

Figure3: bone resorption evaluation based on Coronal CBCT radiography

39 constitute to our functional follow-up, one of the most common complications is wound infection often resulting in graft failure. On one year follow up 2(5.1%) in VBG and 5(12.8%) in NVBG graft failure were noted which statistically not significant ($p=0.312$) (Table2). Shusterman et al.⁷ reported a 7% failure rate in 14 patients (1 patient), whereas Blackwell et al.⁸ found an unacceptably high (40%) failure rate of plate in 10 patients (4 patients) who were followed up for at least 12 months. In his study, Egyedi P in 38 mandibular reconstructions using autogenous bone graft, infection occurred in 10 patients' recipient site, which resulted in loss of the graft in 3 patients⁹. Leakage of saliva into the graft area, even if rigorous suction wound drainage is applied is a risk factor for infection.¹⁰ The presence of dead space and a lengthy surgical procedure may also increase the risk of wound infection and wound dehiscence.^{11, 9} Our evaluation of functional effects showed good results; most of the patients had a normal restoration of function. Only pain after one month follow-up was statistically significant, and was considered better in VBG than NVBG group ($p= 0.03$). On the other hand there was no statistically significant difference between the VBG and NVBG groups for infection, speech, recurrence and pain after 6 and 12 month (Table 3).

Among the 39(100%) total patients success rate was 87.2 %. however in VBG group ($n=18$) the success rate was 94.4% with only fibular reconstruction, in the NVBG ($n=21$) success rate was 81.2% (2 grafts failure in Rib and 2 in Iliac crest) was observed. Our success rate is in line with literature where success rates have been reported between 46% and 100%^{12,13}. Mustafa et al¹⁴ also reported the success rate for both fibula and iliac crest flaps were 100% and 92% respectively. Nonvascularized bone grafts could be used judiciously for reconstruction of selective mandibular resection defects where there is not much of soft tissue loss,^{15, 16, 17}. In his study van Gemert et al concluded that Nonvascularized iliac crest bone grafts for segmental reconstruction of the mandible is the method of choice on the condition that the defect is truly lateral and only an extraoral approach is used.¹¹ M. Osborn et al reported that non-vascularized iliac crest bone grafts

are highly successful in mandibular continuity reconstruction for non cancer patients and should be considered as first choice for defects less than 9 cm. complication and morbidity with NVBG were relatively minor and within acceptable range.¹⁸ on the other hand several authors considered free fibula flaps to be the first choice for mandibular or maxillary reconstruction of extensive malignant defects especially that do need adjuvant post-surgical radiotherapy.^{19, 20}

CONCLUSION

Prior studies have attempted to compare outcomes following mandibular reconstructive, mainly radiographs or functional, but few have specifically evaluated long-term outcomes in factors admit both radiograph and functional evaluation of vascular and nonvascular mandibular bone graft. Vascularized bone graft is the method of choice, especially in extensive malignant defects. On the other hand due to our result, nonvascularized bone graft (81.2% success rate) is a suitable complementary flap for mandible reconstruction mainly in benign and healthy patients. For future studies, large sample size with long-term follow-up more than 1 year will be required to validate our study.

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