

Cohort Study

A retrospective study on mandibular reconstruction using iliac crest free flap

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ABSTRACT

Purpose: To assess the availability, success rate and complications of microvascular iliac crest free flap for reconstruction of mandibular segmental defects.**Methods:** In this retrospective-descriptive study, we report patients who had undergone segmental mandibular resection for pathologic lesions and received reconstruction with iliac crest microvascular free flap between 2016 and 2019. Clinical and demographic data of all the cases were collected. Success was regarded as complete consolidation of the bone graft in panoramic radiograph. Postoperative complications were defined as major or minor based on the need for intervention. T-test, Kolomogorov_Smirnov, and multivariate analysis were used and the p-value < 0.05 was considered to be statistically significant.**Results:** Of all 30 patients, 16 were women and 14 were men with an average age of 27.2 years (range 14–40). Patients were followed for 12–60 month (mean: 38.4). One flap was lost due to unsalvageable venous thrombosis. Six other cases had post-op complications while smoking and diabetes were associated with more complications (P = 0.036). Twenty-three patients received primary reconstruction which was more successful than secondary ones (P = 0.003). Osteogenic sarcoma was associated with greater risk of complications (P < 0.01).**Conclusions:** The results of this study suggest that iliac crest microvascular free flap serves as a promising option for the reconstruction of mandibular defects, providing excellent contour and acceptable success rate with low donor site morbidity. Future studies will focus on the role of systemic diseases in post-op complications and flap failures.

1. Introduction

Extensive resection of tumoral tissue often results in major defects in bone and soft tissue. Mandibular segmentectomy often leads to retrusion of lower third of the face and severe ptosis of lower lip which causes considerable functional, esthetical, and social problems followed by decrease in health-related quality of life [1,2]. From an anatomic point of view, it is important to reconstruct not only the mandibular continuity, but also the associated soft tissue defect.

Immediate reconstruction of the mandible is therefore preferred, aiming to restore function and esthetics [3]. Currently, composite free vascularized flaps offer the best option to achieve these goals [4].

Due to advances in micro vascular surgery and improved knowledge

of donor site anatomy, up to 94% success rate has been reported for the reconstruction of mandible with free vascularized bone flaps [3,4]. Nevertheless, free tissue transfer is becoming the reconstructive option of choice for many head and neck defects [3,5].

Several vascular systems are available for harvesting osseous free flaps. The frequently used flaps for oromandibular reconstructions are peroneal, deep circumflex scapular and deep circumflex iliac artery systems [6,7].

Fibula flap is the only flap that enables reconstruction of large segmental mandibular defects. In addition, this flap can be harvested with a remarkable skin paddle for reconstruction of defects with osteocutaneous flap [8]. However, the height of the bone is less than that of the native mandible [9]. The scapular flap is also insufficient in terms

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of height and cannot be used to reconstruct large defects [10].

The iliac crest flap is the only free flap that enables reconstruction of the initial width and height of the mandible, and immediate placement of dental implants [11,12]. Disadvantages are unavailability to reconstruct some of the large defects and excessive soft tissue bulk which renders it unsuitable for reconstruction of intraoral defects [13].

This study presents experience and the rationale for employing a free flap of iliac crest for mandibular reconstruction, believing that this flap is particularly indicated for that purpose.

2. Methods

In this retrospective study patients in whom segmental mandibular resection for pathologic lesions was performed with iliac crest microvascular free flap between 2016 and 2019 were included. Surgical procedures were performed in one of the largest public hospitals, (XXX), by one oral and maxillofacial surgeon with more than 11 years of experience in head and neck reconstruction and one plastic surgeon with 4 years of experience in head and neck surgical oncology. These patients did not have the history of mandibular resection of any other head and neck surgery.

The study protocol was reviewed by the independent ethics committees of institutional review board of (XXX). All patients signed a written informed consent for analysis and reporting of clinical data, radiographs and photographs (XXX).

Preoperative intervention included fluid therapy and monitoring of vitals. Prior to the induction of anesthesia, the vital of patients were monitored and stabilized. Prophylactic antibiotic therapy was provided to all the patients.

Clinical data such as gender, past medical history, pathologic disorder, site of mandibular defect and donor site surgical complication were collected.

Success was regarded as complete consolidation of the bone graft within the first two years in panoramic radiograph (Figs. 1 and 2). If a postoperative recipient-site complication required surgical intervention

under general anesthesia or was potentially life-threatening, it was defined as major, otherwise minor complication, which would resolve without or with minimal intervention. The follow up period of these patients lasted until 60 months.

Statistical analyses were performed by SPSS V. 20, using T-test, Kolomogorov Smirnov, and multivariate analysis. *P*-value less than 0.05 was considered significant.

The work has been reported in line with the STROCSS 2019 criteria [14].

Research Registry Unique Identifying Number: Researchregistry6590.

3. Results

Of 30 patients, 16 were women and 14 were men, with an average age of 27.2 years (range 14–40). Patients were followed for 12–60 month (mean: 38.4). The average size of tumors was 9.06 cm (S.E.mean: 0.52). Clinical characteristics of all patients are shown in Table 1.

Mandibular reconstruction was necessary for all patients due to post resection defects. Primary reconstruction was performed for 22 patients and the other 8 patients received secondary reconstructions. Patients were followed every week for first month, every 3 months for first year and every 6 month for 5 years. Patients were followed for 12–60 month (mean: 38.4).

Among post-surgical complication groups, follow up periods were almost equal and also sex, age, tumor length and location were not significantly different, $p > 0.05$, Table 2. None of the patients had evidence of locoregional recurrence or distant metastasis. The relation between past medical history and smoking with post-surgical complications was significant ($P = 0.036$) in a way that from the total of 7 patients with post-surgical complications, 3 had history of smoking and 3 were diabetic while one had no past medical history. One flap was lost due to unsalvageable venous thrombosis. Twenty-three patients received primary reconstruction which was more successful than secondary ones ($P = 0.003$). Osteogenic sarcoma was associated with

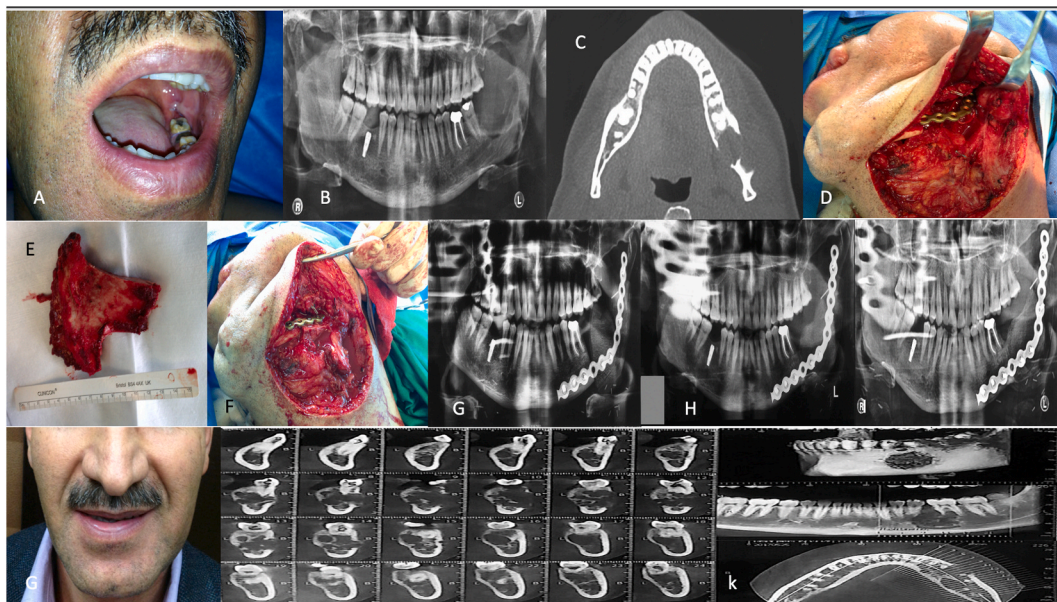


Fig. 1. A. Preoperational photograph of a 40 y/o male case presenting Ameloblastoma of left side of mandible. B. Preoperational panoramic radiograph showing the extension of tumor from angle to the ramus and coronoid process. C. Diagnostic CT-Scan showing the perforation of buccal and lingual plates. D. Intraoperative photograph after tumor resection and reconstruction plate fixation. E. The iliac crest free flap with vascular pedicle was harvested. F. The graft was inserted into the defect, fixed to the existing reconstruction plate and the pedicle was anastomosed to the recipient artery and vein. Note the contour of the graft, which is similar to that of the defect. G. Immediate post operational panoramic radiograph. H. Twelve month follow up panoramic radiograph. I. Fifty six month follow up panoramic radiograph. J. Five year follow up photograph showing excellent contour and symmetry. K. Preoperational Cone-Beam CT scan of a 24 y/o case presenting Ameloblastoma of left side of mandibular body.

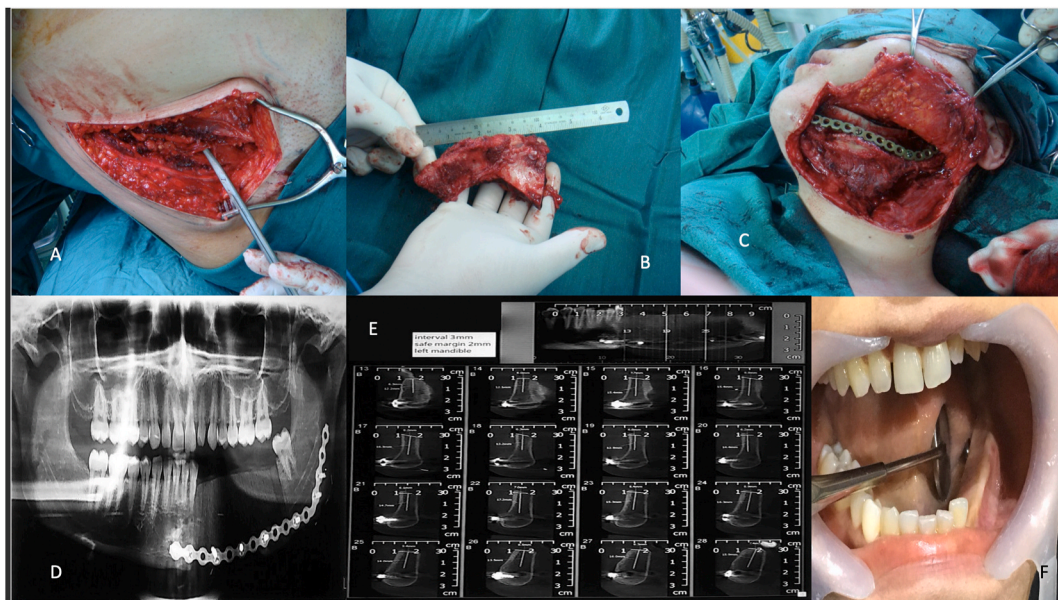


Fig. 2. A. Intraoperative photograph of the donor site. B. Intraoperative photograph of the iliac crest free flap with vascular pedicle. C. Intraoperative photograph after tumor resection, reconstruction plate fixation and graft fixation to the plate. D. Immediate post operational panoramic radiograph. E. Thirty eight months follow up radiograph. F. Thirty eight months follow up- Clinical view.

Table 1

Data of cases with mandibular defects reconstructed using iliac free flap.

Patient No.	Tumor	Age	Sex	Extension To Soft Tissue	Length Of Defect (Cm)	Type Of Reconstruction	Follow Up (Months)	Postop Complications
1	Ameloblastoma	24	Female	No	7	Primary	40	No
2	Ameloblastoma	27	Female	No	8	Primary	39	No
3	Ameloblastoma	40	Male	No	14	Primary	56	No
4	Ameloblastoma	32	Male	No	14	Primary	55	No
5	Ameloblastoma	26	Female	Yes*	8	Secondary	46	No
6	Ameloblastoma	24	Female	No	10	Primary	38	No
7	Ameloblastoma	14	Male	No	15	Primary	32	No
8	Ameloblastoma	22	Male	No	6	Primary	60	No
9	Ameloblastoma	28	Female	No	8	Primary	13	No
10	Ameloblastoma	30	Female	No	12	Primary	31	No
11	Central Giant Cell Granuloma	34	Female	No	12	Primary	55	No
12	Central Giant Cell Granuloma	27	Female	No	10	Primary	36	No
13	Central Giant Cell Granuloma	25	Female	No	10	Primary	28	No
14	Central Giant Cell Granuloma	28	Male	No	12	Secondary	52	No
15	Central Giant Cell Granuloma	27	Male	No	14	Primary	41	No
16	Central Giant Cell Granuloma	35	Female	Yes*	10	Secondary	60	Yes*
17	Desmoplastic Fibroma	18	Female	No	4	Primary	24	No
18	Desmoplastic Fibroma	18	Female	No	6	Primary	12	No
19	Hemangioma	24	Female	No	6	Primary	48	No
20	Hemangioma	28	Male	No	10	Primary	50	No
21	Hemangioma	28	Female	No	9	Primary	42	No
22	Hemangioma	24	Female	No	8	Primary	17	No
23	Odontogenic Myxoma	32	Male	No	6	Primary	60	No
24	Odontogenic Myxoma	31	Male	No	8	Primary	50	No
25	Osteogenic Sarcoma	18	Male	No	8	Secondary	23	Yes*
26	Osteogenic Sarcoma	32	Male	No	8	Secondary	40	Yes*
27	Osteogenic Sarcoma	20	Female	No	6	Secondary	23	Yes*
28	Osteogenic Sarcoma	22	Female	No	6	Secondary	23	Yes*
29	Osteogenic Sarcoma	30	Male	No	8	Primary	32	Yes*
30	SCC	40	Male	Yes*	10	Secondary	26	Yes*

Table 2
Baseline Participants' characteristics by post-surgical complication group.

Characteristic	N (%)	With post-surgery complication	Without post-surgery complication	P. Value
No. (%)	30 (100%)	7 (23.3)	23 (76.7)	
Age, Mean (S.E Mean), Year		28.14 (3.14)	9.39 (1.18)	0.656
Tumor length, Mean (S.E Mean), Cm		8 (0.62)	9.39 (3)	0.216
Follow up duration, Mean (S.E. Mean), Month		32.43 (5.18)	40.22 (5.6)	.435
Tumor type				
Ameloblastoma	10 (33.3%)	0	10	0.00*
Central Giant Cell Granuloma	6 (20)	2	4	
Osteogenic Sarcoma	5 (16.7)	5	0	
Hemangioma	4 (13.3)	0	4	
Desmoplastic Fibroma	2 (6.7)	0	2	
Odontogenic Myxoma	2 (6.7)	0	2	
Squamous Cell Carcinoma	1 (3.3)	1	0	
Tumor Location				
Body of mandible	12 (40)	2	10	0.436
Ramus of mandible	11 (36.7)	4	7	
Body and ramus of mandible	7 (23.3)	1	6	
Reconstruction				0.003*
Primary	23	2	21	
Secondary	7	5	2	

Table 3
Baseline Participants characteristics by post-surgical complication Group.

Major complications	N	Minor complications	N
Hematoma	1	Hematoma	2
Total necrosis	1	Infection	2
Fistula	1	Partial necrosis	0
Venous thrombosis	1	Fistula	0
Arterial thrombosis	0	Dehiscence	0
Partial necrosis	0		
Wrong positioning of flap	0		
Plate exposure	0		
Infection	0		
Dehiscence	0		
Hemorrhage	0		
Total	4	Total	4

greater risk of complications ($P < 0.01$). Participants' characteristics by post-surgical complication group are shown in [Table 2](#).

The most frequent complication was hematoma (3 cases). The frequency of other major and minor are summarized in [Table 3](#). In patients without any post-surgical complication, no past medical history was found ([Figs. 1 and 2](#)).

4. Discussion

Defects in head and neck region not only compromise the function but also cause severe aesthetic and social problems affecting quality of life, thus reconstruction of these defects seems to be crucial. Among the available options, vascularized free flaps seems to be the most promising ones due to significantly less bone resorption and failure rate and relatively sufficient amount of soft tissue available for reconstruction of soft tissue defects [15]. Several donor sites are introduced in literature for

harvesting vascularized free flaps mainly fibula, scapula and iliac crest. Usually flap selection is mainly based on a balance between the site and size of the defect, donor vessels and the amount of bone and soft-tissue available [16,17]. This study reviewed 5-year experience focusing on advantages of iliac crest free flap in reconstruction of mandibular defects, stressing the functional and aesthetic aspects of these reconstructions.

Taylor [18] and Sanders [19] were the first ones who introduced iliac crest free flap for mandibular reconstruction and 9 years later Riediger [20] placed dental implants for complete rehabilitation of the morbidity. Since then, this flap has known as a progressive success.

In our institute iliac crest free flaps are mainly used for reconstruction of large defects because of the shape resemblance between the iliac crest and the hemimandible, relatively wide amount of bone available for three dimensional reconstruction of mandible, rich blood supply due to immediate perfusion of blood, proportionately more cancellous bone which improves infection resistance and osseointegration of the dental implants, sufficient amount of cortical bone providing acceptable primary stability for dental implants, possibility of immediate insertion of dental implants, suitable for reconstruction of large soft tissue defects requiring bulk and less complicated donor site anatomy [11,12,15,17,21]. Also, while osteotomies can be performed on the outer cortical layer, the periosteum is left intact on the inner aspect which decreases the risk of compromised blood perfusion and bone resorption [22]. Ozkan [23] presented case series of 5 patients who underwent anterior mandible reconstruction using single osteotomy of iliac crest flap. The study reported 100% success rate without any case of wound infection or hematoma.

Although the iliac crest flap represents as one of the best available flaps for reconstructions, several drawbacks are reported. First, its preparation may cause donor site complications such as hematoma, inguinal hernia [22] and gait disorders [12] and persistent pain [24,25]. Therefore, the authors suggest that this flap to be used for the defects which cannot be reconstructed with simpler flaps. In some cases, such as that of composite grafts, the soft tissue might be bulky and the skin paddle can be unreliable [17]. Alternatively nasolabial flap or internal oblique muscle have been reported for intraoral soft tissue reconstruction [16,26]. Furthermore, multiple osteotomies of this bone may obstruct the blood supply of the flap [27] as in this study, one flap was lost due to unsalvageable venous thrombosis. However, neither free fibular flaps nor scapular flaps are needless of various osteotomies to resemble the shape of mandible.

Further reasons for such complications can be explained by clinical comorbidities and characteristics of the cases. Tumor type and past medical history or smoking habits were correlated with complications in our findings, such that patients with osteogenic sarcoma, history of diabetes and smoking encountered more post-op complications. Tobacco consumption is known to be correlated with surgical complications in head and neck free flap reconstructions [28,29], increased risk of local complications particularly wound infection [30]. Also, diabetes mellitus is reported to be associated with post-op surgical and medical complications and in some cases, mortality [30,31]. It seems that conditions causing vasculopathy can decrease the success rate of free flaps, however more study need to be done to understand the role of systemic diseases in post-op complications.

Primary and secondary reconstruction was discussed in literature and is consistent with our results, the primary reconstructions with microvascular free tissue transfer, are reported to be more successful than secondary ones [32,33].

Rising trend of treating patients with extensive mandibular defects due to tumorectomies uses virtual surgical planning. The concept of restoration-oriented planning is introduced for accurate iliac bone harvesting and plate bending to reconstruct the defect with the most appropriate shape for implant-supported restoration [34,35]. As a limitation to our study, we did not plan the surgery nor prosthetic reconstruction with 3D models and surgical navigation, though the authors

surmise that based on the forthcoming evidence, restoration-oriented planning might be a promising approach in treatment [36,37].

The follow up period of the cases discussed in this study is not consistent which might have led to variable conclusion. Furthermore, the retrospective nature of the study did not allow us to record patients' satisfaction following the surgery.

5. Conclusions

Vascularized free flap reconstruction of oromandibular defects provides acceptable results. The results of this study suggest that iliac crest microvascular free flap serves as a promising option of choice for these reconstructions, providing excellent contour and acceptable success rate with low donor site morbidity. Future prospective and cross-sectional studies to focus on the role of systemic diseases and smoking habits in post-op complications and flap failures can give better conclusion.

Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Author contributions

Dr. Ata Garajei: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Dr. Seyed Rouhollah Miri: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Ali A. Kheradmand and Dr. Azadeh Emami: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Research registration number

- 1.Name of the registry: N/a.
- 2.Unique Identifying number or registration ID: IR. TUMS.IKHC.REC.1399.458.
- 3.Hyperlink to the registration (must be publicly accessible): <https://ethics.research.ac.ir/ProposalCertificateEn.php?id=179733&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true>.

Guarantor

Seyed Rouhollah Miri.

Human and animal rights

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

Author statement

All the patients in the study agreed to participate in this research by giving a written consent to Imam Khomeini Hospital, Tehran, Iran. Also, the present study was approved by the Ethics Committee of Medical

Research at Tehran University of Medical Sciences, Tehran, Iran (IR.TUMS.IKHC.REC.1399.458).

<https://ethics.research.ac.ir/ProposalCertificateEn.php?id=179733&Print=true&NoPrintHeader=true&NoPrintFooter=true&NoPrintPageBorder=true&LetterPrint=true>.

Disclosure

Approval of the research protocol: N/A.

Informed Consent: Informed consent was obtained from each participant.

Consent for publication

Informed consent was obtained from each participant.

Availability of data and materials

All relevant data and materials are provided with in manuscript.

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any means during the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2021.102354>.

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