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Outcome of Mandibular Reconstruction Using Non-Vascularized Block Iliac Bone Graft

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ABSTRACT

Objectives: The purpose of this study was to investigate the degree of success of nonvascularized block iliac bone graft for mandibular reconstruction, one year post-operative.

Methods: Sixty-nine patients with segmental mandibular resection, reconstructed by nonvascularized iliac bone grafts, were evaluated both clinically and radiologically one year after mandibular reconstruction.

Results: Thirty-five patients showed complete bone healing, thirty patients showed bone healing with complications, and four patients showed total graft necrosis.

Conclusion: Non-vascularized iliac bone graft seems to be a reliable reconstructive option for mandibular defects up to 7cm in size.

Key Words: *Mandibular reconstruction – Nonvascularized iliac bone graft – Segmental mandibular resection – Block iliac – Bone healing.*

INTRODUCTION

Mandibular defects developing after segmental mandibular resection often result in major challenges to the surgeon and the patient **[1,2]**. For the surgeon, there is the challenge of mandibular reconstruction to restore normal anatomy and function of the mandible **[3,4]**. For the patient, there are varying degrees of aesthetic, functional, and psycho-social challenges which may severely affect the quality of the patient's life.

Many reconstructive options have been mentioned in the literature including autograft, allograft and xenograft **[5]**. Recent options for distraction osteogenesis and genetically engineered bone are also becoming increasingly available options by surgeons as new possibilities for mandibular reconstruction **[6]**.

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For example, the use of alloplast as bridging plates has several advantages, such as ease of placement, long term stability of shape, no morbidity of donor site, and satisfactory aesthetic outcome in the early post-operative period. However, they have many disadvantages as plate fracture, there is a risk of hardware rejection and plate exposure, plus there is a danger of a lack of dental implants insertion. Indeed, 60-80% failure rate for alloplastic material has been reported in the literature **[3]**.

Segmental mandibular defects fewer than 6cm, defects with no soft tissue need, and defects with ability for secondary reconstruction, are defects that can be reconstructed with non-vascularized bone grafts (NVBG) **[7,8]**. Non-vascularized bone grafts need shorter procedures, allow for faster recovery, and can facilitate insertion of dental implants. Anterior and posterior iliac crest are often the most common donor sites as they give a large volume of bone and high concentration of osteocompetent cells to be used **[9]**.

PATIENTS AND METHODS

This study was conducted from 2010 to 2019, and 69 patients were included in this retrospective study. Those with segmental mandibular defects underwent mandibular reconstruction using non-vascularized iliac bone grafts in maxillofacial surgery center, at King Fahd Specialist Hospital, Qassim region, Saudi Arabia.

All grafts were bicortical iliac bone grafts harvested from anterior border of iliac bone. Fixation to the mandible was done by titanium reconstruction plates (Stryker, Freiburg, Germany). All patients were operated upon using extraoral approach for benign lesions.

All patients demographic data and medical information were collected. This included age, gender, cause of mandibular resection, site and size of defect, and type of reconstruction either primary or secondary.

Delimitation factors were used for exclusion. Such exclusion criteria included patients with mandibular resection due to malignant disease when reconstruction was conducted by free flaps, patients reconstructed by split bundle rib graft due to condylar resection, patients with missed data and missed radiographs, and patients who lost contact with the study at some point prior to the follow-up debriefing.

One year after reconstruction, patients were clinically evaluated for proper healing, and radiologically through CT scans (Fig. 1)

Also, titanium plates were removed in many patients. Success of reconstruction was evaluated by maintenance of continuity of bone with complete consolidation and absence of infection on intraoperative examination during plate removal or by CT scan.

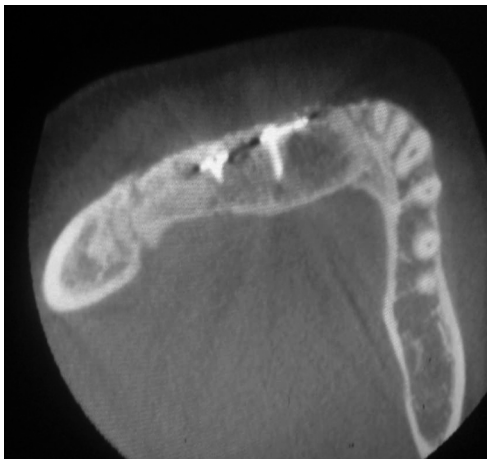

Fig. (1): CT scan for non-vascularized block iliac bone graft one year post-operative.

Ethical approval: This study was approved by the university's Institutional Review Board (IRB). It was conducted in accordance with principles of Helsinki and its modifications. All patients signed written informed consent for possibility of use of their data in research.

Conflict of interest: As noted above, this study was approved by the university's IRB.

RESULTS

Of the 69 patients who participated in this study, 47 were males and 22 were females, their ages ranged from 38 to 61, with a mean 49.5. 45 of the patients had primary reconstruction after mandibular resection. Twenty-four of patients had secondary reconstruction, and this reconstruction was done after some time of the mandibular resection, this interval ranged from 8 to 48 months.

The etiology for mandibular resection was ameloblastoma in 28 patients, ossifying fibroma 9 patients, odontogenic myxoma 8 patients, recurrent odontogenic keratocyst 5 patients, complicated mandibular trauma 5 patients, mandibular osteomyelitis 5 patients, complicated other mandibular cyst 4 patients, central giant cell granuloma 3 patients, and mandibular gunshot injury in 2 patients (Table 1).

In 35 (50%) patients, the defect was at the angle region between the molar teeth and mid ramus. Yet, 19 (28%) patients had their defects in the mandibular body region between canine and molar teeth, while 8 (12%) patients had their defect in the ramus region from 3rd molar to subcondylar region, and 7 (10%) patients had their defect in the symphysis region, from canine to canine (Table 2).

Table (1): Different causes for mandibular resection*.

Etiology of mandibular resection	Number of patients
Ameloblastoma	28
Ossifying fibroma	9
Odontogenic Myxoma	8
Recurrent Keratocyst	5
Complicated Trauma	5
Mandibular osteomyelitis	5
Complicated other cysts	4
Central giant cell granuloma	3
Mandibular gunshot injury	2

*The range of the defect size was from 3.3cm to 7cm, with a mean of 5.6.

Table (2): Shows the distribution of the defect sites.

Defect site	Number of patients
Angle	35
Body	19
Ramus	8
Symphysis	7

Patients classified according to result into three groups. First group of complete success involved thirty-five patients (50%), second group of partial success involved thirty patients (43.5%), and third group of failure with total graft loss included four patients (5.8%) (Table 3).

Table (3): Distribution of the studied cases according to final outcome (n=69).

Final outcome	No. (%)
Complete success	35 (50.7%)
Success with complications:	30 (43.5%)
a- Intraoral sinus	13 (18.8%)
b- Extraoral sinus	8 (11.6%)
c- Intraoral plate exposure	6 (8.7%)
d- Extraoral plate exposure	3 (4.3%)
Total graft loss	4 (5.8%)

Moving to other clinical evaluations, such success can be measured in a variety of methods. For this study, success of healing of grafted bone was evaluated clinically and radiologically. Both will be discussed individually.

Clinical evaluation:

Clinical evaluation was used in the detection of proper wound healing, namely the detection of plate exposure and direct bone examination-absence of any sinus either intra or extraoral during plate removal in 28 patients.

Radiological evaluation:

Computed tomography (CT), done routinely to all patients one year postoperatively, for evaluation of bone continuity and healing (Fig. 1). One year postoperatively 35 patients showed successful bone healing with no complications, 30 patients showed bone healing with complications, and from these 21 showed oral or cutaneous sinuses with purulent discharge. Additionally, 6 patients showed intraoral exposed plate and 3 patients showed extraoral exposed plates. Four patients showed severe infection and complete bone loss, with graft removal and secondary interference (Table 3).

All these complications were managed conservatively by saline irrigation, curettage, antibiotics after culture and sensitivity, and when these conservative measures failed, plate removal was done. Graft removal was done in 4 patients with complete failure, and they needed further reconstruction using free flaps. *p*-value was significant for graft site and size, but was non-significant for age, sex and type of reconstruction.

Table (4): Comparison between the three studied groups according to different parameters.

	Complete success (n=35)	Final outcome Success with complications (n=30)	Total graft loss (n=4)	Test of Sig.	*p*
Age (years):					
Mean ± SD.	47.8±6.5	45.4±6.9	49.3±6.6	F=1.258	0.291
Median (Min. - Max.)	49 (38-61)	43 (38-60)	49.5 (41-57)		
Sex:					
Male	21 (60%)	23 (76.7%)	3 (75%)	χ^2=2.148	^{MC}p=0.339
Female	14 (40%)	7 (23.3%)	1 (25%)		
Site:					
Angle	20 (57.1%)	15 (50%)	0 (0%)	χ^2=19.571*	^{MC}p=0.001*
Ramus	7 (20%)	1 (3.3%)	0 (0%)		
Body	8 (22.9%)	10 (33.3%)	1 (25%)		
Symphysis	0 (0%)	4 (13.3%)	3 (75%)		
Size (cm):					
Mean ± SD.	4.8**b**±0.9	6**a**±0.8	6.4**a**±0.6	F=18.888*	<0.001*
Median (Min. - Max.)	4.9 (3.3-6.4)	6 (4-7)	6.3 (5.8-7)		
Type of reconstruction:				χ^2=1.555	^{MC}p=0.547
Primary	25 (71.4%)	18 (60%)	2 (50%)		
Secondary	10 (28.6%)	12 (40%)	2 (50%)		

Fig. (2A): Pre-operative lateral and front views of patient with Ameloblastoma.

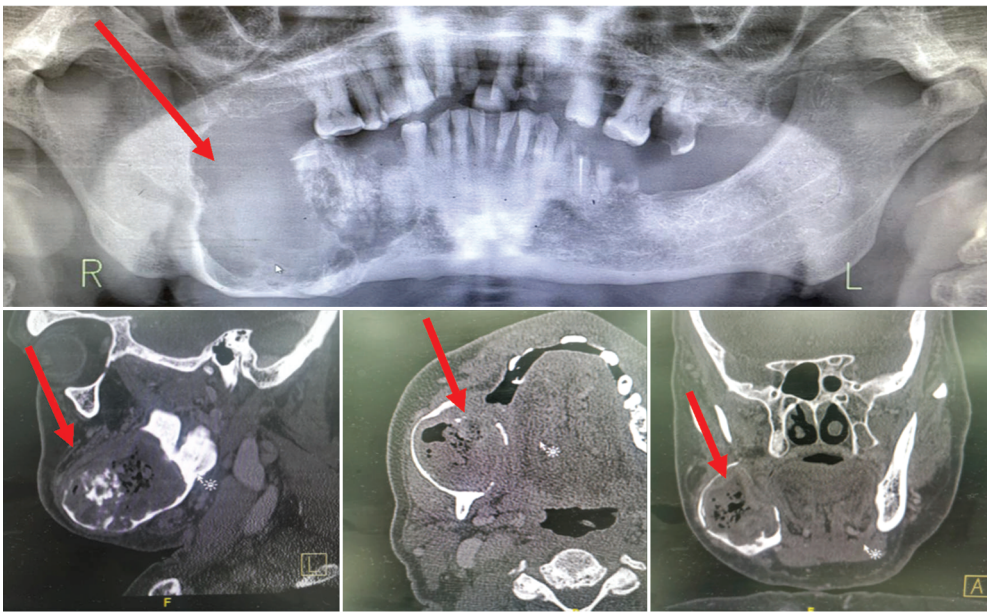

Fig. (2B): Pre-operative panoramic and CT scan of the Ameloblastoma Tumor at different section.

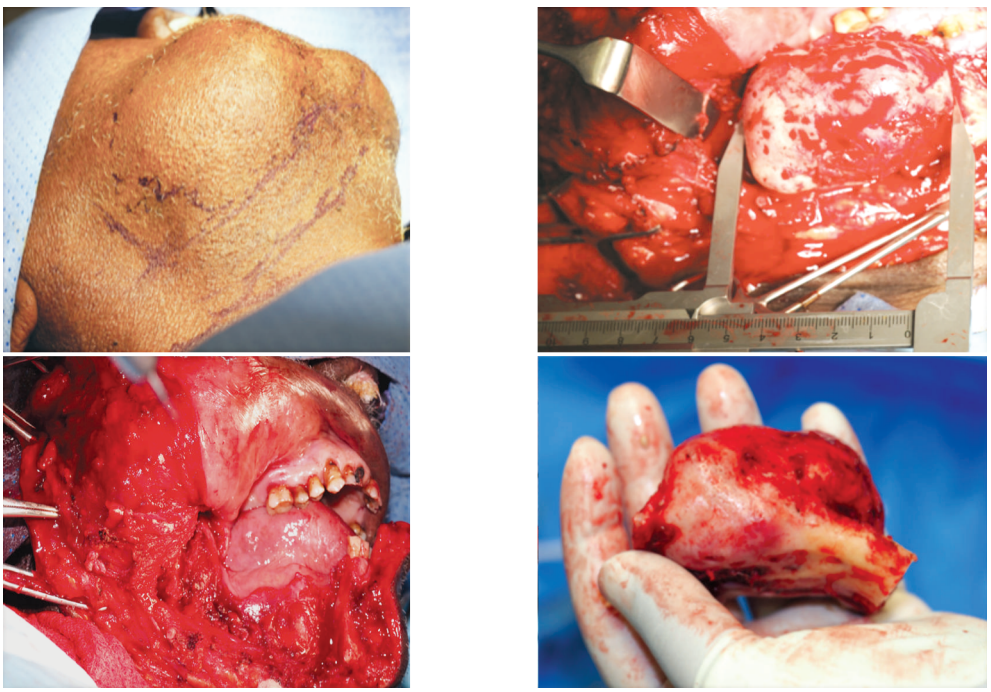

Fig. (2C): Pre-operative marking and design of the submandibular approach, Inteaopertive tumor Exposture, Tumor Excision with 6cm lenghth and, intraopertive segmental mandibular defect Tumor.

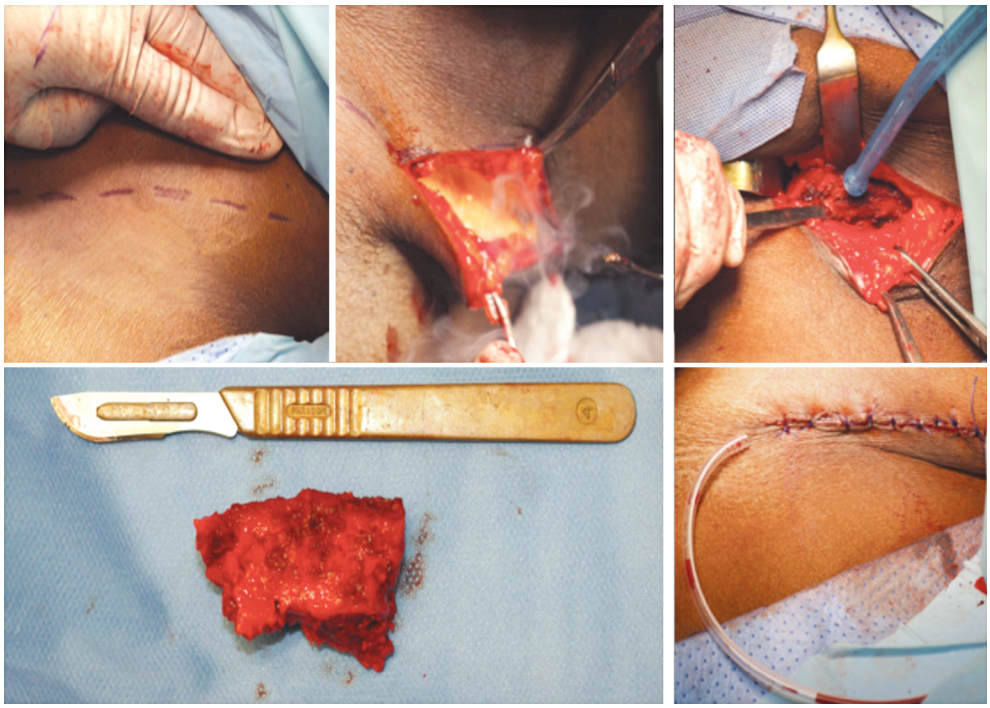

Fig. (2D): Harvesting of iliac bone graft and closure of donor site with drain insert.

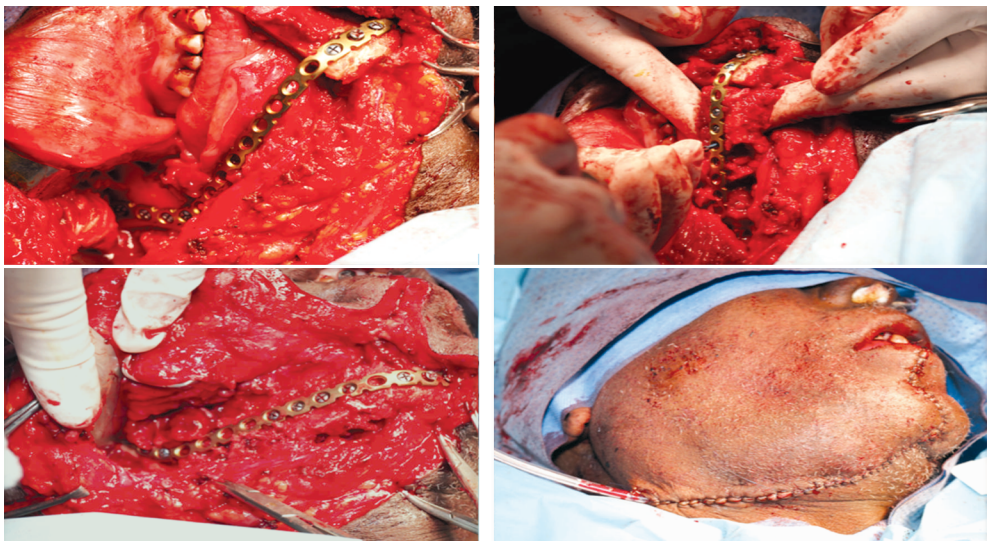

Fig. (2E): The reconstruction of a tumor-related segment defect was accomplished with a rigid titanium plate and wound closure.

Fig. (2F): A. 3-month follow-up panoramic radiograph of the resection and bone graft, with Post-operative extra-oral and intra-oral photograph of the patient.

DISCUSSION

Segmental mandibular defects result from resection of mandibular tumors **[11]**, osteomyelitis of the mandible and mandibular trauma. It adversely affects speech, mastication and aesthetics with subsequent deterioration of the patient's quality of life **[12]**, so mandibular reconstruction is a must following segmental mandibular resection **[13]**. Iliac crest graft has many advantages, such as great availability of bone, good quality of bone tissue including cortical and medullary bone, curved contour that resemble that of mandible, so it is widely preferred by surgeons **[14,15,16]**.

In this study, as shown in Table (3), the patients were divided into three groups, first group is patients with complete success without any reported complications, this group involved thirty-five patients (50%).

The second group was patients with success of graft healing with a reported complication, this group involved 30 patients (43%), but these complications could often be treated and did not represent treatment failure. All these complications were managed conservatively by saline irrigation, simple curettage and antibiotics, so the overall success rate was 93%.

This high success rate could be explained by exclusion of patients with mandibular resection due to malignancy with their poor prognosis due to greater mandibular defects and neck radiotherapy. The third group involved four patients who had total graft loss, and required further surgical management by free vascularized flaps.

Regarding the effect of the site of mandibular defect (which had a significant *p*-value), the best results observed in the mandibular angle region with 57% complete success, 50% success with complications, 0% failure, followed by the mandibular body region with 23% complete success, 33% success with complications, 25% failure, and next the ramus region with 20% complete success, 3.3% success with complications, 0% failure, and finally the worst results are seen in the mandibular symphysis region extending across the midline, with 0% complete success, 13.3% success with complications, and 75% complete failure.

High success rates associated with posterior defects could be explained by adequate soft tissue coverage and less torsional forces in the mandible. Similar results were observed by Holtz, Foster et al., and Maurer et al., who found best results obtained with mandibular reconstruction using non-vascularized iliac bone graft, in the posterior mandibular region **[17,18,19]**.

Lower success rate associated with symphysial mandibular defects, could be explained by lack of adequate soft tissue coverage, loss of insertion of oral floor and tongue musculature, with torsional forces in the mandible leading to plate exposure, infection and subsequent graft loss and lower success rate. Again, similar results were observed by Van Gemert et al., Guerrier et al., and Gadre et al., **[9,15,20]**.

We agree with other authors who recommend the use of free vascularized fibula for reconstruction of long symphysial mandibular defects, especially defects crossing the midline **[16]**. In this study, there was significant effect of the graft size on the success rate, (significant *p*-value), which is consistent with the findings of many authors. Vu and Schmidt **[21]**, mentioned that mandibular defects up to 6cm can be safely reconstructed with non-vascularized iliac bone grafts, and defects more than 6cm can also be reconstructed with the same graft with 17% failure rate. Mooren et al., **[22]** noted that mandibular defects up to 5cm can be safely reconstructed by non-vascularized iliac bone graft.

Ndukwe et al., mentioned that longer nonvascularized iliac bone grafts have less success rate, and a 75% loss rate observed in grafts equal or more than 12cm. **[23]**.

There was no significant difference in the success rate between primary and secondary reconstruction (non-significant *p*-value), but this is different with some other authors. El Sheikh et al., found that primary reconstruction has many advantages, presence of sufficient tensionfree soft tissue, ease of shaping, contouring, and positioning of the graft, and muscle insertion, in addition to shorter patient's rehabilitation period **[24]**.

Secondary mandibular reconstruction, has disadvantages, as smaller quantity and quality of the soft tissue used for graft coverage, and presence of hypovascularized, scarred tissues in the graft bed area **[25]**. No patients had plate fracture (0%), rigid fixation done using reconstruction plate for all patients, rigid fixation of the graft is mandatory, for proper healing and graft integration, any micromovement at the interface between the graft and mandibular contact sites may affect capillary ingrowth from recipient sites, leading to avascular necrosis and graft loss. Tissue engineering techniques, could be able in the future to replace au-

togenous bone transplantation, especially for smaller defects **[26]**.

Conclusion:

It can be concluded that non-vascularized block iliac bone provides an affordable and less technical choice for mandibular reconstruction after mandibular segmental resection up to 6-7cm, due to benign pathology. We therefore recommend its use for reconstruction of mandibular defects resulting from excision of benign odontogenic tumors and trauma.

However, primary mandibular reconstruction by free flaps, gives higher success rates in the literature, and should be the first option whenever possible.

REFERENCES

1- Johannes T.M., Robert J.J., Ellen M. and Ron K.: Non-vascularized bone graft for segmental reconstruction of the mandible a reappraisal. J. Oral Maxillofacial Surg., 67: 1446-52, 2009.

2- Akinbami B.O.: Reconstruction of continuity defects of the mandible with nonvascularized bone grafts. Systematic literature review. Craniomaxillofac. Trauma Reconstr., 9: 195-205, 2016.

3- Agrawal A., Mehrotra D., Mohammad S., Singh R.K., Kumar S. and Pal U.S.: Randomized control trial of non-vascularized fibular and iliac crest graft for mandibular reconstruction. J. Oral Biol. Craniofac. Res., 2: 90-6, 2012.

4- Hanasono M.M.: Reconstructive surgery for head and neck cancer patients. Adv. Med., 2014: 795483, 2014.

5- Akbay E. and Aydogan F.: Reconstruction of isolated mandibular bone defects with nonvascularized cortico-cancellous bone autograft and graft viability. Auris Nasus Larynx, 41: 56-62, 2014.

6- Verrier S., Alini M., Alsberg E., Buchman S.R., Kelly D., Laschke M.W., Menger M.D., Murphy W.L., Stegemann J.P., Schütz M., Miclau T., Stoddart M.J. and Evans C.: Tissue engineering and regenerative approaches to improving the healing of large bone defects. Eur. Cell Mater, 32: 87-110, 2016.

7- August M., Tompach P. and Chang Y.: Factors influencing the long-term outcome of mandibular reconstruction. J. Oral Maxillofac. Surg., 58: 731-737, 2000. [PubMed] [Google Scholar].

8- Pogrel M.A., Podlesh S. and Anthony J.P.: A comparison of vascularized and non-vascularized bone grafts for reconstruction of mandibular continuity defects. J. Oral Maxillofacial Surg., 55: 1200-1206, 1997. [PubMed] [Google Scholar].

9- Van Gemert J.T.M., van Es R.J.J., Van Cann E.M. and Koole R.: Nonvascularized bone grafts for segmental reconstruction of the mandible-a reappraisal. J. Oral Maxillofacial Surg., 67: 1446-1452, 2009. [PubMed] [Google Scholar].

10- Boyd J.B., Mulholland R.S. and Davidson J.: The free flap and plate in oromandibular reconstruction: Longterm review and indications. Plast. Reconstr. Surg., 95: 1018-1028, 1995. [PubMed] [Google Scholar].

11- Mehta R.P. and Deschler D.G.: Mandibular reconstruction in 2004: An analysis of different techniques. Curr. Opin. Otolaryngol. Head Neck Surg., 12: 288-93, 2004.

12- Kurz L.T., Garfin S.R. and Booth R.E. Jr.: Harvesting autogenous iliac bone grafts. A review of complications and techniques. Spine (Phila Pa 1976). Dec. 14 (12): 1324-31, 1989.

13- Obiechina A.E., Ogunlade S.O., Fasola A.O. and Arotiba J.T.: Mandibular segmental reconstruction with iliac crest. West Afr. J. Med., 22; (1): 46-9, 2003.

14- Bai X.F., Wushou A., Zheng J. and Li G.: An alternative approach for mandible reconstruction. J. Craniofac. Surg., Mar. 24 (2): e195-8, 2013.

15- Guerrier G., Alaqeeli A., Al Jawadi A., Foote N., Baron E. and Albustanji A.: Reconstruction of residual mandibular defects by iliac crest bone graft in warwounded Iraqi civilians, 2006-2011. Br. J. Oral Maxillofac. Surg., Jul., 53 (6): e27-31, 2015.

16- Akbay E. and Aydogan F.: Reconstruction of isolated mandibular bone defects with non-vascularized cortico-cancellous bone auto-graft and graft viability. Auris Nasus Larynx, 41: 65-62, 2014.

17- Holtz G.: Reconstruction of mandibular discontinuity defects with delayed non-vascularized free iliac crest bone grafts and endosseous implants: A clinical report. J. Prosthet Dent, 76: 350-5, 1996.

18- Foster R.D., Anthony J.P., Sharma A. and Pogrel M.A.: Vascularized bone flaps versus non-vascularized bone grafts for mandibular reconstruction: An outcome analysis of primary bony union and endosseous implant success. Head Neck, 21: 66-71, 1999.

19- Maurer P., Eckert A.W., Kriwalsky M.S. and Schubert J.: Scope and limitations of methods of mandibular reconstruction: A long-term follow-up. Br. J. Oral Maxillofac. Surg., 48: 100-4, 2010.

20- Gadre P.K., Ramanojam S., Patankar A. and Gadre K.S.: Nonvascularized bone grafting for mandibular reconstruction: myth or reality? J. Craniofac. Surg., 22: 1727-35, 2011.

21- Vu D.D. and Schmidt B.L.: Quality of life evaluation for patients receiving vascularized versus nonvascularized bone graft reconstruction of segmental mandibular defects. J. Oral Maxillofac. Surg., 66: 1856-1863, 2008.

22- Mooren R.E., Merkx M.A., Kessler P.A., Jansen J.A. and Stoelinga P.J.: Reconstruction of the mandible using preshaped 2.3-mm titanium plates, autogenous cortical bone plates, particulate cancellous bone, and platelet-rich plasma: A retrospective analysis of 20 patients. J. Oral Maxillofac Surg., Oct. 68 (10): 2459-67, 2010.

23- Ndukwe K.C., Aregbesola S.B., Ikem I.C., Ugboko V.I., Adebiyi K.E., Fatusi O.A., et al.: Reconstruction of mandibular decfects using nonvascularized autogenous bone graft in Nigerians. Niger J. Surg., 20: 87-91, 2014.

24- El-Sheikh M.M., Zeitoun I.M. and Medra A.M.: The split rib bundle graft in mandibularreconstruction. J. Craniofac. Surg., 20: 326-332, 1992.

25- Chiapasco M., Colletti G., Romeo E., Zaniboni M. and-Brussati R.: Long-term results of mandibular reconstruction with autogenous bone grafts and oral implants after tumor resection. Clin. Oral Implants Res., 19: 1074-1080, 2008.

26- Handschel J., Naujoks C., Langenbach F., Berr K., Depprich R.A., Ommerborn M.A., Kubler N.R., Brinkmann M., Kogler G. and Meyer U.: Comparison of ectopic bone formation of embryonic stem cells and cord blood stem cells in vivo. Tissue Eng. Part A, 16: 2475-2483, 2010.