

Concepts and Challenges in the Surgical Management of Edentulous Mandible Fractures: A Case Series

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Abstract

Keywords

- ▶ edentulous/atrophic mandible fractures
- ▶ rigid internal fixation
- ▶ load bearing and load sharing principles

Functional rehabilitation of complex edentulous or atrophic mandibular fractures is surgically demanding. The high incidence of bone fractures in geriatric age group is secondary to the loss of bone mineral content with age. So far, there is no consensus regarding the best treatment for repair of fractures of the severely atrophic mandible. Thus, the choice of treatment for such fractures should be based on the degree of atrophy, considering its inverse relationship to the amount of rigid fixation required. Hence, open reduction and internal fixation (ORIF) is considered to be a reliable method for treating the edentulous mandible fractures. The authors present a case series of patients treated with ORIF with load bearing (LB; reconstruction plate) and load sharing (LS; miniplates) principles. No complications related to infection, plate exposure, fibrous union, nonunion, and trismus, were observed.

Edentulous or atrophic mandible fractures in the geriatric group pose a surgical challenge¹ due to unfavorable conditions, like associated comorbidities; psychological issues; decreased cross-section of the bone stock; a smaller surface contact area of the fractured fragments; and the dense, sclerotic, poorly vascularized nature of the bone, leading to diminished bone regeneration capacity and delayed healing.^{2,3}

The basic aim in the fracture management, either in edentulous or edentulous patients, remains restoration of the form and function with anatomic reduction and immobilization.^{4,5} However, in edentulous patients, achieving adequate reduction is of great concern due to lack of anatomical landmarks to guide the alignment of the fragments.³ Additionally, in such cases, preventing the nutritional impairment becomes a challenge for early restoration to function, considering the masticatory load that the mandible undergoes. Over the decades, the treatment of the edentulous/atrophic mandible fractures has been controversial in regard to either advocating a conservative/closed treatment reduction or a more aggressive open reduction of these fractures. The essence of this

dispute focuses on the relevance of comorbid disease in the elderly patient resulting in an increased general anesthesia risk, as well as the compromised vascular supply of the atrophic jaw bone.^{1,6} Although the evolution of treatment has led to the replacement of closed techniques by open techniques,⁶ a controversy still persists regarding the type of osteosynthesis used for open reduction and fixation procedures. Currently, a better understanding of the biomechanics of the edentulous mandible and associated fractures support the application of a strong bone plate (with or without bone grafts) to achieve adequate stability and long-term favorable functional outcomes. The modality of osteosynthesis selected, either miniplate or reconstruction plate, depends upon the fractured site, associated displacement and height of the mandible. The plate-screw-bone assembly functions are based on the biomechanical principles of load sharing (LS) or load bearing (LB). The LS mechanism is exhibited by the plates placed across the fracture according to the Champy's ideal lines of osteosynthesis counteracting the outcome of bending, axial, and rotational forces at the fracture site. The LB principle is exhibited by the larger plates (reconstruction plates) that

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counter the shear forces at the fracture by converting them to compressive axial forces.⁷

We present a case series of four patients treated with open reduction and internal fixation (ORIF) with LB and LS principles.

Case 1

An 85-year-old male was presented with difficulty in chewing for 4 days following an alleged history of fall while climbing stairs. Associated comorbidities of hypertension, renal impairment, bronchopneumonia, and tuberculosis were managed medically.

Clinical examination revealed deviation of mouth to the right side on opening and tenderness over the right preauricular region, completely edentulous maxilla and mandible with segmental mobility in left parasymphysis region of the mandible.

Radiological findings with orthopantomogram (OPG), Posteroanterior (PA) mandible X-ray, and computed tomography (CT) were suggestive of right condylar and left parasymphysis fracture of the mandible with a bone height of 11 mm adjacent to the fracture (ORIF) site in the parasymphysis region (►Fig. 1A, B).

The planned treatment was ORIF of the fractured fragments with minimal stripping of the periosteum under local anesthesia due to the associated comorbidities. The fractured site was addressed via an intraoral approach. Anatomical reduction of the fractured segments was achieved and internal fixation was done using LS principle with one

2 mm four-holed titanium miniplate and screws. The high condylar fracture on the right side was treated conservatively by restricted mandibular movements and a soft diet for a period of 1 month (►Fig. 1C, D). A 6-month follow-up revealed adequate healing following which he was prosthetically rehabilitated with complete dentures. The patient was well satisfied with the functional outcome of the prosthesis.

Case 2

A 74-year-old female was reported with pain in the lower jaw for 10 days. History revealed alleged fall from a bike. The comorbidities of hypertension and diabetes mellitus were medically treated.

Clinical examination revealed an extraoral hematoma over the lower border of the mandible and step deformity over the body region bilaterally. An intraoral evaluation revealed completely edentulous upper and lower arches, vestibular obliteration, and segmental mobility in the bilateral body region of the mandible.

Radiological findings with OPG, PA mandible X-ray, and CT findings were suggestive of the bilateral body fracture of the edentulous mandible with the bone height near the fractured site being 5.5 mm on the right side and 3.7 mm on the left side (►Fig. 2A, B).

The surgical plan was of ORIF of the bilateral body fracture of the edentulous mandible under general anesthesia. The fractured site was exposed via an extraoral incision over the neck skin crease (►Fig. 2C). The anterior segment between the bilateral fractures was noted to be rotated

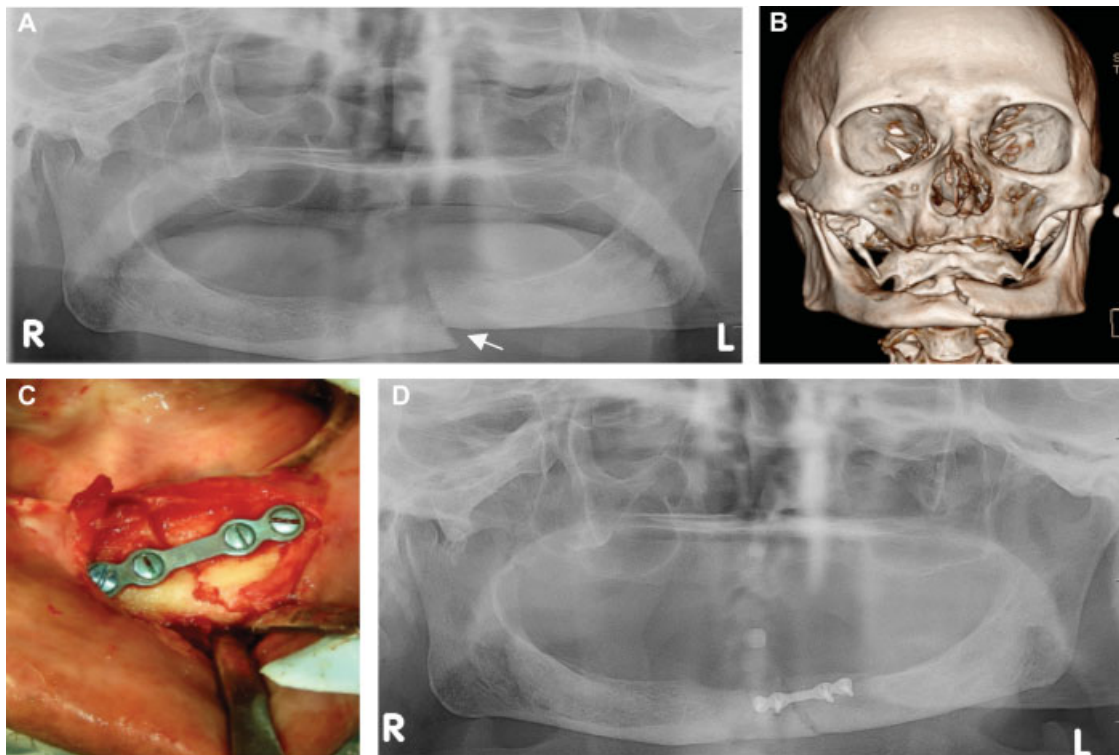


Fig. 1 (A) Preoperative orthopantomogram (arrow shows the left parasymphysis fracture site); (B) three-dimensional image showing fracture site; (C) fixation using load sharing principle; (D) postoperative orthopantomogram.

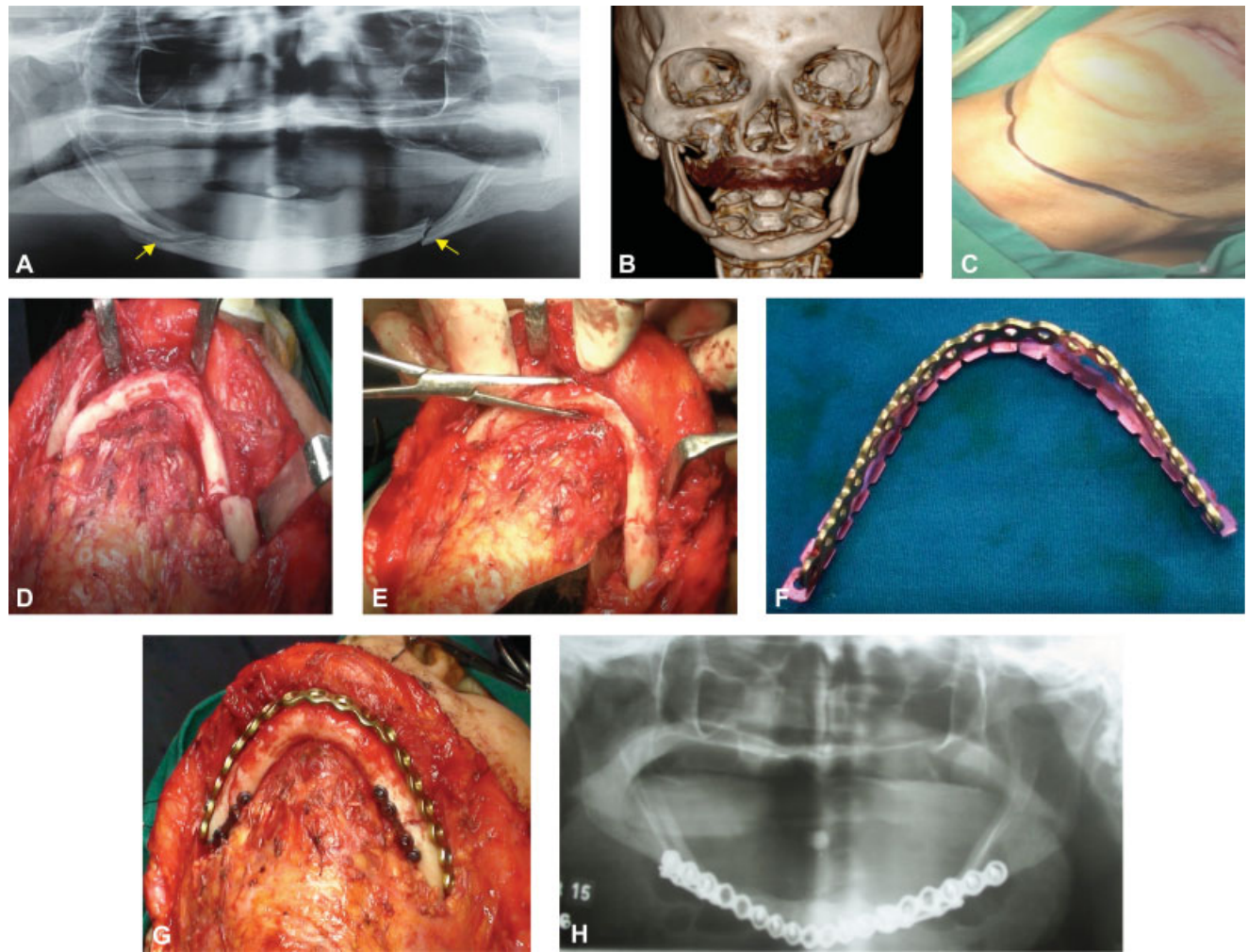


Fig. 2 (A) Preoperative orthopantomogram (arrows show bilateral body fracture site); (B) three-dimensional reconstruction image; (C) marking for the extraoral incision; (D) exposure of the fracture site; (E) reduction of the fracture segments; (F) template for recon plate contouring; (G) fixation using load bearing principle; (H) postoperative orthopantomogram.

inwards and downwards (→Fig. 2D). Anatomical reduction of the fracture segments was achieved (→Fig. 2E). A reconstruction plate was adapted as per the contour of the mandible using a template and AO (Arbeitsgemeinschaft für Osteosynthesefragen) principle (→Fig. 2F). The internal fixation was done with two 2 mm four-holed titanium miniplates and screws at the inferior border of the mandible bilaterally at the fractured site to stabilize the fragments following which fixation was done using LB principle with a 2.7 mm 18-holed titanium reconstruction plate with 6 mm screws near the inferior border of mandible (→Fig. 2G, H). The wound was closed in layers and two minovac drains were placed. A 6-month follow-up revealed excellent healing without any morbidity. The patient was rehabilitated with a modified flange complete denture to restore the function.

Case 3

A 74-year-old male was presented with pain and inability in chewing food for 3 days. As per the patient, there was an alleged history of fall from a bike, 3 days prior. Medical history

revealed that he was under medication for hypertension and diabetes mellitus.

Clinical examination revealed an extraoral hematoma and concomitant paresthesia over the chin and a step deformity over the left body region of the mandible. The intraoral evaluation revealed completely edentulous upper and lower arches and segmental mobility across the left body of the mandible.

Radiological findings with OPG, PA mandible X-ray, and CT findings were suggestive of a left body fracture of the edentulous mandible with the bone height near the fractured site being 8 mm, a right ramus fracture of the mandible and an undisplaced left zygomaticomaxillary complex fracture (ZMC; →Fig. 3A).

The treatment plan comprised of a conservative approach for the left ZMC fracture and ORIF of the left body and right ramus fracture of the mandible under general anesthesia. The fractured site was exposed through a submandibular incision. Anatomical reduction of the fracture segments was achieved. A reconstruction plate was adapted as per the contour of the mandible using a template and AO

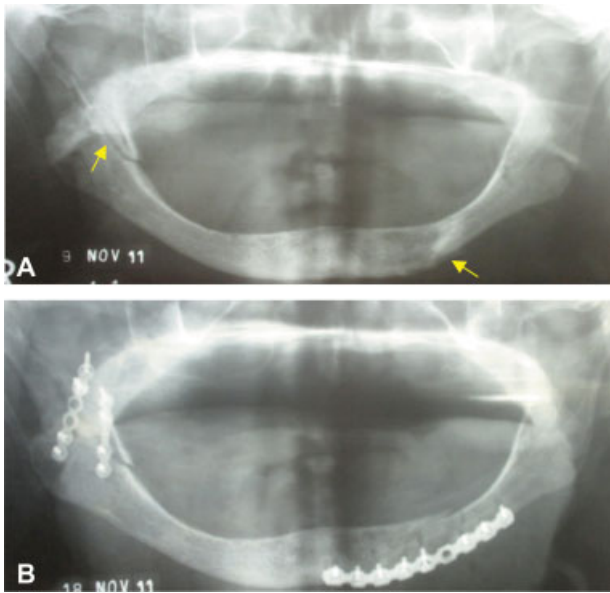


Fig. 3 (A) Preoperative orthopantamogram (arrows show left body and right ramus fracture); (B) postoperative orthopantamogram.

principle. The internal fixation of the left body fractured site was done using LB principle with a 2.5 mm eight-holed titanium reconstruction plate with 6 mm screws near the inferior border of the mandible whereas at right ramus fractured site internal fixation was performed with two miniplates, one 2 mm four-holed with gap titanium miniplate with 6 mm screws at the anterior border and one 2 mm six-holed without gap titanium miniplate with 6 mm screws at the posterior border (→ **Fig. 3B**). The wound was closed in layers. A transient facial nerve weakness was noted on the left side which resolved by 2 months postoperatively. A 1-year follow-up revealed satisfactory healing and adequate masticatory efficiency following prosthetic rehabilitation with complete dentures.

Case 4

A 68-year-old male reported with pain in the lower jaw since 1 day. On eliciting the history, it revealed that the patient had an alleged history of slip and fall in the bathroom. He was under medical treatment for urinary incontinence.

Clinical examination revealed a diffuse swelling in the left lower third of the face. The intraoral findings included an edentulous lower arch, with vestibular obliteration, tenderness, and segmental mobility in the left body region of the mandible.

Radiological findings using OPG, PA mandible X-ray, and CT findings were suggestive of a left body fracture of edentulous mandible with the bone height of 9.5 mm near the fractured site (→ **Fig. 4A**).

The treatment plan was of ORIF of the left body fracture of the edentulous mandible under general anesthesia. A sub-mandibular incision was used to expose the fractured site. Anatomical reduction of the fractured segments was achieved. The internal fixation was done using LB principle with a

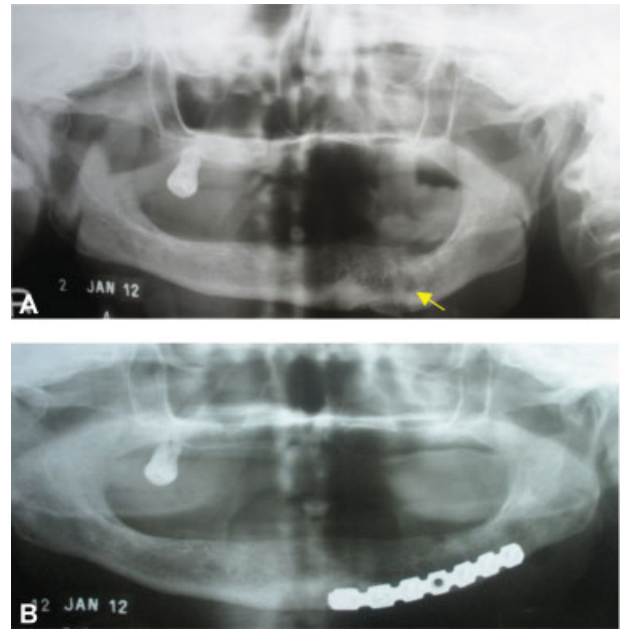


Fig. 4 (A) Preoperative orthopantamogram (arrow shows left body fracture site); (B) postoperative orthopantamogram.

2.4 mm seven-holed titanium reconstruction plate with 6 mm screws near the inferior border of the mandible (→ **Fig. 4B**). The wound was closed in layers. The prosthetic rehabilitation was done using preoperative complete denture of the patient which fitted well postoperatively.

Discussion

Atrophic edentulous mandible fractures constitute a part of facial injuries, commonly seen in the elderly individuals. A study by Mugino and colleagues noted 11 of 335 (3%) fractures to be edentulous/atrophic.⁸ Over a period of 7 years (details as mentioned in → **Table 1** and described in the cases), we encountered 4 of 608 (0.65%) fractures of the mandible to be edentulous. The age group in our series ranged from the youngest being 68-year-old to oldest being 85-year-old suggestive that the edentulism in this group makes the mandible susceptible to fracture due to the progressive resorption of alveolar bone consequent to teeth loss and the use of dentures. The common etiology of the fracture in this age group was found to be a fall, followed by violence and road traffic accidents (RTA) as reported by most of the studies. In our series, we noted that the etiological factor was a fall for three cases, whereas, RTA for one case.

Luhr and colleagues, in 1996, developed a classification for the fractured atrophic mandibles based on the bone height at the fractured site and considered a height of less than 20 mm as atrophic. Class I fractures include those in which the bone height is 16 to 20 mm, Class II fractures are 11 to 15 mm in height, and Class III fractures are less than 10 mm in height.² Fractures of the severely atrophic (< 10 mm) edentulous mandible are not common, representing less than 1 to 5% of all the mandibular fractures, as reported in most studies.⁹ In our series of four cases, three cases (0.49% of all mandible

Table 1 Details of patients with edentulous mandible fracture

Sr. no.	Age (y)	Sex	Comorbidities	Site of fracture	Associated fractures	Approach	Treatment ORIF with	Complications
1.	85	M	HTN, TB, Broncho-pneumonia	Left parasymphysis and right condyle	–	Intraoral	LS	Nil
2.	74	F	HTN	Bilateral body fracture	–	Extraoral	LB	Nil
3.	74	M	HTN, DM	Left body, right ramus	Right ZMC (managed conservatively)	Extraoral	LB + LS	Transient facial nerve weakness on left side
4.	68	M	Urinary incontinence	Left body	–	Extraoral	LB	Nil

Abbreviations: DM, diabetes mellitus; F, female; HTN, hypertension; LB, load bearing using reconstruction plate; LS, load sharing using miniplate; M, male; ORIF, open reduction and internal fixation; TB, tuberculosis; ZMC, zygomaticomaxillary complex.

fractures) were of Class III category and one case (0.16% of all mandible fractures) was of Class II category.

All the patients were intervened as quickly as was safe after their injuries with the longest delay being of 11 days. In the era of modern plating techniques, most investigators have reported infection rates approaching 4 to 7%, even after delays of 3 to 72 days.^{9–11} Some have reported a lack of correlation between delayed and successful treatment and infection, with an average treatment time of 6.2 days after injury.¹⁰

The evolution of the treatment modalities over past 70 years range from conservative/closed reduction to a more aggressive open reduction. The treatment choices primarily comprise of the closed reduction using pre-existing dentures and/or splint; skeletal fixation using external pins with or without skeletal traction; ORIF with either circumferential wiring, transosseous wiring, mesh, bone clamps, or bone plates with or without bone grafts (noncompression plates, dynamic compression plates, eccentric dynamic compression plates, and reconstruction plates).⁵

In 1940s, the use of Gunning's splint which was an alternative to the pre-existing dentures, gained popularity, either of which could be maintained with circummandibular and/or piriform aperture wiring.^{5,12,13} In 1979, Marciani and Hill, after reviewing 33 cases, put forth the recommendation of treating the fractures of the atrophic mandibular body by closed reduction.¹⁴ However, over the years, there has been an increasing incidence of complications, such as nonunion, malunion, and delay in functional recovery for over 6 months, when a closed/conservative course of treatment is advocated for such fractures.

Later, in 1993, Bruce and Ellis noted that 81.5% of 104 patients were treated with ORIF using a bone plate with satisfactory outcomes.¹⁵

In our series of four cases, one case was addressed via an intraoral approach and was treated using LS osteosynthesis principle, while three cases were addressed by an extraoral approach and were treated with LB osteosynthesis principle. There has been further discussion in the literature about an intraoral versus an extraoral approach for open reduction procedures. The advantages of an intraoral approach focus on

the ease and speed of dissection and closure¹ along with its feasibility to be performed under local anesthesia in compromised cases. However, the concomitant disadvantages include salivary contamination, visualization difficulties, and risk of inadvertent injury to the mandibular neurovascular bundle/mental foramen which may indeed lie close to the crest of the alveolar ridge in severely atrophic fractures.¹ Conversely, the advantages of an extraoral approach include excellent visualization and manipulation of the fractured site, as well as ease of thicker and stronger hardware application which indeed would take up the masticatory load thus preventing the refracture and/or incidence of nonunion. However, the disadvantages include a facial scar which often in the elderly can be hidden in a well-placed incision in a facial rhytid and a risk for facial nerve injury as encountered in one case in our series. The transient facial nerve weakness encountered was resolved by 6 months postoperatively. Ultimately, the approach to access the fracture must be tailored to the patient's case and must allow the surgeon to adequately visualize the fracture easily and easy hardware application.¹

The controversy regarding the quality of blood supply to the atrophic mandible stems from a 1975 article by Bradley. Using angiography, he documented that the inferior alveolar artery provided inconsistent supply to the atrophic mandible.¹⁶ Intrinsic impediments to successful wound healing in fractures of the atrophic edentulous mandible are reputed to include a reduced cross-sectional area of each segment at the fracture site, the diminished metabolic and cellular repair capacity of the elderly patient, preexisting osteoporosis, and a reduced blood supply with minimal marrow present surrounded by a dense cortex.⁹ Thus, the best technique for fixation in such cases involves the one that causes minimal surgical trauma while maintaining the blood supply and providing adequate stabilization and increasing the chances for bony union.

Some studies have advocated using the smallest plate available in treating the fractures, the current recommendations include using larger plates.¹ Iatrou et al concluded that a single Champy's miniplate used for reconstruction of mandibular fractures in edentulous patients may be

considered as a reliable method, with only a 3.9% reoperation rate in 51 fractures. Unfortunately, these reports provided no information on the degree of atrophy in the study patients.¹⁷ In an atrophic mandible, biomechanical analysis suggests that the body of the mandible is subjected to forces from several directions during function and also that the decreased cross-section area reduces the quantity of internal buttressing along with the resistance to oppose muscle groups of mandible, thereby lowering the LS capacity of the bone along the fracture line leading to the fracture of miniplates resulting from fatigue failure, when cyclic loading weakens the plate to the point where it fractures. As most of the load is placed on the bone plates making it necessary to either have a second plate or a larger/LB plate to counteract the stresses and strains placed on the mandible.⁴

An addition of a second miniplate can greatly strengthen the construction, with a prerequisite of adequate bone height (at least 10 mm) for the placement of two miniplates since the outer diameter of most 2.0 mm miniplates is approximately 5 mm. Even if the height is adequate to allow the placement of two miniplates, one above the other, the stability provided to the fracture by such an arrangement, although better than one plate, is not as effective as it would be in a dentate mandible based on the fact that the stability provided to a fracture construct directly correlates with the increasing distance between the plates.⁴ The AO and others have recommended the application of load-bearing fixation in the form of a reconstruction bone plate, spanning the area of the fracture, and secured in the areas of the mandible where the bone is stable and healthy. This usually means that for fractures through the atrophic body of the mandible, a reconstruction bone plate is secured with screws placed in the bone of the ramus and the symphysis. There is good reason for this recommendation. Biomechanical constructs show that as the mandible becomes more atrophic, the amount of bone buttressing that can occur along the inferior border is greatly diminished. This means that the bone along a fracture line in an atrophic mandible can share none, or very little, of the load. Thus, the bone plate must bear the entire load applied across the fracture. As a result, the smaller the bone, the larger the plate must be.⁴ According to one of the largest series of edentulous mandibular fractures found in literature, as described by Bruce and Ellis, the recommendation for the optimal treatment for this kind of fractures is open reduction accompanied by stable fixation with large osteosynthesis plates.¹⁵ In our case series, one case was treated using load sharing principle, two cases using load bearing principle, and one case using a combination of load sharing and load bearing principles.

Locking plating systems provided plates with greater stability, as well as easier plate adaptation. Currently, the locking plating system is available in the same configuration as the conventional plating system. The 2.0 locking system is an excellent option in rigidly fixating the atrophic fracture with factors favoring its ease of adaptation, excellent stability across the fracture, and significantly increased strength compared with a conventional 2.0 miniplate. Ellis and Price⁴ recommended this plate with six holes, three bicortical screws on

either side of the fracture, located at the inferior border of the jaw to provide strong and stable reduction.^{1,4}

In the severely atrophic mandible, the tension and compression lines merge at the level of the inferior alveolar canal, and a single stiff bone plate at either the lateral or inferior border of the mandible is sufficiently strong to maintain stabilization.⁹ In 2006, Madsen and Haug published an article with a biomechanical focus comparing the placement of a reconstruction plate placed along the inferior border of the mandible versus one placed along the lateral border of the mandible for simulated atrophic mandibles. In this study, there were no significant differences between the two groups.¹⁸

In 2015, Flores-Hidalgo et al reviewed 11 cases treated with reconstruction plates and locking screws placed at lateral border of mandible with or without autogenous bone graft. They concluded it to be an effective procedure with no major complications.¹⁹

In 2011, Müller et al reported a need for removal of the macro plates (reconstruction plates) in 5 of 18 patients for the need of prosthetic rehabilitation.²⁰ In the present case series, all four patients were rehabilitated with dentures following the surgical intervention. ORIF concept institutes accurate anatomic reduction and rigid fixation. Application of a single reconstruction plate near the inferior border of mandible minimizes the incidence of functional disturbances of inferior alveolar neurovascular bundles and does not interfere with prosthetic rehabilitation of the patient.⁹ The masticatory functional efficacy is improvised as it does not demand much modification of the complete dentures and also permits the use of implants and implant supported prosthesis. All of which adds to a better health of the geriatric individuals contributing to the overall quality of life of the patients.

The most common site of fracture in edentulous mandibles is the mandibular body. Understandably, fibrous union or nonunion arises most frequently at this site, especially when the amount of the residual mandible is less than 20 mm (particularly < 10 mm).⁴ In 2006, Wittwer et al reviewed their outcomes of the treatment of 30 patients treated with different plating systems, they concluded that the more atrophic a fractured mandible is, the more rigid the fixation of the fracture needed to be.¹⁰ Tiwana et al, in 2009, suggested that for ideal healing of edentulous/atrophic mandible fractures, bone grafting is needed in addition to a large reconstruction plate and a bone graft.²¹ Nonunion and fibrous union were and are a well-recognized complication when treating these patients.⁶ Bruce and Strachan stated that there was a 20% incidence of nonunion after treatment of these types of fractures.²² Bruce and Ellis reported either delayed or fibrous union in 21 of 167 (12.6%) fractures of the edentulous are mandible.¹⁵

In our case series, all the patients received appropriate antibiotics, analgesics, nutritional supplements of protein, and multivitamins and chest physiotherapy. Transient facial nerve weakness was observed in one patient but otherwise no incidence of infection, paresthesia, and nonunion of

fractured fragments were reported over 1-year follow-up period for all patients.

Conclusion

To conclude, the present case series demonstrates the less frequency of edentulous mandible fractures which are commonly seen in geriatric group presenting with multiple complex comorbidities which needs detailed evaluation, specific consideration of the alveolar bone height available for treatment planning of load sharing, and load bearing concepts as seen in our case series to seek good functional outcome and minimal morbidity.

Conflicts of Interest

All the authors declare that there is no conflict of interest regarding the publication of this paper.

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