

Vertical Distraction Osteogenesis: An Adjunct to Prosthodontic rehabilitation in Vascularised free Fibular Graft

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Abstract : Aim of the study was to carry out successful prosthetic rehabilitation in patients who have received vascularised free fibular grafts as a replacement of resected mandible utilizing vertical alveolar bone distraction to attain optimum vertical bone height. 14 individuals with various pathologies / post trauma were taken up for rehabilitation of the resected mandibular segment with vascularised free fibular grafts. Pre-prosthetic alveolar vertical distraction of the consolidated free fibular graft was done in all cases and bi cortical implants were placed in the distracted bone for subsequent rehabilitation with implant tissue borne prosthesis. Follow up period ranged from 08 months to 1 year.

All the 14 cases had satisfactory desires outcomes with vertical increase of bone height ranging from 09 mm to 18 mm. Successful implantation of bicortical implants was possible in all the cases with prosthesis fabrication and loading within a week of implant placement. Load bearing efficacy was found to be totally satisfactory in 12 cases (85.71%) and partially satisfactory in 02 cases (14.28%). Clinical and radiographical review was done in all cases and negligible (<5%) bone resorption was found in 12 cases (85.71%) and between 5-8% resorption and loss of height was seen in 02 cases (14.28%) at the end of the follow up phase. Histological review out of the quality of the distracted new bone carried out art multiple phases showed most bone composed of lamellar compact bone in which pockets of bone remodeling was present. **Conclusion:** Distraction osteogenesis has established itself as the procedure of choice in a multitude of conditions owing to its versatility. This technique shows better and long lasting stability with good quality of bone.

INTRODUCTION

Mandibular reconstruction continues to be one of the most common surgical challenges faced by oral and maxillofacial surgeons. The mandible assists in speech, oral competence, mastication, deglutination and airway support; it is also a major aesthetic highlight of the face. With oro-mandibular pathology, a loss of not only bony support but also neighboring soft tissues, muscles, and nerves is frequently present. Thus, large complex defects can be created during resection. Functional and aesthetic outcomes become less favorable as the extent of resection increases. Free fibular graft continues to be gold standard and workhorse flap in reconstruction of mandibular defects. Prosthetic rehabilitation of these patients is most successful when it includes osseo-integrated dental implants. Vertical bone height augmentation utilizing distraction osteogenesis has emerged as an imperative adjunct to the rehabilitation process.

MATERIAL & METHODS

14 individuals with 12 male cases (85.71%) and 02 female cases (14.28 %) were selected. 09 patients had squamous cell carcinoma of the oral cavity (64.28 %), 03 patients were cases of GSW for secondary reconstruction (21.42%), 01 case was of vascular lesion of anterior mandible (7.14%) and 01 patient had osteogenic sarcoma of the mandible (7.14%). All the cases had undergone rehabilitation of the resected mandibular segment with vascularised free fibular grafts. The patients were within an age group ranging between 36 years to 57 years with an average age of 46 years. Individuals selected for the study were critically evaluated for:

- Clinical, radiological and biochemical evidence of being disease free in cases of malignancies.
- Feeling the necessity for the rehabilitation programme on the

- part of the individuals.
- Rule out other systemic disorders, systemic illnesses like any coagulopathies secondary to coumadin therapy, deep vein thrombosis or mechanical heart valves and hypercholesterolemia etc.
- Habits like smoking which could have compromised results were excluded.
- Obese individuals were excluded.

Preoperative investigations included the following:

- Preoperative extra oral and intra oral photographs.
- Radiological investigations included Plain radiographs (PA mandible and Orthopantomogram (OPG)) and CT imaging with 3-D image reconstruction.

Surgical armamentarium included the following:

- Standard microvascular set along with Microscope (Carl Zeiss 8X to 10 X magnification) & Operating Loupe (4X magnification)
- Distraction and Implant Kits (Fig 1).

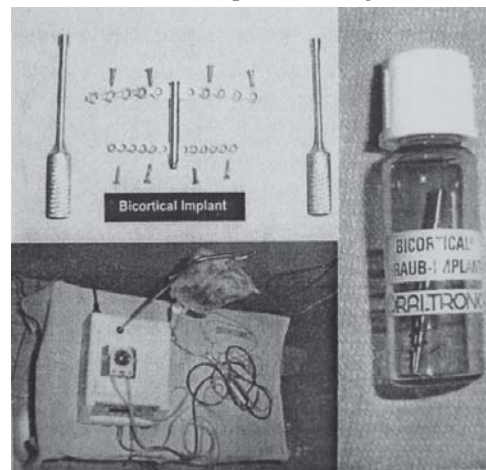


Figure 1:
Armamentarium

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Treatment Protocol

Phase 1: Vascularised fibular graft placement

Segmental Mandibular distraction was performed on fourteen patients. Incisional biopsies for all cases were performed in the Oral & Maxillofacial Surgical division for histological diagnosis. All the cases had to undergo surgical intervention with resulting gross facial deformities. All patients, other than etiology being trauma, had undergone post operative chemotherapy / radiotherapy as per indication in each case. After 6 months of follow up, on being termed disease free, these individuals underwent a secondary and tertiary surgical procedure to restore the continuity of the resected mandible with a micro-vascular fibular graft). Individuals who had sustained GSW face and had already received primary treatment for the same were referred to this centre for correction of facial asymmetry and rehabilitation with prosthesis.

Phase 2: Placement of vertical alveolar distractor after performing osteotomy of the fibular grafted bone after a phase of 6 months on ascertaining radiological evidence of graft acceptance (Fig 2). All individuals underwent distraction of the fibula using intraoral applied vertical distraction devices. The interval b/w transplantation and start of distraction osteogenesis is as per Table 1. The length of the horizontal segment required to be distracted ranged from 25 mm to 68 mm. The locations are listed as per Table 2. Distraction was carried out as per standard protocol.

Phase 3: Removal of distractors and insertion of bicortical implants 02-03 months after completion of the distraction procedure.

Phase 4: Prosthetic rehabilitation with implant tissue borne prosthesis (Fig 3).

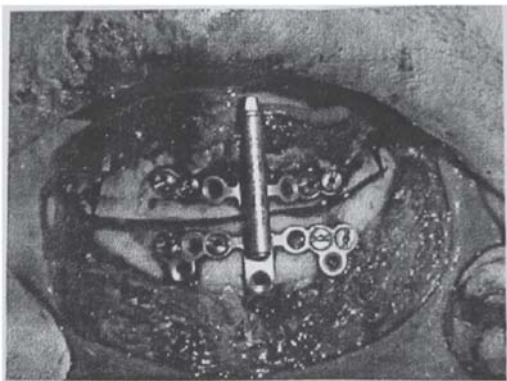


Figure 2: Placement of Intraoral Distractor

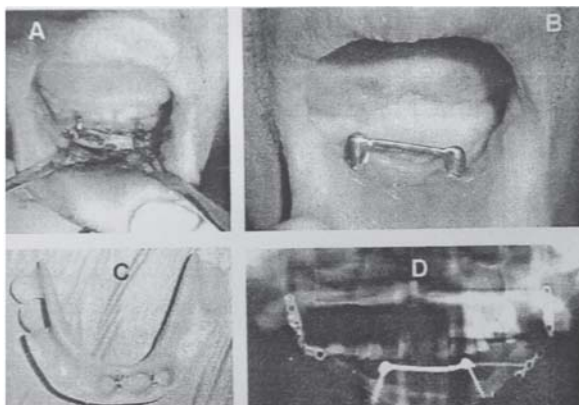


Figure 3: Prosthetic Rehabilitation With Implant Tissue Borne Prosthesis

Table 1: Age and Sex at the time of distractor implantation

Patient	Sex	Age at the time of diagnosis (Year/Month)	Diagnosis	Interval between mandibular reconstruction and distractor implantation (Month/ Days)
1.	M	46/9	SCC	7/2
2.	M	51/5	SCC	6/8
3.	M	45/1	SCC	6/1
4.	F	54/6	SCC	6/5
5.	M	53/9	SCC	6/12
6.	M	49/4	SCC	7/1
7.	M	56/10	SCC	9/4
8.	M	37/2	OS	8/1
9.	M	57/2	SCC	6/21
10.	M	54/8	SCC	6/1
11.	F	36/5	VL	6/7
12.	M	38/7	GSW	7/6
13.	M	41/8	GSW	6/20
14.	M	39/1	GSW	9/4

Table 2: Data on site of resection, distraction, size and location of the implant fixation and type of prostheses provided to the subjects of this study

Patient	Region of bone resected	Length of distracted segment	Increase in bone height (mm)	Number & Length (mm) of bicortical implants placed in distracted bone	Prosthetic solution
1		55 mm	12 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
2		51 mm	10 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
3		40 mm	11 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
4		50 mm	12 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
5		47 mm	10 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
6		50 mm	12 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
7		49 mm	12 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
8		41 mm	10 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
9		51 mm	12 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
10		59 mm	109 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
11		59 mm	109 mm	2 X 4.5 mm X 25 mm	Implant & tissue supported
12		57 mm	18 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
13		51 mm	14 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported
14	Treatment under progress	46 mm	17 mm	2 X 4.5 mm X 23 mm	Implant & tissue supported fabricated and followed up

Protocol followed for histological evaluation of distracted bone:

During the phase of information and consent subjects were explained regarding the necessity of obtaining minimal bone sample at various phases of treatment. Bone sample for histological studies were obtained to study the biological events in membranous bone during and after the phase of distraction. Samples measuring approximately 3 mm x 2mm were obtained at various stages as follows:

- a. After 5 days of latency (02 cases; 14.28%)
- b. After 5 & 21 days of latency (05 cases ; 35.71%)

- c. After 6 weeks of latency (03 cases; 21.42%)
- d. After 1 days of latency (01 case; 7.14%)

These samples were evaluated in the Dept of Pathology and Molecular Sciences by H/E stain for morphology, Masson trichone stain for collagen fibres visualization and CD 68 for osteoclasts and precursors as per the protocol laid down by Adi Rachmeli¹.

Radiographic protocol

According to the study protocol photographs, OPG and other relevant photographs were obtained pre operatively, after one week of active distraction, at the end of distraction and at the end of consolidation before placing dental implants.

RESULTS

All 14 patients who had underwent distraction of free fibular graft along with implant fixation showed satisfactory results. The amount of additional alveolar height achieved ranged between 09-18 mm clinically and on OPG 9 (Table 2). After the removal of distractor all patients received bicortical implants for prosthetic rehabilitation.

At various stages of treatment samples measuring approximately 5 mm X 3 mm were obtained. On histological evaluation the following was revealed:

After 10 days of osteotomy (Distraction + 05 days)

- a) Number of cells invading the fibrin clot increase in number
- b) Cell population found to be heterogenous
- c) Presence of both polygonal and mesenchymal like cells
- d) Presence of fibroblast like spindle shaped cells

After 26 days of osteotomy (Distraction + 21 days)

- a) Central proliferative zone (mesenchymal proliferative area) characterized by presence of many mesenchymal like cells
- b) Proximal or distal zone (trabecular minearlisation area) characterized by presence of delicate woven bone trabeculae which began to grow from the edges of the old bone.
- c) Para-central zone (collagenous fibroblastic area) present on either side of the central zone - the number of cells diminished & were being replaced with a wavy collagenous extracellular matrix.

After 56 days (Consolidation)

- a) Bony trabeculae became a mixture of thicker lamellar & woven type & were still oriented in the direction of distraction.
- b) These were partially rimmed by osteoblasts. Many osteocytes could be seen inside lacunae residing in the trabeculae.
- c) CD 68 marker revealed decreased number of positive cells & most of these cells were mature osteoclasts.

After approximately between 330 days and 360 days:

- a) Most bone was composed of lamellar compact bone in which pockets of bone remodeling was present.
- b) Parallel fibred or lamellar bone contained the characteristic ellipsoidal osteocytes with the major axis parallel to the lamellae
- c) Most osteoblasts had converted to flat bone lining cells laying down osteoid tissue.
- d) Evidence of periosteal bone formation on the surface of cortical bone.
- e) Neo-osteoid tissue deposited by osteoblasts derived from progenitor cells in the cambium layer of the periosteum which is a feature of bone healing response in stable and rigid fixation.

Results also included various parameters dealing with implant

mobility, inflammation of the mucosa and bone loss. Moreover each patient answered a questionnaire about comfort, function, esthetics and phonation after treatment. During review, each patient was evaluated for fit, retention and stability of the prosthesis provided, effect on perioral structures and masticatory experience along with psychological satisfaction with esthetics.

A comparatively longer period of adjustment to the prosthesis was required than the usual time. Averagely, all individuals required 2 - 5 weeks of routine review and functional and prosthesis adjustment in phases for total acceptance of the prostheses. At the end of three months, all the individuals had totally adjusted to the prosthesis, both functionally (mastication, phonetics etc) and esthetically.

At the completion of the study, 12 individuals (85.71 %) had more than 95% masticatory efficacy and effective phonation.

DISCUSSION

Mandibular reconstruction following trauma, infections, post radiation exposure defects, neoplasms, congenital defects, mandibular deformities as a result of ablative surgery for surgical extirpation of oral cavity carcinoma continues to be one of the most common surgical challenges faced by oral and maxillofacial surgeons. Reconstruction of mandibular defects has been revolutionized by the modern microvascular techniques. Different donor sites, such as the iliac crest, the fibula, the scapula and the radius have been proposed in the recent past with predictable long term results².

The free fibular flap was first used by Hidalgo in 1989 for reconstruction of mandibular defects and presents many advantages like sufficient length of the bony segment with adequate length of the vascular pedicle, good quality and shape of bone and good vascularization³. The main drawback is it's limited diameter/height, which when compared with the height of the mandible often leads to a considerable deficient vertical distance between the reconstructed segment and the occlusal plane of the dentate mandible. This can cause both functional and aesthetic problems⁴. Moreover, in cases with reconstructed dentate mandibles rehabilitation with implants can be challenging due to bulk of soft tissues and poor retention of the over denture⁵.

In order to overcome these problems, a number of alternative approaches like interpositional and/or onlay bone grafting, double-barrel fibula flap or distraction osteogenesis of the fibular bony flap. The development of the alveolar bone distraction device has enabled to perform vertical distraction of the fibular bone. The quality of the neogenerated bone is excellent with adequate characteristics for implant osseointegration⁶.

Alveolar distraction osteogenesis uses biologic principles described in the orthopedic literature^{7,8}. After performing an alveolar bone osteotomy, a distractor device is placed in the transport segment, which remains fully vascularized via its periosteum. Subsequently, the bony segment is subjected to gradual traction that separates it from the basal bone; this traction activates tissue growth and regeneration, forming a distraction callus that progressively matures into bone. The resultant bone mass and shape depends on the vector of distraction, mechanical forces, and the blood supply. Vertical Distractor allows the surgeon to control vertical height and soft tissue expansion necessary for endosseous implant placement. Therefore the concerns of second donor site harvesting, allograft compatibility and resorption of bone grafts can be reduced significantly⁹.

Results achieved were highly encouraging in terms of very good