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PROSTHETIC REHABILITATION OF SURGICALLY RECONSTRUCTED MANDIBLE WITH INCREASED CROWN HEIGHT SPACE

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Abstract:

The application of vascularized fibula graft has become a standard methodology in the reconstruction of sizeable maxillo-mandibular defects. Fibula graft provides bi-cortical anchorage for dental implants. However, the mobile non-keratinized tissue on bone presents with proliferation after prosthetic intervention. The large prosthetic space also poses a challenge. Excessive height of the prosthesis above the implant platform creates a vertical cantilever that magnifies torque stresses on the crestal bone. This causes an overload on the implant-bone and the abutment-implant interface. Hence, there is a high chance of loosening or fracture of connecting screw. Increased prosthetic space makes it difficult for the patient to maintain oral hygiene. This paper presents cases with the prosthetic management of fibula reconstructed jaws with various types of implant supported prostheses that provide solutions to the above-mentioned challenges.

Key words: Mandibular reconstruction, free flap fibula, implant bar overdenture, vertical cantilever, resected mandible, hybrid denture

Introduction

Large tumor resection and trauma in the head and neck region result in facial disfigurement and soft tissue mutilations. This results in unaesthetic facial forms and challenges in speech, mastication, and swallowing. The correction of the deformities of the maxilla and mandible can be done by surgical reconstruction. Prior to the introduction of microvascular reconstruction, conventional rehabilitation methods failed to re-construct the hard and soft tissues to satisfy anatomical and functional needs. Every reconstructive technique must satisfy the following key objectives:

1. Elimination of the deformity

2. Restoration of speech and mastication among other functions

3. Formation of a foundation for prosthetic reconstruction of the facial defect

4. Aesthetic reconstruction of the facial form

Microsurgical methods have resulted in tremendous improvements in oral rehabilitation by re-establishing facial appearance. Vascularized bone

grafts can be transplanted along with the muscle, skin, surrounding blood supply and innervation, which permits the simultaneous reproduction of both hard and soft tissue with satisfactory esthetic and functional results.[1] The other donor sites suggested for reconstruction of the defective jaw are radius, scapula, thoracic rib, iliac crest, and fibula. It was Taylor et al who first reported the application of the vascularized free fibula flap.[2] In 1989, Hidalgo et al modified the method for the restoration of partial mandibulectomy defects.[3] Multiple case reports have also been depicted in the literature for the use of this graft to reconstruct an assortment of maxillary defects. Currently, the vascularized fibular graft is not only the best treatment modality for mandibular reconstruction but for the maxilla also. The documented advantages of the vascularized free flap fibula are:

1. The fibular graft is viewed as one of the perfect grafts for extensive mandibular defects and is better than the iliac crest grafts, particularly in older patients
2. The bone length provided is more suitable for placement of dental implants as compared to the other graft options.[4-6]
3. The possibility of obtaining an adequately thin, broad slice of skin along with the bone graft for the reconstruction of the skin defects.
4. Its periosteal blood supply permits complete opportunity in osteotomy site choice using templates
5. Due to the distance between the two locations, a 2-team approach can be performed[4,6,7]
6. There are less chances of morbidity of the donor site

Although reconstruction of defects using vascularized free flap fibula is picking up prominence with continued developments in its techniques, it has a few difficulties. The substantial height difference between the reconstructed mandible and the intact mandible can make the prosthetic restoration of such patients very demanding.[7] Due to the reduced height of the reconstructed mandible, a large vertical prosthetic space is created from the crest to the occlusal plane. If the crown-root ratio is greater than 1:1, high leverage forces are created, which can be detrimental to the implants in cases of exclusively implant-borne super-structures, and to the supporting teeth in free-end circumstances. This can jeopardize the life span of the superstructure. Additionally, deviation of the residual mandibular segment toward the side of the defect results in an abnormal maxillo mandibular relationship and limited masticatory function.[4]

There are few available methods for compensating the increased vertical height such as double barrel technique for placement of fibula bone graft, vertical distraction osteogenesis of the fibula, placement of the graft 1cm higher than the lower border of the intact mandible and prosthetic management of the vertical height. These surgical modalities are technique sensitive and time consuming. Moreover, there is little literature describing the various prosthetic options available to decrease the crown height space and thereby increase the longevity of the graft as well as the implant placed. This paper aims at presenting the prosthetic possibilities of management of the increased crown height space with implant supported prosthesis.

Case Series

Patient 1

A 35 years old male reported to the Department of Head and Neck surgery in 2013 with the chief complaint of swelling in lower right mandible for 5 years. The clinical examination and investigations confirmed the diagnosis as ameloblastoma. Surgical resection of the lesion (segmental mandibulectomy) and reconstruction of the region

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spanning lower right canine to molar was done with free fibula flap under general anesthesia. After a period of one year, a radiograph was taken to ensure adequate union of the graft with the mandible (Fig 1). Debulking of soft tissues was done. Dental implant placement was then planned, where 3 dental implants of dimensions 3.7X11.5mm, 3.7X10mm and 3.7X13mm(Zimmer Dental Inc., Carlsbad, Calif) (Tapered Screw Vent®), in regions from first premolar to second molar was carried out (Fig 2 and 3). After 5 months of adequate osseointegration of implants, prosthetic

Patient 1

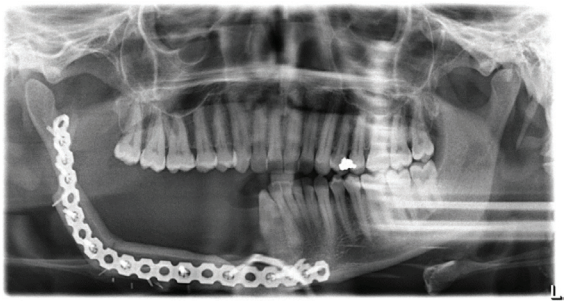

Fig 1: OPG of Fibula reconstructed

Fig 2: Measurement of the height of the bone available

Fig 3: Implant placement done and healing collars placed

Fig 4, 5: Abutment placement done

Fig 6, 7: Maxillo-mandibular relationship recorded

Fig 8: Metal try in of the hybrid denture

Fig 9, 10: Interim Prosthesis inserted

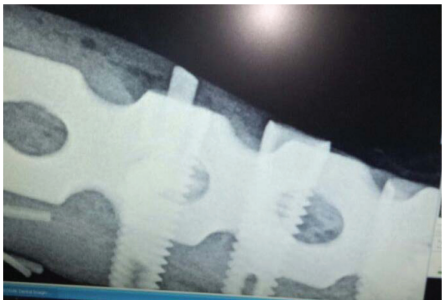

Fig 11, 12: Review of the patient showing excessive prosthetic space

rehabilitation in terms of a fixed hybrid prosthesis was planned. Split thickness graft placement and soft tissue debulking were performed to increase the sulcus around the bone and the implant (Fig 4)

In the prosthetic phase, transfer copings were attached to the implants and an impression was made using closed tray transfer method with addition silicone impression material (AQUASIL soft putty, Dentsply, India) (Fig 5). Following this maxilla-mandibular relation was recorded and a wax trial was done for the interim prosthesis (Fig 6, 7 and 8). After metal try in, the final hybrid prosthesis with metal substructure and acrylic wraparound was screwed onto the implants. (Fig 9 and 10)

The patient is followed up annually. Recently, in May 2018 the patient reported with a complaint of loosening of the prosthesis. On examination a fracture of the connecting screw in relation to the distal most implant was noticed along with screw loosening in the anterior two implants. This may have resulted due to the prosthetic design selected for the excessive prosthetic space that existed. (fig 11 and 12)

Patient 2

A 25-year-old female patient reported to the Department of Head and Neck surgery in 2016 with complaint of pain in right lower jaw and inability to open mouth. Clinical examination revealed a

Fig 13: Intra-oral view after fibula reconstruction

Fig 14: Radiographic stent

Fig 15: Radiographic stent placed intra-orally with zinc oxide eugenol markers

Fig 16: Implant placement done and healing collars placed

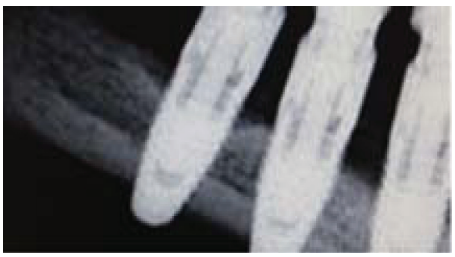

Fig 17: RVG of the placement of implants showing bi-cortical anchorage

Fig 18: Transfer copings placed

Fig 19: Verification of the placement of the transfer copings with OPG

Fig 20: Transfer copings stabilized with ligature wire and self-cure acrylic resin\

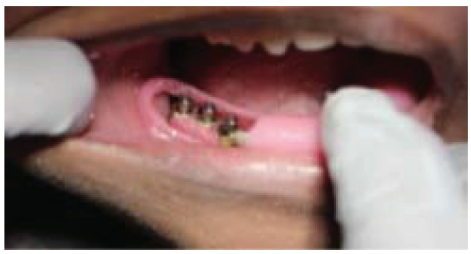

Fig 21: Verification of the position of the special tray for open tray impression

tender swelling over the right mandibular ramus. Radiographic and histopathological findings confirmed the lesion as Odontogenic keratocyst. The patient did not have any systemic disease and all routine investigations were normal.

Management:

Mandibular resection was done followed by reconstruction with free fibula flap under general anesthesia (Fig 13). After a period of 5 months, radiographic assessment was done. It showed adequate integration of the fibula flap with mandible. Implant supported fixed prosthetic rehabilitation of right mandible spanning canine to second molar region was planned. Impressions were made and jaw relations were recorded. Prosthetic space was assessed. Crown height space was found to be 17mm in the canine region and 18 mm in the premolar region. A radiographic acrylic stent was fabricated to determine the implant position. (fig 14 and 15) A cone beam CT was made. After taking into consideration the crown height space and the buccolingual relationship of the fibular graft to the opposing teeth it was decided to go ahead with a prosthetic rehabilitation using a hybrid denture with a milled bar and acrylic wrap around.

De-bulking of tissues was done prior to implant placement. 3 dental implants (Nobel BioCare Replace select® System, Zurich, Switzerland) of dimensions 4.3x13mm in relation to canine, 4.3x10mm in relation to 1st premolar and 1st molar were placed in the reconstructed mandible. (fig16 and 17) After 3 months of healing and

Fig 22: Open tray impression made and the transfer copings exposed

Fig 23: Open tray impression

Fig 24: Verification jig

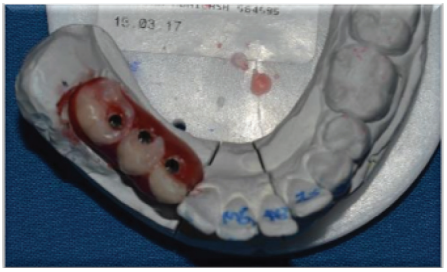

Fig 25 and 26: Wax trial of the hybrid prosthesis

Fig 27 and 28: Final prosthesis

osseointegration, prosthetic rehabilitation was done. An implant supported fixed hybrid prosthesis was planned due to the amount of inter-arch space available

Implant level impression was made with polyvinyl silicone impression material (AQUASIL soft putty, Dentsply, India), using customized open acrylic resin trays. The transfer copings were stabilized with ligature wire and pattern resin prior to impression making. The impression was poured with type IV dental stone to fabricate the definitive cast. (fig 18 – 23)

A jig trial was done to check the proper position of the abutments (Fig 24). A panoramic radiograph was taken to confirm this. Thereafter, a wax try-in was carried out (Fig 25 and 26). The final prosthesis comprising a metal framework and an acrylic wrap around with 2 premolars and a single molar was screwed into position. (fig 27 and 28)

Patient 3

A 63 years old female patient reported to the Department of Head and Neck surgery in 2016 seeking management for ameloblastoma that was diagnosed elsewhere. Further investigations revealed bony hard swelling clinically and a cystic

Fig: 29: Intra-oral photograph after fibular reconstruction

Fig 30: OPG after Fibular reconstruction

Fig 31: Implants placed

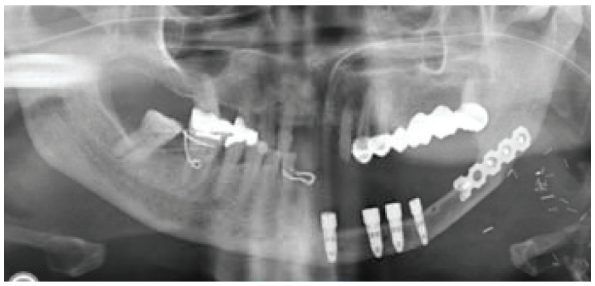

Fig 32: OPG after implant placement showing bi-cortical anchorage

Fig 33: Transfer copings placed

Fig 34: Placement of special tray for open tray transfer impression

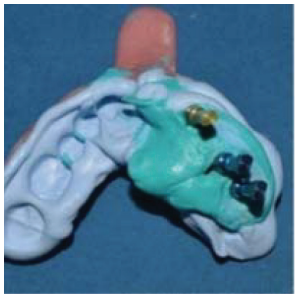

Fig 35: Open tray impression

Fig 36: Maxillo-mandibular relationship recorded

Fig 37 and 38: Interim acrylic denture with soft liner inserted

swelling with lingual expansion radiographically on left side of mandible, which confirmed the diagnosis. With all blood investigations normal, she was posted for surgery.

Management:

A left segmental mandibulectomy followed by reconstruction with free flap fibula was performed under GA (Fig 29). Radiographic assessment was done after one year which showed a adequate union of the fibula graft with mandible. (Fig 30) Impressions were made, jaw relations were recorded. Prosthetic space was measured in the cast it was found to be 23mm in the canine region and 25mm in the posterior region. Owing to an increased prosthetic space, it was decide to go ahead with a Paris bar supporting an hybrid denture retained with locator abutments. A second surgery was done under general anesthesia where vestibuloplasty and dental implant placement in relation to 31, 33, 35 and 36 regions were carried out. 4 Implants of dimensions 4.3X10mm (2) and 5X10mm (2) (Nobel Biocare Replace Select®, Zurich, Switzerland). (fig 31 and 32)

After 6 months, panaromic radiograph was taken to assess the dental implants. One implant failed to integrate. Prosthetic rehabilitation was then planned with CAD/CAM milled bar retained implant overdenture to compensate for the increased inter-arch space. Implant level impression was made using open tray transfer method with addition silicone impression material. Transfer copings were attached to the implants and secured with orthodontic wires and pattern resin (Fig 33-35). A definitive cast was fabricated with the impression made. Maxillo-mandibular relationship recording was done and an interim removable partial denture prosthesis with soft liner was inserted. (Fig 36-38)

A CAD/CAM milled Paris bar (Nobel Biocare, Procera, New Jersey, USA) was fabricated and screwed into position. A panaromic radiograph was taken to check proper seating of the bar into the implants. (fig 39 and 40) Jaw relations were recorded. (fig 41)

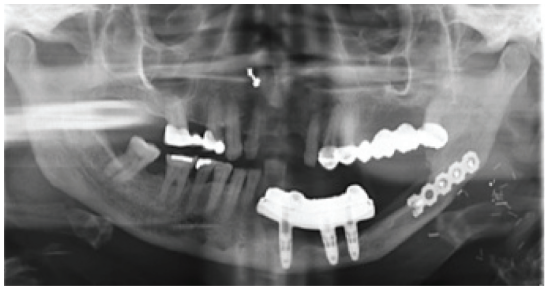

Fig 39 and 40 – CAD /CAM milled Paris bar screwed into implants and position confirmed with OPG

Fig 41 – Bite registration done

Fig 42, 43, 44 – implant bar overdenture in position

The removable supra-structure comprising of a metal framework with overlying acrylic resin replacing the lower left dentition from central incisor to first molar was inserted. (fig 42-44)

The patient continues to use the prosthesis till date without any complications.

Discussion

Reconstruction of severe maxillary and mandibular defects to restore form and function continues to be a challenge. Since being introduced in 1989 by Hidalgo, vascularized free flap fibula has been the long-standing mode of treatment of these defects. It is established that mandible withstands high amounts of load and thus it must be sturdy. This being said, fibula, being a tubular bone with a thick layer of cortex, is considered to be the sturdiest of all the vascularized grafts as portrayed in the literature. Thus it is suitable for withstanding the loaded intraosseous implants.[8] Following reconstruction of the defects, prosthetic rehabilitation is necessary for the restoration of form and function. The design of the prosthesis is based on the amount of crown height space available and fulfillment of prosthodontic criteria of support, stability, and retention.[5] The various methods in which prosthetic rehabilitation can be carried out are using removable prosthesis, implant retained overdentures, conventional implant supported prosthesis, hybrid dentures or implant supported bar overdenture.

Using removable prosthesis may create forces on the underlying bone, opposing dentition and the surrounding musculature.[6] According to the literature available, implant supported prosthesis have an excellent long-term survival and success rate (ranging from 86-99%) for implants placed in reconstructed jaws.[7-9]. Hidalgo and coworkers have reported a success rate of 100% for a series of 19 patients over a 10-year follow- up.[3] Kramer reported a success rate of 96.1% after an observation period of 1400 day.[7] Therefore, implant supported prosthesis is the preferred treatment modality.

Patient who have undergone reconstruction using fibular graft present with an increased prosthetic space. The buccolingual position of the fibula may also not be favorable owing to the anatomic differences in the contour of mandible and fibula. the prosthetic design is dependent on the available space and the position of the implants in the fibula. When the prosthetic space is more than 15mm a hybrid denture with an acrylic wrap-around a milled bar is the preferred choice. When the prosthetic space is in excess a hybrid denture can impose cantilever load on the implants, resulting in screw loosening or screw fracture When the prosthetic space is in excess of 18mm a Paris bar or similar substructures may be planned over which a hybrid denture maybe retained using a precision attachment. Figures 1- 12 show pictures of a patient who reported with a failed prosthesis with a fractured screw due to increased crown height space, and improper prosthesis design. Patient also reported difficulty in maintaining oral hygiene.

Hybrid Denture (FP-3)

A hybrid denture consists of a metal substructure with an acrylic wrap around. Studies suggest that there is an impact force generated during mastication which is well tolerated by the resiliency of the periodontal ligament fibers in natural dentition, but in cases of implant supported prosthesis, the impact of the force is tolerated by the flexibility of the implant bone anchorage.[11] It has been hypothesized that a soft layer on the prosthesis such as plastic or acrylic resin may reduce the impact forces on the implant bone interface.[10] Consequently, a metal substructure is used with an acrylic wrap-around. The treatment of edentulous or partially edentulous patients with hybrid dentures has been seen to accomplish more noteworthy masticatory work and psychological satisfaction than with regular over-dentures. Additionally, use of screw-retained prosthesis is

recommended for patients suffering from weak denture retention because this type of prosthesis can be easily placed and retrieved.[4] Apart from the said advantages, hybrid prostheses can also replace soft tissue defects. It should be kept in mind that passive fit is the prerequisite for survival of implants in bone and not achieving it leads to mechanical and biological failures. Passive fit can usually be achieved through precise laboratory work and special attention during framework. The amount of inter-arch space decides the use of hybrid prosthesis. For space of 15mm or more, a hybrid denture can be recommended. This restoration design uses a smaller metal framework, with denture teeth and acrylic to join these elements together. It is less expensive to fabricate and is highly esthetic.[12]

Implant bar overdenture (RP-4)

An implant bar overdenture is typically a three-segment structure containing the embed, over which a milled bar is put which acts a substructure for a removable acrylic prosthesis with precison attachments. This being said, it can be thought to be a fixed removable kind of prosthesis. As per M. Marinbach, there are two considerations for prosthetic height. The first is the distance between the connection framework to the crest of the bone. The higher the crown height distance, the more the stress connected to the bar, screws, and implants. The second consideration is the separation from the connection to the occlusal plane This crown height represents the increase in prosthetic stress applied to the attachment. These conditions create a higher lever activity to the prosthesis than at the implant interface and results in increased instability of the restoration during lateral forces. In such situations where there is an increased crown height space, a hybrid denture or an implant supported overdenture will act as a vertical cantilever, amplifying off-axial load at the implant abutment interface. There is also an increased possibility of tissue proliferation because of collection of debris. In addition, in a fibula reconstructed mandible, the implant abutment interface lies at a level lower than whatever is left of the dentition, because of the distance from the fibula. in order to discredit the impacts of the torsional stress on the implant, and diminish the vertical cantilever, a milled metal sub-structure can be manufactured. This also empowers uniform dissemination of forces in the implant. A removable acrylic prosthesis can be manufactured over this substructure with precision attachments. This leaves an exceptionally polished milled bar for the patient to maintain. There are a few points of interest to such a prosthesis. The close adaptation of the secondary casting to the milled bar gives additional stability and retention which is not accessible in implant supported prosthesis as well as tissue-supported prostheses. The inflexibility of the prosthesis braces the implants by splinting them together. Moreover, it is negligibly cantilevered (or lacks cantilevering), which brings about a favorable biomechanical design. Sufficient phonetics and esthetics are accomplished because of the capacity to legitimately frame palatal and labial shapes in the flexible compound. Appropriate oral cleanliness strategies can be performed by patients, and negligible soft tissue coverage by the sub-structure promotes mucosal health.

Conclusion

Excellent form and function can be achieved while using vascularized free flap fibula for the reconstruction of mandibular defects. In order to successfully rehabilitate reconstructed jaws, certain factors must be considered

1 Graft type

2 Quality of the soft tissue

3 Buccolingual relationship of the fibula to the opposing arch

4 Prosthetic space available

5 Occlusion

6 Affordability of the patient

List of Abbreviations

CAD/CAM : Computer aided designing/ Computer aided machining

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Conflict of interest statement:

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