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Different Osteosynthesis devices used in fixation of anterior mandibular fracture: review article

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Abstract

Symphysis/ parasymphysis, fracture represents most encountered casualties of the mandibular fractures alone or in combination with other sites. The aim of any fracture intervention should be to reestablish pre-fracture function and aesthetic.

Currently, Open reduction internal fixation (ORIF) is the method of choice for symphysis and parasymphysis fracture region because it is considered a challenging area due to torsional variable directional forces and muscle pull. Many studies investigate the use of different Osteosynthesis devices starting from stainless steel wiring, miniplates, rigid plates (heavy locking and non-locking), and lag screws. However locking miniplate involves higher costs, and they are not designed to replace the heavier plates designed for complex continuity defect fractures.

Although comparisons of clinical and radiographic treatment outcome exist, the choice for the ideal device still needs to be experienced, knowledgeable surgeon. Therefore the purpose of this study was to review and clarify the use of different Osteosynthesis devices used in the treatment of mandibular symphysis/parasymphysis fractures.

Keywords: symphysis, parasymphysis, mandibular

Review of Literature

Mandibular fractures management occupies a considerable percentage of the clinical workload for Oral and Maxillofacial Surgeons. It represents about 40 to 62 % of all facial fractures.[1-3]

Symphyseal and parasymphyseal fracture is one of the most frequently fractured regions with a frequency of 9% to 57%[4-6]. Ellis and walker[7] studied 3462 cases of mandibular fractures and reported that the distribution of the fracture sites were 33 % involving the body, 29.3 % in the condylar region, 23.1 % in the angle, 8.4 % in the symphysis, 2.6 % in the ramus, 2.2 % in the coronoid process and 1.4 % in the alveolus.

The results of a study created at the Department of Oral and Maxillofacial Surgery, Cairo University over one year (1996-1997) reported that the majority of facial fractures occur in males of age 21-30 years. Also, it showed that the incidence of mandibular fractures (85.9%) is higher than that of mid-face fractures (41.1%). The most frequent location in mandibular fractures was parasymphyseal area (33.9%). The most common etiologic factors in descending order were road traffic accidents, falls, sports, fights, associated with direct and indirect chin trauma and this agree with many other articles.[8-13]

There are many Classifications used for mandibular fracture identification however the most usable one is that classify According to the location: symphysis, parasymphysis, body, angle, Region of the ramus, condylar process and coronoid process. According to WHO/1997, 2003 the international classification of mandibular fractures is: alveolar fracture, body fracture, fracture condyle, coronoid fracture, ramus fracture, fracture symphysis, fracture angle and multiple fracture mandibles.[14]

Diagnosis

For diagnosis of mandibular anterior fracture, the physical examination as with trauma patient begins with the application of the advanced trauma life support (ATLS) protocol as a primary survey which was originally introduced by the American College of Surgeons Committee of trauma. It includes evaluation of the patient's airway, breathing, circulation, disability, and exposure (ABCD &E). This survey is necessary to control the life-threatening conditions that should be managed first before any definitive repair of facial fractures. After ensuring the patient's stability by the primary survey a secondary survey is carried out to accurately diagnose the injuries, maintenance of the stable state and determine priorities in treatment. Then the clinical examination is completed by a combination of inspection, palpation, auscultation, and percussion.[15] More severe impact over the symphysis can lead to considerable disruption of the anatomy.[16]

Radiographic evaluation

The overall management of patients with facial bone fractures has been considerably influenced by advances in radiology and imaging during recent years, although CT scan is now widely available, the

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majority of facial bone fractures can be diagnosed from conventional radiographs and tomograms. Computer software can be used to generate a 3- dimensional C T imaging.[17]

Fracture healing

The concept of bone healing differs according to the treatment method and means of fixation of the fracture.[18] The indirect bone healing (healing by secondary intention) is the only natural mean of fracture healing. It is seen in spontaneous bone healing without surgical intervention or healing after non-rigid fixation (MMF, interosseous wiring) or semi-rigid fixation (miniplates).[19] These means of fixation allows some degree of interfragmentary mobility with muscles activity during swallowing or yawing.[20] The steps of indirect bone healing have been well defined by an initial stage of hematoma, cellular proliferation and fibroblast invasion followed by the soft cartilaginous callus which then classifies into woven bone known as the bony hard callus. The last step is remodeling in which woven bone slowly restructures into the lamellar bone.[19] Radiographically, the indirect bone healing is characterized by the appearance of callus and initial resorption of bone ends. The extent of callus formation depends on several factors including location, displacement, degree, and type of bone fracture, devitalization of bone segments, injury to vascular channels and surrounding soft tissue as well as the degree of reduction and stabilization. The healing process by secondary intention takes a longer time and is more liable to complications.[21]

When using means of fixation which allow for absolute interfragmentary immobilization as RIF, direct bone healing (healing by primary intention) is observed without danger of infection, delayed union, malunion, or nonunion.[21] Histologically, direct bone healing is characterized by intracortical remodeling across the fracture site whereby new Haversian system gradually replaces the fractured bone cortex. Radiologically, no resorption of the fragment ends and no callus formation was observed. Direct bone healing allows immediate pain-free treatment, shorter hospital stay and earlier return to function.[19] Direct bone healing has two forms; contact and gap healing. Schilli[22] described for the first time in 1963 the so-called contact healing which was observed under stable osteosynthesis. Contact healing occurs by longitudinal growth of capillaries and osteogenic cells across the fracture line by way of cortical tunnels.

Danis[23] was the first to advocate the use of compression for stabilization of bone fracture as axial compression yields tight approximation of the fragments at the fracture site thus bone healing occurs without external callus formation. Many investigators concluded that compression produces absolute stability across the fracture site leading to direct bone healing and they claimed that compression stimulates osteogenesis. On the other hand, under optimal rigid compression, Luhr[24] observed gap healing as microscopically small gaps were seen between the irregular fracture ends. Reitzik and School[25] noted that no primary bone healing was observed when a gap of 0.8 mm occurred between cortical edges and a callus was formed even when minimal or no functional force acted upon segments. Furthermore, several authors contended that compression itself does not have any osteogenic effect other than increasing stabilization of the bone ends. Hicks found in his study that the amount of callus formation was inversely proportional to the degree of rigidity of the fixation. The work of Muller et al.[26] showed that fracture healing under completely stable internal fixation (IF) and full function formed no callus and did not show signs of fracture disease. However, it has been found that there is no difference between the net result of primary and secondary bone healing; bone has the capacity of regenerating itself and restoring the lost structure. If the bone fragments are properly aligned, the bone continues to undergo adaptation and remodeling until it presents a form and function similar to its pre-injury state.

Methods of mandibular fractures fixation

The AO classify the fractured mandible to simple and complex fracture and recommend for each type several methods of treatment as following, simple symphyseal and parasymphyseal fracture may be managed with closed treatment or ORIF (two lag screws, one lag screw and a plate, one plate and arch bar or two plates), and complex symphyseal/parasymphyseal fracture may be managed with closed treatment or ORIF (two plates at basal triangle, reconstruction plate at basal triangle, reconstruction plate in comminuted fracture or with external fixator).[27]

Bone plates for rigid internal fixation

Rigid plates with simple round holes were the earliest plates used for rigid internal fixation (RIF). They were placed simply to secure, align and stabilize bone segments. During the 1940s, Danis[23] proposed the use of compression combined with plate fixation of fractures. Initially, he applied a conventional bone plate to one bony segment after compression was applied to the bony interface using a device attached to one end of the rigid fixation plate. Using this technique Danis successfully treated fractures of the forearm bones and of the Tibia. He called such healing as Sonder Autogene. Also, Bagby and Janes were the first to report a rigid plate with self-compressing features incorporating the sloped edge of a screw hole. Other modifications of compression plates were developed shortly thereafter.[28] There are different types of bone plates which were developed such as:

Dynamic compression plate: The design of a compression plate is that the inferior aspect of the screw countersink contains a spherical surface and the inner portion of the screw hole in the plate contains the inclined plane, when a screw is tightened in bone against the inner surface of the hole of a plate, vertical, as well as horizontal displacement forces, result, the spherical surface moves inferiorly in the inclined plane forcing the screw to the deepest part of the hole. The bone attached to the screw moves in the same direction as the screw the plate is forced in an opposite direction. Securing two bony segments to the plate by complete tightening of the screw results in bony movement such that compression is applied at the area of the fracture.[29]

Depending on the design of the screw and inclined plane, the amount of displacement and the resulting force can vary. The inclined slope within a plate hole may vary from 16 to 60 degrees. In a hole with a 16-degree slope, tightening the screw produces a larger horizontal displacement of the plate but generates relatively little compressive force. On the other hand, an incline of 60 degrees within the hole produces little horizontal displacement as vertical compression is applied during screw tightening.[29] In current terminology, a 27-degree hole produces moderate horizontal displacement and is referred to as a distance compression hole, whereas a hole with an incline of 45 degrees is referred to as a power compression hole. It appears that 45 degree of incline produces the most efficient generation of force while providing some horizontal movement.

The rigid fixation, which applies compression, produces both mechanical as well as biologic effects on bone healing. Two primary mechanical effects result from rigid compression plate fixation. First, the extreme rigidity of the plate provides motionless adaptation at

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the fracture. This occurs without compression and results from stable screw fixation and the rigidity of the plate itself. Additionally, when compression is applied the areas of the bony interface are placed in direct apposition under compression to produce significant friction in this area. This frictional resistance in combination with the motionless adaptation due to plate rigidity enhances the stability of the fracture. In addition to the mechanical effects, biologic benefits may result from primary bone healing following compression.[3]

The basic principle of compression through inclined planes in screw holes is incorporated in several bone plating systems. The number of compression holes, their placement within a plate, the degree of slope inclination with a plate and the degree of slope inclination within each hole vary widely.[8]

Eccentric dynamic compression plate: The concept of an eccentric dynamic compression plate uses the standard principle of horizontal compression in the two screw holes closest to the fracture site and combines them with angled holes at a point further from the fracture site.[30] The initial screws are placed applying compression at the inferior border. Compression at the superior aspects of the mandible is added by placing screws in holes which are arranged at an angle of approximately (45^o-90^o) degrees to the long axis of the inner compression holes. The resultant displacement leads to rotation of the bony segments around the screws closest to the fracture site and results in compression at the superior border of the mandible.[30]

Eccentric dynamic compression plates are available in 2.7 mm sizes with many variations in term of the number of holes and placement of angulated compressive holes. The use of EDCP has become less attractive to the maxillofacial surgeon because it must be placed by extraoral incision and it does not completely eliminate the need for a tension band.[16]

Large non compression plate systems: The use of compressive forces during plate placement and bony segment stabilization is contraindicated in some cases, such as in the bridging or reconstruction of the large mandibular continuity defect. After placement of the plate, tightening of screws in compression holes would not result in compression. Some bridging plate systems area available without inclined planes in the holes; compressive forces cannot be generated. In other systems, even the large bridging reconstruction plates contain compressive holes. If the screw is initially placed in the most inferior portion of the inclined plane (side of the hole nearest bony defect) no displacement or compression results as the screw is tightened.[27]

The rigid reconstruction plate is useful in stabilizing comminuted fractures. Rather than applying compression over a long span of comminuted bone a reconstruction plate provides rigidity to the mandible similar to that created in a continuity defect.[31] The firm stabilization of the comminuted bone allows for adequate bony healing even under function. In these instances, the use of the compression features in the screw holes is of no benefit and may only serve to displace free comminuted segments. Reconstruction plates are available for maxillofacial surgery in 3.5mm and 2.7mm sizes. A variety of plate lengths and configurations are available including straight plates and pre-bent plates for the configurations found at anatomic sites in the mandible.[32]

Biodegradable plates and screws: The work on resorbable synthetic materials has progressed from the original experimental work of Gutter et al.[33] who reported the use of plates made of polylactic acid in the internal fixation of fractures in dogs. Subsequently, the strength of these plates increased by the use of fabric woven in polyglycolic acid which was incorporated into the polyglycolic acid plates. Stainless steel screws were used for fixation of these plates.[34] At the present time, the greatest problem remains the dimensions of the biodegradable plates and also the fact that during degradation a marked collection of fluid occurs at the site, resulting in an unacceptable clinical swelling. However, the feasibility of biodegradation has now been demonstrated.[35-37]

Miniplates osteosynthesis: Recently, a major interest in fixation for maxillofacial surgery has encouraged the development of many small plating systems not designed to produce compression. The plating systems are available primarily in 2.0 mm and 1.5 mm sizes and in a variety of configurations. A microsystem using 0.8 mm screw has also been recently developed. Many surgeons term them small non-compression plates or semi-rigid plating systems. The primary use of the semi-rigid plate is in midfacial surgery (osteotomies and fractures).[38]

The small plating systems also may be used as an adjunctive stabilization for mandibular fracture treatment.[7] The use of miniplate osteosynthesis in fractures of the horizontal mandible has become a generally accepted procedure. Nevertheless, the mechanical characteristics of the miniplate systems produced by different forms can vary widely.[39]

The most common types of mandibular fractures treated with miniplates are symphysis-parasymphysis fractures, angle fractures, and body fractures. To neutralize torsion forces in the symphysis-parasymphysis region between the mental foramina, two parallel plates should be used. The inferior plate is placed with bicortical screws at the inferior border of the mandible, followed by a superior one that acts as a tension band plate placed with a monocortical screw. The gap between them should be 4-10mm. It is recommended that the lower plate be fixed first and then the subapical plate. In addition, Michelet et al.[40] were the first to publish the analysis of 300 cases of mandibular fractures treated with miniaturized screwed non-compression Vitallium bone plates in the maxillofacial region in which he obtained excellent results. This method allowed monocortical, subapical and juxta-alveolar fixation without compression and an intraoral approach was used without MMF.

Champy et al.[41] conducted their study on the use of semirigid miniplates and after that disadvantages and complications of this conventional (standard) plates appeared.

Locking Plate: In order to improve conventional miniplates Osteosynthesis, locking screws avoid secondary displacement of basal triangles on tightening that occurs with conventional screws. In addition, Chritah et al.[42] conducted their study using a 2.0mm locking miniplates (LMP)/screw system in the treatment of mandibular fractures with one week period of maxillo-mandibular fixation (MMF) and obtained a good result. Also, Gautier and Sammer[43] recommended locking plates as it will work as the fixator principle and provide increased primary stability. Also, it was proved that the loading forces which are applied on the screw are more favorably distributed over the whole thread contour.[13] However; there are certain types of fractures such as continuity defect fractures or comminuted fractures where the surgeon may need to use a larger profile load bearing heavy plates.[44]

Conclusion

From the clinical studies and biomechanical background,, it appears that the use of a single2.0-mm locking plate at the inferior border and no tension band plate at the alveolar border of the mandible to treat all

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linear non comminuted mandibular fractures, are extremely attractive because they combine 3 primary characteristics that make it an ideal plate: a low-profile, locking screw–plate system and high-strength titanium alloy.

Conventional Miniplate osteosynthesis is adequate in single linear and minimally displaced fresh parasymphyseal fractures; however 2.0-mm locking plates placed at the inferior border of the mandible can be regarded as 2 miniplates, with a greater amount of stability, especially in severely displaced fractures. The decision to use 2.0-mm locking or standard plates should be based on cost and ease of placement.

Recommendation

- The impact of bone plating of the mandibular fracture over periods of bone healing remains an open question for further investigation.
- Further study is needed to assess the difference between the fixations systems used in mandibular fracture management.

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