

An Algorithm for Oro-Mandibular Reconstruction

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ABSTRACT

Segmental mandibular defect may result from tumor resection, trauma, inflammation (osteomyelitis) or from osteoradionecrosis. The defects left especially after ablative surgical procedures are composite defects associated with loss of either the outer coverage, the inner lining or both of them (oromandibular defects). Defects at the body of mandible differ from the defects at the ramus of mandible and both differ from the defects affecting the TMJ (temporomandibular) joints. Malignant defects are more difficult to be reconstructed than the benign defects especially when postoperative radiation is needed. The size of the defect affects the reconstruction option. The general condition of the patient is also a very important factor in choosing the reconstruction option. What complicates the reconstruction even more is the need to restore the function (the speech, the mastication and the oral continence) in addition to the form. This study is an attempt to put an algorithm which help translating all the previously mentioned associated factors into a surgical plan.

INTRODUCTION

Oro-mandibular defects are usually the result of ablative cancer surgery, but are also caused by trauma, infection and osteoradionecrosis. The mandible functions to provide structural support for the floor of mouth, tongue and lips and the mobile bony plate-form for the teeth, allowing chewing [1].

Mandibular defect from trauma are oftentimes straightforward as the defect is usually present prior to the reconstructive surgery. The surgeon must be aware of the potential change in mandibular and soft tissue blood supply from the trauma. Also, documentation and planning for neural deficits are critical in achieving the optimal reconstruction. Ideally definitive reconstruction should wait until all non-viable tissue has demarcated [1].

Involvement of the mandible with cancer is a diagnosis that is often made based on clinical impression supplemented by radiographic evaluation (CT scan, Panorax and MRI). Control of cancer often necessitate loss of mandibular continuity and the creation of soft tissue defects that can include

the lips, the mentum, the cheek, the floor of mouth, the tongue and the pharynx [1].

Jawar et al., [2] proposed the HCL classification system for the mandibular defects. This system provides extremely simple method of classifying the mandibular defects. Defect "C" includes the entire central mandible bearing the canine and incisive teeth. Defect "L" means lateral segment defect without affection of the condyle. Defect "H" means lateral segment defect including the condyle. In this system there are only eight possible bony defects; C, L, H, LC, HC, LCL, HCL & HCH.

To this bony classification is added soft tissue affection. When the bone only is affected the letter "o" is added. When skin is affected the letter "s" is added. When mucosa is affected, the letter "m" is added. When both skin and mucosa are affected, "sm" is added [2,3].

Anatomical classification of mandibular defects based on the location and size of the mandible and soft tissue (intraoral and cutaneous) defects is not enough to plan for reconstruction. Inclusion of associated clinical variables into the plan is very important. It is essential to clearly understand the defect pathology (benign or malignant). The patient age, co-morbidities, preference and motivation are also important. The condition of the ipsilateral neck vasculature should be known before reconstruction [1,4].

A multidisciplinary team should assess and treat the patient with an intraoral, cutaneous or osseous malignancy that will require segmental resection of the mandible. The team consists of head and neck surgeons (otolaryngologists), plastic surgeons, maxillofacial prosthodontists, radiation oncologists, medical oncologists, radiologists, pathologists, speech and occupational therapists, internists and psychologists [4].

The ideal reconstruction restores the preopera-

tive appearance and occlusive relationship, the competence of the oral sphincter and the ability to chew and swallow food and allows for dental rehabilitation and normal speech [5]. Therefore the surgeon must not only attempt to restore preoperative aesthetics but also preoperative function.

The reconstruction options include; no bony reconstruction, plate reconstruction, non-vascularized and vascularized bone grafts [1].

Segmental mandibular reconstruction by distraction osteogenesis was first tried experimentally by Costantino et al., then by Annino et al., and Jonsson and Siemssen, [6-8]. Clinical applications were then followed [10-15].

The anatomical classification that depends only on the site, size and tissue involved and ignores the associated clinical features will not provide adequate planning for reconstruction. The aim of this work is to design an algorithm that includes all anatomical and clinical variables and at the same time simplify decision-making and planning for ideal oro-mandibular reconstruction.

PATIENTS AND METHODS

We operated on twenty-four patients for mandibular reconstruction. Eight were females and sixteen were males. The etiology was traumatic in four cases all of them were males. The etiology of the mandibular defect in the rest was tumor excision. As regards the segments affected, the central segment was affected in six patients, Hemi-mandibular affection in nine cases, lateral segment affection in nine cases. In one case of hemi-mandibular affection, the skull base was affected too.

Soft tissue coverage included: free rectus abdominis and free and pedicled latissimus dorsi as mentioned before and skin paddle over the vascularized free fibula. Soft tissue lining included tongue flaps, pedicled platysma and sternomastoid flaps and free latissimus dorsi flaps.

Table (1) shows six reconstruction categories. For each category the table shows the reconstruction option, the number of cases, the defect site and size and the time of reconstruction.

In two of the three free vascularized fibulae (Fig. 1) vertical (height) distraction was done for the fibulae later on (Figs. 2,3,4). Intra-oral distractors were used.

Free vascularized rib grafts were elevated with the free latissimus dorsi flaps (osseomyocutaneous flaps).

Free non-vascularized rib and costal cartilage (12 cm) were used for hemimandibular defect in patient who refused free vascularized bone graft (Figs. 5 & 6).

Table (1)

Reconstruction category	Reconstr. option	No. of cases	Site of defect	Size of defect	Time of reconstruction
No bony Reconstruction (soft tissue only)	Free rectus abdominis muscle flap	1	H defect	12 cm	Immediate
Free vascularized bone grafts	Free vascularized fibula graft	3	1 C defects & one L defect	5,7 cm	Immediate in C & delayed in L
Free vascularized bone grafts	Free vascularized rib grafts	4	1 C defects & 2 L defects	3,4 cm	Immediate
Free non-vascularized bone grafts	Free non-vascularized rib bone	4	1 C defects & 2 L defects	4-5 cm	Immediate in C & delayed in L
Free non-vascularized bone grafts	Free non-vascularized rib/costal cartilages	3	2 L defects & one H defect	5,6 cm	Immediate in L & delayed in H
Reconstruction plates	Reconstr. plates	9	L & H defects	5-14 cm	Immediate

RESULTS

From the management of these cases and from reviewing the literature we were able to design an algorithm for management of any oro-mandibular defects. The algorithm included all variables that affect the plan for reconstruction and all the reconstruction options. We had two partial bone infections in cases of free non-vascularized bone grafts that needed debridement and healed. Exposure of the reconstruction plates occurred in two cases. Partial lining loss occurred in a case of free latissimus. The algorithm for mandibular reconstruction is as follow:

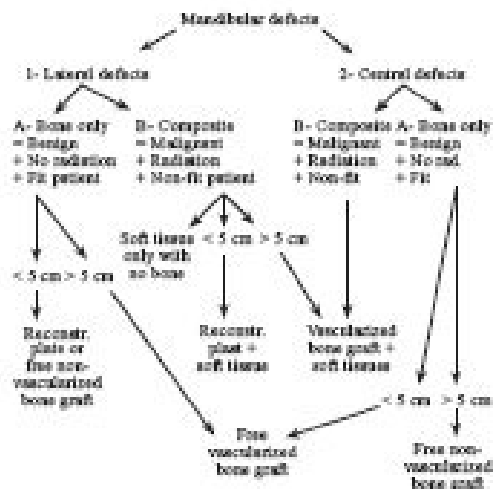




Fig. (1): Inserting free vascularized fibula graft into lateral mandibular defect.



Fig. (2): Internal distractor fixed over the vascularized fibula after horizontal osteotomy to increase the height of the reconstructed central segment.



Fig. (3): Activation of the internal distractor before closure of the wound to insure adequate osteotomy.



Fig. (4): Panoramic view to show the vascularized fibula fixed by plate and screws and the distracted segment after full distraction during the consolidation phase.



Fig. (5): Free non-vascularized costo-chondral graft shaped by reconstruction plate.



Fig. (6): Inserting the free non-vascularized costo-chondral graft into hemi-mandibular defect.

Explanation of the algorithm:

- The lateral defects in the algorithm mean the lateral segment (L) defects and the hemi-mandibular (H) defects as described by Jewer et al. [2].
- The central (C) defects include the entire central mandible bearing the canine and incisive teeth.
- Benign defects affect mainly the bone and spare the soft tissues. Sometimes soft tissues are affected as in traumatic defects. In these cases, soft tissue reconstructions are also needed.
- Malignant defects are usually composite. There will be a need to reconstruct soft tissue too. Defects are usually irradiated or will need irradiation. The general conditions of the patients are usually poor.
- Irradiated defects will not accept free non-vascularized bone grafts even if the defects are less than 5 cm in size.
- Non-irradiated defects lesser than 5 cm in size could be successfully reconstructed with free non-vascularized bone grafts.
- Defects larger than 5 cm have to be reconstructed by free vascularized bone grafts to restore preoperative aesthetics and functions. Pedicled vascularized bone grafts will restore preoperative function but not aesthetics.
- Central defects should be reconstructed by bone grafts and never by plates alone.
- Rate of hardware failure increases in lateral defects larger than 5 cm. To increase success rate, vascularized bone grafts have to be used.
- In non-fit patients, composite lateral defects can be managed by pedicled vascularized bone grafts and soft tissues, reconstruction plates and soft tissues or even by soft tissues alone (without bony reconstruction).
- The only option to reconstruct composite central defects in non-fit patients is the pedicled vascularised bone grafts if the preoperative function is to be restored.

DISCUSSION

The goals of mandibular reconstruction include normal appearance and function. The normal appearance can be obtained in most cases provided that only the mandible is missing simply by restoring the contour of the lower border of the mandible [14].

As regards the function, the patient must have not only retention and full range of motion of both temporo-mandibular joints (TMJ) but also normal muscle function and pliable soft tissue that permit

the patient to wear denture or undergo successful dental implantation. If the patient is missing not only the mandible but also the lip, the cheek, the tongue and the cervical skin, a normal appearance is highly unlikely regardless the skills of the reconstructive surgeon [14].

As mentioned above the reconstruction options include, no bony reconstruction, plate reconstruction, non-vascularized and vascularized bone grafts [1]. Distraction osteogenesis is a relatively new option [8-15].

The no bony reconstruction option was used in a hemi-mandibular mandibular defect case. The defect was managed only by soft tissue reconstruction using free rectus abdominis. The patient with this defect had skull base tumor and co-morbid condition and could not withstand long operation. This was constant with Farwell and Futran publication [1], who stated that lateral defects can be managed without bony reconstruction in patients with co-morbidities. These patients can still maintain adequate speech and swallowing but with disturbances in facial contour.

On the other hand we did not use the no reconstruction option in any of the central mandibular defects regardless the general condition of the patients. Anterior mandibular arch resection "segment C" without reconstruction, results in striking functional and aesthetic morbidity "Andy Gump deformity". These patients have major problems with oral competence, eating, speaking and swallowing [1].

Reconstruction plates were used for management of nine patients with lateral and hemi-mandibular defects. Plates allow immediate reconstruction of the mandible without donor site morbidity. The sizes of the managed defects were variable (5-14 cm). The plan was to temporary use plates in large defects in non-fit patients with possibility to secondary reconstruct the defects by bone grafts when the general condition improve. Short-term follow up was successful.

Arden et al., [17] evaluated the success rate of plate reconstruction in lateral defects against the size and extent of the original defects. This study showed that patient with losses greater than 5 cm had a dramatically increased hardware complication rate compared with those patients with smaller bony defects. The ideal patient with a less than 5 cm bony defect and small soft tissue defect had a 10% complication rate compared with an 87% complication rate in patients with larger bony and soft tissue defects.

We have never used the reconstruction plates alone to reconstruct central mandibular defects. Boyd et al., [18] found out that the greatest number of complications occurred in patients with anterior segment defects when managed by reconstruction plates alone. Whereas patient with lateral defects had only 5% failure rate, anterior defects had a 30% failure rate.

This difference in the percentage of failure rate between the central and lateral defects was hypothesized by Boyd et al., [18] to be due to two factors. The first is that disconnection of all mouth-opening muscles resulting in plate rising up and acting like a cheese cutter through the soft tissue flap or suture line. The second is that denervation of the lower lip musculature causing palulous, incontinent lips, which act by gravity to pull against and expose the plate. Therefore, they concluded that patients with anterior segment defects should be reconstructed with bone if at all possible.

Rigid mandibular fixation using a reconstruction plate permits non-vascularized bone grafting under ideal circumstances. These include small defects less than 5-6 cm, minimal or no oral contamination, no scarring or irradiation of the recipient bed and well-vascularized cover [1,20]. We used free non-vascularized iliac bone in two cases (4 & 5 cm) and free non-vascularized ribs with or without cartilages in three cases (3,6,12 cm). The 12 cm defect was not ideal for reconstruction by non-vascularized graft but the patient refused the option of vascularized bone graft and is being followed up.

Our results were satisfactory despite that other studies have shown that reconstruction using non-vascularized bone grafts is generally unreliable even when reconstruction plates are used [21,22]. These studies together with the high success rate of vascularized bone grafts, encouraged many centers to use vascularized bone grafts even under these ideal conditions [19].

We used free vascularized bone grafts in seven defects. Free vascularized fibula in three cases and free vascularized rib carried with latissimus in four cases. The results were consistent with those in the literature [23,24].

The mandibular defects were reliably reconstructed with transfers of free vascularized rib, fibula, iliac bone, radius and scapula [25-27]. Success rate of free flaps exceeds 90% even in irradiated beds [2,24,26-32].

We performed vertical distraction in horizontally

placed free vascularized fibula grafts to increase bone height for future osseointegrated dental implants. This distraction has been completed successfully using intraoral distractors. This is consistent with the distraction of free vascularized fibula grafts used for mandibular reconstruction by Siciliano et al., and Levin et al., [33,34].

Pedicle vascularized bone grafts that can be used in non-fit patients, who have co-morbidities include parietal bones, ribs and clavicles [35-38].

We did not include the distraction osteogenesis option to reconstruct mandibular defect in the algorithm because it needs second operation to remove the intervening soft tissue between the transport segment and distal stump (docking site) to achieve bone-bone union [7,8,11]. When this problem is going to be solved, distraction osteogenesis can be added to the algorithm. This will be very beneficial because this option can be used even in irradiated mandibles [39,40].

We adopted immediate reconstruction option in all but four cases. Immediate-reconstruction results in improved outcomes. By avoiding scar contraction and the unopposed muscle actions, mal-alignment of the remaining mandibular segment can be reduced. Secondary alignment and aesthetic reconstruction become significantly more challenging in this setting especially after post-operative radiation therapy. In addition primary reconstruction will preclude operating in a fibrotic tissue bed with altered vascularity. Therefore immediate single stage reconstruction is preferred over delayed [1].

In traumatic defects we used immediate reconstruction plate followed by delayed bone grafting. This delay is to be sure that all non-viable tissues were debrided before applying bone grafts. Osteomyelitis occurred in the non-vascularized bone grafts because of the poor vascularity. Loose plate is another cause of osteomyelitis. Smoking was responsible for the necrosis of distal parts of some soft tissue flaps. Radiation delayed wound healing and led to plate exposure.

There are many options for soft tissue lining and/or coverage. These options are by flaps that are either pedicled or free. Example for pedicled flaps are the forehead flaps, the temporoparietal fascial flaps, pectoralis major flaps, trapezius flaps, tongue flaps, sternomastoid flaps and platysma flaps. In this study we used the last three options; the tongue flaps, the sternomastoid flaps and platysma flaps because they are near-by, do not cross flexion areas like the neck and do not require

second operation for division. Examples for free soft tissue flaps are the radial forearm free flaps, the lateral arm free flaps, the rectus abdominis flap, the latissimus dorsi flap and the skin paddles over the vascularized fibula graft. In this study we used the rectus abdominis free flaps and the latissimus dorsi free flaps because they are expendable, easily harvested and with hidden donor sites.

This algorithm allows inclusion of all variables of mandibular defects in the reconstruction plan. It is different from the previous classification systems as the HCL classification, which is based only on site of bony and soft tissue defects. The algorithm includes the pathology, the co-morbidity and the radiation variables. The plan based on all these variables will end up with reconstruction that fulfill both aesthetic and functional goals. But we should know that the task is not easy. Not every flap success is an aesthetic triumph. Often the patient remains deformed despite an otherwise successful procedure.

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