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Internal Fixations of Mandibular Angle Fracture

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Abstract

This study was done to review various internal fixation methods for the treatment of Mandibular angle fractures. It reviewed: 1) the epidemiology, 2) the aetiology, 3) the cross-section area of the angle along with presence and absence of mandibular 3rd molar, 4) the biomechanics of the angle, 5) the history of management of MAF's, 6) the miniplates, 7) the approaches and 8) the strut plates. The current trends in treating a mandibular angle fracture is to use a single miniplate at the superior border for favourable angle fractures and 3D strut plates via a trans-buccal approach using trocar for unfavourable angle fractures.

Keywords: Mandibular angle fractures, Mandibular third molars, Miniplates, Strut plates.

Abbreviations

- AO– Arbeitsgemeinschaft für Osteosynthesefragen
- 3D – Three dimensional
- MAF – Mandibular angle fractures
- MMF – Maxillomandibular fixation
- M3 – Mandibular third molars

Introduction

In conjunction with the development of civilizations and human society, accidents have become more frequent[1]. The urbanization and industrialization of modern society has led to an increase in the population and traffic leading to greater possibilities of maxillofacial trauma. Along with the nasal bone, the mandible is one of the most fracture prone facial bones due to its projection and prominent position[2]. The exposed portion of the human head in relation to the body seems to be the reason why the facial skeleton is frequently affected in traumatic events[3]. Mandibular fractures comprise most of the traumatic injuries which are treated by oral & maxillofacial surgeons. The most common etiological factors are road traffic accidents (45.3%), falls (42.6%), assaults (8.9%), sport injuries (2.2%) and gun-shot wounds (0.89%)[3]. Before 1980's, open reduction of mandibular angle fractures was controlled trans-orally with a 24 -gauge wire secured at the superior border plus 6 weeks of IMF. When wiring became troublesome, the

surgeon often approached the fracture trans facially increasing the time spent in the operation room leading to potential complications. The availability of non-rigid plates in 1980's facilitated fragmentary control and access, better than wires[4]. Towards the end of 1980, a clear change appeared in the fracture treatment and during the course of this decade, the type of osteosynthesis changed from wire and miniplates to compression plates and lag screws. A variety of different treatment modalities for the management of mandibular angle fractures by surgical reduction and fixation have been described which includes closed or open reduction, extraoral open reduction and fixation with reconstruction plate, intra-oral open reduction and fixation using different mini-dynamic compression or non-compression plate[5]. Recently, the miniplate fixation method has most often been applied because of its procedural simplicity and good clinical outcomes. Furthermore, efforts have been made to assist functional healing and minimize post-operative complications. Osteosynthesis compression was invented by Luhr in 1968. Later, Michelet introduced the use of non-compression plates and mono-cortical screws for the treatment of mandibular angle fractures in 1973. Champy et al asserted that the most stable fixation of the mandible could be achieved by placing a single miniplate and screws along the superior border of the mandible following the ideal line of osteosynthesis. This technique results in no external scarring and injury to marginal mandibular nerve plus it also allows direct visualization and confirmation of occlusion during plate placement. Despite many advances in internal fixation, angle fractures remain among the most difficult and unpredictable fractures to treat compared with other areas of the mandible. A lot of debate regarding the approach and the design of plate for treating mandibular angle fractures has been seen in the literature. The aim of the treatment was always to restore the anatomical form and function as well as establishing the pre-operative occlusion. The short comings of rigid fixation and semi-rigid fixation led to development of 3D miniplates (strut plates) whose geometry conceptually allowed stability in 3 dimensions and resistance against torque forces while maintaining a low profile and malleability. This study evaluates the various modalities of internal fixations for treatment of mandibular angle fractures.

Discussion

Mandibular fractures aren't uncommon and have increased significantly in the last decade accounting for 23 to 42% of all facial fractures[6,7]. According to Essam Ahmed Al-Moraissi and Edward Ellis, the Mandibular angle fractures are the most common mandibular fractures in developed countries comprising 30% of all of them[8,9]. Among mandibular fractures, the angle is the first most frequent region for fractures caused by sports activities, second most frequent region for fractures caused by violence and third most fractured region in cases of traffic accidents involving automobiles[8]. According to Ashish Vyas et al. and Heidrun Schaaf et al. the most frequent cause of fracture was road traffic accident (RTA), followed by falls, assaults, sport injuries and least commonly gun-shot wounds[5,10]. The angle of the mandible is more prone for injury due to its thin cross-section area, presence of 3rd molars and bone thickness in the angle region[7,11,12].

The occurrence of mandibular angle fracture is usually related to factors such as direction and severity of the impact, presence of soft tissue bulk, occlusal loading pattern and biomechanical characteristics such as bone density, bone mass and weak regions of anatomic structures. The mandibular angle forms the junction between the ramus and the body because of which its

commonly associated with 3rd molars (M3s). The association between M3s and MAF is believed to be due to the impacted M3s occupying more osseous space in the jaw that would otherwise be occupied by bone, thereby decreasing the quantity of the bone and weakening the mandibular angle which was supported by Reitzik et al[13]. According to Rahimi-Nedjat et al. and Lida et al. the MAF's were more likely to occur with the presence of retained M3's, which might be due to decreased bone mass. The presence of M3's markedly decreases the tensile strength of bone and encourages the propagation of fracture along the least resistant path. The external oblique ridge provides a pillar of strength for the mandible in that region of the jaw. When the M3's are completely in occlusion, the external oblique ridge remains intact and when the M3's are partially impacted, the tension line can be disrupted, weakening the mandibular angle and making it more susceptible to fracture. Fuselier et al. said that angle fractures are more common with mesioangluar M3's, whereas Ma'aita and Alwrikat found higher risk associated with vertical distoangular angulations, Choi et al reported the risk of MAF's as highest in class IIB and Gaddipati et al[13] reported it to be highest in class IIA[13].

Aside from M3 presence and position, other factors may influence the risk of angle fractures, such as the character of the soft tissues adjacent to the mandible and the state of remaining dentition. The pterygomasseteric muscle sling provides protection against the traumatic forces to the angle region of the jaw. 3D study by Tams et al. characterized the biomechanical properties of the mandible during angle fractures which showed the angle region as having the greatest amount of positive bending moment (resulting in tension at the alveolus and compression at the inferior border), a small amount of torsion (resulting in proximal segment being lingually displaced and the distal fragment being buccaly displaced), and the greatest amount of shear force (caudal displacement of the proximal segment and cranial displacement of distal segment)[14]. According to Jose Luis Munante-Cardenas and Luis Augusto Passeri[15] the angle possessed some particular features which differentiated it from other mandibular areas, such as reduced section area at the fracture line and the presence of impacted teeth. They found that two parallel miniplate techniques had statistically greater resistance to compression loads than the Champy technique and 3D fixation systems which was in slight accordance to the study carried out by D.M.C Gonzales, G Spagnol, C.E Sverzut and A.E. Trivellato[16.] It also showed that 3D plates positioned on the oblique line can be a good alternative in the treatment of angle fractures and also that more studies need to be done to confirm the advantages of using a 3D plate on the oblique line. On the other hand, a study by Alper Alkan et al showed that not only dual miniplates technique but even 3D strut plates had greater resistance to compression loads than the Champy technique[17].

Francois X. Michelet was the first person who described fixation with plates in the 1970's. Francois X. Michelet, J. Deymes and B. Dessus et al[18]. described Stellite plates of various lengths like 12,18, 25 mm and width 4 mm which had 4 holes and were fixed to the outer osseous layer. The advantages of these plates were that it provided intra-oral access to the fracture site for osteotomy preventing skin scar, possibility of watching simultaneously the reduction of fragments, restoration of occlusion and having an excellent tolerance of osteosynthesis material and strength of the device at the level of the facial bones. According to Edward Ellis, the functional forces need to be neutralized by restoring the tension and compression trajectories in the mandible. So, the AO Reconstruction bone plate was introduced which is a reinforced plate that is thicker and stronger than the AO compression bone plate. It comes

with pre-bent areas for use in the mandibular angle. The plate is 3-dimensionally bendable allowing accurate contouring to the surface of the mandible. The use of 3 screws on each side of the fracture with this bone plate provides adequate neutralization of functional forces in the absence of compression. It is useful in areas of comminution, bone loss, or obliquity where using standard compression plate isn't feasible[19]. According to R. Bryan Bell and David M. Wilson, the use of arch bars for intra-operative MMF has been a time-honored and reliable technique which helps in reduction and stability of the plate. It also helps the occlusion which maybe controlled post-operatively with elastic bands or MMF. However, the disadvantages are that its time consuming and there is a risk of skin puncture which can result in disease transmission to the surgeon. The use of arch bars as an aid to open reduction, stabilization, and fixation is not always necessary for successful outcomes. So, the clinician should select the appropriate technique based on the patient's injury pattern and expected compliance, as well as the treating surgeon's experience and available resources[20]. Mathieu Laurentjoye, Claire Majoufre-Lefehvre, Philippe Caix, Francois Siberchicot and Anne-Sophie Ricard used a technique which was described by Michelet et al and its scientific foundations were laid down by Champy et al. The method was semi-rigid fixation after perfect manual anatomical and functional reduction with a 3-dimensional biomechanical justification. Korkmaz confirmed the advantages of a 2-plate system to produce a more stable condition in mandibular body fractures. This technique reduced the operating time and the risk of complications as well[21]. David R. Kang and Michael Zide, introduced the 7 angle plates which are long and flat with 7 holes designed to be applied at the inferior border of the angle. Its access was easier than a 2-plate technique or the strut plate because of its placement on the superior border of the mandible. Indications for using the plate were given as a) failure to reduce/fixate a malleable plate using the champy technique; b) secondary fractures, Eg: condylar fracture necessitating rehabilitation; c) bone loss from extraction of 3rd molar, d) loss of posterior support, no posterior occlusion, e) diminished bone stock as in a partially edentulous mandible, f) traumatic or inflammatory bone loss, g) late fracture treatment , obliquity or instability, g) social issues suggesting the need for greater stability of the fracture and h) infection of fracture requiring more rigid fixation. They summarized it by saying that this plate eliminates the complexity of a 2-plate technique or the facial scar and nerve risk of AO rigid plate fixation transfacially[4].

The use of non-compression monocortical miniplate fixation for the osteosynthesis of mandibular fractures was advocated by Michelet and Champy in the 1970s and Champy said that the plate should be fixed on the superior border for successful outcomes[6]. The management of MAF's has been controversial due to its anatomic relations and complex biomechanical aspects including thin cross-sectional area, abrupt change in curvature, attachment of masticatory muscles and presence of 3rd molars[9]. The cost of 2 miniplates in addition to extra time for the surgery and expenses point to the fact that 2 miniplates isn't a necessity for treating angle fractures[5]. According to Edward Ellis[22], time taken for placing a single miniplate was less as compared to 2 miniplates plus the placement of 2nd plate at the inferior border requires more experience to become facile. Biomechanical tests have favored the 2 miniplate system but various studies have shown the 2 miniplates to have more complications compared to the single miniplate system which showed that biomechanical tests can't be trusted alone. The 2 miniplate system showed high rate of wound dehiscence,

infection, exposed hardware and bone which could be due to greater periosteal and muscle stripping in the angle region compromising the blood supply and healing. This was dissimilar to the single miniplate system and fortunately it was also the system which was found easy to master and offered best results[9,22]. The current trends use a single non-compression 2.0mm miniplate with mono-cortical screws at the superior border. According to Heidrun Schaaf et al. the lag-screw highlighted the possibility for primary bone healing and when the screws are aligned in a position perpendicular to the fracture line, the fracture segments are forced together, resulting in primary bone healing and this method offers internal fixation for the tension zone of the mandible with good compression on the fragments to support bone healing. Treatment with a solitary lag screw resulted in a lower duration of surgical intervention than that for the miniplate method and it also demonstrated a smaller fracture gap concluding that the lag screw application seems to be a more delicate surgical intervention than the fixation using miniplates[5].

Champy's miniplate has been widely used for the treatment of mandibular angle fractures as it utilizes a single miniplate placed along the superior border which acts a tension zone. However, the superior border tension zone is seen only when the load is applied along the incisal edge. To overcome these disadvantages, 3D strut plates were developed. It consists of two 4-holed miniplates joined by 4 inter-connecting cross struts which provides room for additional screws placement adding to torsion and 3D stability of the fracture. The ease of application, simplified adaptation to the bone without distortion or displacement of the fracture and the simultaneous stabilization at both superior and inferior borders are also few advantages over the conventional miniplates. According to Vineeth et al. there were more fracture instability with the miniplates as compared to the strut plates and the opening up of the lower border with some displacement of fragments has been an issue with the conventional miniplates. This plate should be used in the neutral zone (between tension and compression areas) of the mandibular angle which virtually allows no torsional movements at the region of the fracture. At the superior border, the miniplates cause bending and torsional forces which cause movement in the in the long axis of the plate, leading to an enlargement of the fracture gap at the inferior border of the mandible and bucco-lingual splaying of the mandible superiorly[23]. Recently, the 3D 2.0 mm eight holed strut plate system has been used in several centres and has shown very promising data[24]. In MAF's, it has been demonstrated that the best site for plating has been is the vestibular osseous flat part located in the 3rd molar region, which will counteract the muscular forces that act naturally to distract the fragments. Champy et al recommended a single non-compression miniplate ventral to the oblique line for MAF, but as it leads to the opening of the fracture line at the lower border, lateral displacement of the fragments at the inferior border, and posterior open bite on the fracture side. Wound dehiscence was seen to be higher with the miniplates as compared to the 3D plates as it may be related to the proximity of the standard incision, when placed on the external oblique ridge line according to the Champy technique. It's rarely seen with the 3D plate as it is covered by the masseter along the buccal cortex, well away from the incision[8]. In the angular region, the powerful elevator muscles that are attached to the ramus transfer their forces to the body of the mandible and this creates great demands on fixation if the rigidity under a functional load is to be maintained. Saguira et al. said that adequate stability couldn't be obtained with a single miniplate and the use of a second miniplate was suggested

to reduce anterior-posterior separation of the fracture line as well as lateral displacement. The second miniplate theoretically establishes a second line of osteosynthesis which protects the fracture site against torsion, bending, and provides increased stability. The thread-lock 3D plates with locking screws were proposed in the locking bone/screw system where the screws are unlikely to loosen from the bone plate and there is decreased incidence of inflammatory complications associated with loosening of hardware. This system requires less precision, adaptation of plate to underlying bone and decreases the chance of screw stripping with associated complications. The advantages that 3D plate has over 2 miniplates are high fracture fragment stability, harmonious occlusion, early return of the patient to his/her normal social life and function, overcoming all the shortcomings of single miniplate satisfying the biomechanical requirements for occlusal loading[25]. According to Sebastian Herbert Hofer et al. the 3D miniplates (grid plates) have many advantages like easy intra-oral fitting, simple adaptation on bone without distortion or displacement of the fracture as well as simultaneous stabilization of tension and compression zones over the miniplates[26].

Extra-oral approach has been used for angle fractures, but they have potential disadvantage of leaving an unaesthetic scar and damage to the facial nerve. However, the advantages have been easy access, direct visualization, better exposure and direct application of plate fixation. The trans-buccal approach is advocated because it results in no external scar, allows direct visualization and confirmation of the proper occlusion during the placement of bone plates. Decision regarding the treatment approaches for ORIF of angle fractures is based on the type of fracture, amount of displacement of fractured segments, number of fractured segments, ease of accessibility and visibility, perfect anatomic reduction of the segments, perpendicular application of drilling device for fixation and approach related complications. Extra-oral approach was once the popular approach towards the management of mandibular angle fractures as compared to the trans-oral approach which was first given by Kazanjian in 1933. However, due to the increasing aesthetic demands of the patient and avoidance of external scar, trans-oral approach has overcome the extra-oral approach in the treatment of MAF's. The fracture line starting anterior to mandibular third molar and ending at antero-inferior border of the insertion of the masseter muscle or posterior body of the mandible can be approached trans-orally. When the fracture line starts; a) posterior or distal to the 3rd molar, b) posterior to the insertion of the masseter muscle c) fracture line extending high in ramus, d) highly unfavourable angle fractures, e) oblique angle fractures, f) muscle entrapment between the fractured segments and g) when there is existing laceration, extra-oral approach is a better choice for reduction and fixation[27]. The trans-buccal approach is indicated for bilateral favourable angle fractures as it results in less inconspicuous scar formation, allows direct visualization of fracture site, confirmation of occlusion status during placement of bone plates and relatively low risk of facial nerve injury. The intra-oral approach is good when treating favourable angle fractures with adequate mouth opening, in female patients and young individuals to prevent the post-surgical scar[28]. Trans-buccal trocar placement is widely used for drill placement and fixation in the reconstruction of mandibular angle fractures and stabilization of the mobilized segments during sagittal split osteotomy procedures. Despite the advantages of this approach, it has been suggested that trans-buccal trocar technique has limitations. Trans-buccal trocar placement is technique sensitive and the surgeon has to be familiar

with the armamentarium and be skilled in the use of the trocar cannula.

Miniplates are being placed along the superior border where they act as tension zones. But they carry a disadvantage that the superior border tension zones are only seen when the load is applied along the incisal edge and to overcome these disadvantages, 3D strut plates were developed. With the ease of application, simplified adaptation to the bone without distortion or displacement of the fracture and simultaneous stabilization at both superior and inferior borders, the strut plates are slowly taking over the miniplates for the internal fixation of MAF's.

Conclusion

This study concluded that:

- For managing favorable angle fractures, a single miniplate placed at the superior border on the external oblique ridge is sufficient.
- For managing unfavorable angle fractures, 3D Strut plate via trans-buccal approach with trocar is sufficient.

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