THE MANAGEMENT OF MANDIBULAR FRACTURES EARLY VERSUS LATE REDUCTION AND FIXATION: A COMPARATIVE STUDY

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Abstract

Background: treatment of mandibular fracture is still a matter of debate regarding optimal timing for surgical open reduction and fixation, the effect of delay of initiation of treatment on complication is not well studied.

Objectives: the aim of the current study is to identify a solid, evidence based statement about optimal timing of open reduction and fixation of mandibular fracture.

Methods: A literature review including Pubmed, Scopus for studies included different timing for open reduction and fixation of mandibular fracture.

Results: In terms of postoperative complications, prior studies have shown an association between prior treatment and diminished disease. Regarding other post-operative complications as TMJ dysfunction, numbness and malocclusion, a non-significant increased rate of such complications was observed in delayed treatment.

Conclusion: It should be possible to treat most patients with mandibular fractures by the end of the day after admission. This would allow enough time for the resolution of any other medical problems such as acute intoxication, the optimisation of a pre-existing medical condition.

Keywords: Mandibular fracture, early treatment, open reduction and fixation.

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Introduction

Adequate treatment of mandible fractures not only restores an individual's ability to speak, chew, breathe, and sleep, but also reestablishes their occlusion and facial aesthetics. An analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database showed that mandible fractures were the most common isolated facial fracture. The causes of mandible fractures are varied and include motor vehicle accidents (MVAs), assault, domestic violence, falls, sports- and work-related accidents, ballistic injuries, and pathologic fractures ***(Kaura et al., 2018)***.

One can further subgroup the etiology and severity of mandible fractures with respect to age, gender, socioeconomic status, substance use, and mechanism of injury. For instance, men most often sustain mandible fractures as a result of assault, MVAs, and falls; whereas women sustain mandible fractures from MVAs, assault, and trauma. Appreciation of the mechanism of injury and anatomy of the mandible will aid the plastic surgeon, oral and maxillofacial surgeon, or otolaryngologist in assessment and management of mandibular fractures. Mandibular fractures will vary in their severity according to number of sites involved, displacement, and comminution ***(Kim et al., 2015)***.

Favorable versus Unfavorable Fractures

Fractures can be classified as favorable or unfavorable based on the stability afforded by the pull of muscles on the fractured segments of bone. The temporalis and masseter muscles exert the primary upward force while the downward force is exerted by the suprahyoid musculature and gravity. If these forces act to bring the fracture line together, the fracture is favorable; if they act to pull the fracture line apart, the fracture is unfavorable. Following callus formation of non-reduced mandibular fractures, reconstruction becomes a surgical challenge requiring complex procedures as osteotomies and/or onlay grafts. Primary repair usually offers best functional recovery as well as easier repair ***(Panesar and Susarla, 2021a)***.

Fracture Fixation Principles

The mandible is the only moveable, load bearing bone of the skull. To properly treat mandible fractures, one must first understand basic fracture fixation principles. These can be grouped into tension versus compression and load-bearing versus load-sharing principles While a complex topic, the biomechanics and forces exerted on the mandible should be understood by the treating physician ***(Spiessl, 2012)***.

Tension versus Compression

At any time, there are counteracting forces of tension and compression on the mandible influenced by muscular attachments and loading. At rest, these forces are equal. While an oversimplification, forces of tension generally separate a fracture and forces of compression bring a fracture together. Under compression, fractures generally undergo rapid healing and a greater resistance to separation. However, without addressing tension forces, overcompression can compromise ideal bony healing leading to nonunion ***(Spiessl, 2012)***.

Studies have shown that in the region of the mandibular body tension exists along the alveolar border while compression exists along the inferior border of the mandible. Moving toward the symphysis and parasymphysis, these two opposing forces become mixed or even inverted due to the introduction of torsional, or rotational, forces ***(Lipski et al., 2013)***.

Biomechanically, it is most advantageous to apply bicortical rigid fixation along the zone of tension. Bicortical rigid fixation along the alveolar border is not feasible due to the presence of tooth roots, thin cortical bone, and thin gingival tissue. The inferior border of the mandible is not constrained by these limitations, with the notable exception of pediatric patients in the primary or mixed dentition. Bicortical screw fixation in this region is extremely stable and then only requires placement of a tension band at the alveolar level (either a continuous arch bar at the dentition or a small plate with monocortical screws) to resist tensile forces ***(Kiruthika, 2016)***.

Load Bearing versus Load Sharing

Fracture fixation can be divided into either load bearing or load sharing. Choosing which type depends on the bone quality, location of the fracture, comminution, or bone loss. With load bearing osteosynthesis, the plate bears 100% of all of the forces of function at the fracture site. Load bearing osteosynthesis is indicated in comminuted mandible fractures, segmental defects, complex fracture patterns, or fractures with compromised bone such as atrophic mandibles or patients with metabolic or endocrine disorders. Fixation is accomplished with 2.3mm-2.7mm diameter locking reconstruction plates ***(Panesar and Susarla, 2021b)***.

When using load sharing osteosynthesis, stability at the fracture site is shared between the plate and well-buttressed bone. Depending on the location, the functional load is either shared equally between bone and plate (e.g., angle fractures), or in more ideal situations the bone assumes a greater share of the functional load than the plate (e.g., body fractures in dentate mandibles). Here, fixation can be accomplished with 2.0mm diameter miniplate systems. Examples of load-sharing fixation include a single miniplate along the oblique ridge for angle fractures (ie, Champy technique), or a single miniplate and an arch bar (providing tension) for body or symphysial fractures, and lag screw fixation ***(Panesar and Susarla, 2021b)***.

Lag Screw Fixation

The use of lag screws was popularized by Niederdellmann et al. in 1976. 14 Lag screws can be use in simple fractures where there is well-buttressed bone such as in symphysis or parasymphysis fractures. A lag screw has threads on only half the shaft so that the portion below the screw head is smooth and will not engage bone. Thus, the threads only engage the inner segment of bone and compress it against the outer segment. Typically, the two screws are placed, with minimal divergence between their long axes ***(Rughubar et al., 2020)***.

Rigid versus Non-Rigid Fixation

Fixation can be grouped into rigid fixation, nonrigid fixation, or semirigid fixation. With rigid fixation, no bony callus if formed during healing and fracture segments are completely immobilized. In nonrigid fixation, micro-mobility of the fracture segments occurs and the fracture cap undergoes callus formation. Rigid fixation techniques include the use of plates and screws (miniplate and tension band with two screws on each side of the fracture), two lag screws, or reconstruction plates with three screws on each side of the fracture. A 2020 paper by Rughubar et al. compared the complication rates in patients with bilateral mandibular fractures randomized to either a combination of rigid fixation for an anterior fracture and nonrigid for the posterior fracture or nonrigid fixation for both fractures and found no significant difference; the risk of complications was significantly higher in patients with moderate to severe fracture displacement, regardless of treatment ***(Rughubar et al., 2020)***.

Complications

Malunion and Malocclusion

Malunion is defined as the osseous union of a fracture in an incorrect position. The area is healed with bony continuity but there are functional and possibly esthetic problems because the reduction was inadequate. Most postoperative malocclusions are caused by malunions and are usually obvious to both the patient and the surgeon. When the degree of displacement of the healed segments is great, facial deformity may also be noted ***(Perez and Ellis, 2020)***.

The most common causes of malunion are inadequate dental reduction during surgery, inadequate osseous reduction during surgery, imprecise application of internal fixation devices, and/or inadequate stabilization. Malunions can occur with closed treatment as well. However, the improper use of rigid internal fixation devices can very easily cause it. Improper bending of a plate, inadequate occlusal reduction due to loss of teeth, and improper application of compression techniques can very easily lead to healing in the wrong position ***(Perez and Ellis, 2020)***.

Fibrous Union/Nonunion

The lack of osseous healing after an adequate period of time (usually 6 months in long bones and 12 weeks in the mandible) leads to fibrous union. Diagnosis of fibrous union is usually made clinically by detecting mobility across the site of fracture. This mobility can be painful to the patient and present itself with or without infection. Sometimes infection is the consequence of a smaller fragment that is loose and working its way out of the body. The most common causes of fibrous union are fracture instability, early infection, and inaccurate reduction with lack of osseous contact between the fragments. Inadequate hardware selection, for example, a bone plate that is too small or not enough screws per side can lead to mobility and nonunion. Similarly, loosening of the bone screws from the bone can lead to fracture mobility ***(Perez and Ellis, 2020)***.

Infection

Infections are one of the most common complications of mandibular fracture management, irrespective of how the fracture was treated. They tend to be more common when fractures are treated open, but this may be due to the more complex cases usually requiring open treatment. The oral cavity is a reservoir for bacteria that can easily colonize the surgical site or internal fixation hardware ***(Christensen et al., 2017)***.

The difference between infection and osteitis is that osteitis has no great component of bacterial cellulitis and no abscess formation or purulent discharge associated with it. Osteitis is an osteomyelitis that is localized and is due to devitalization of the bone from traumatic and/or surgical disruption of superficial blood supply. The fracture may be completely stable with osteitis or infection, but infection is more likely to be associated with fracture instability ***(Odom and Snyder-Warwick, 2016)***.

Fracture instability can also lead to infection. When mobility is present during the early stages of healing, disruption of blood supply occurs, and the interference in revascularizing leads to devitalization of bone. The presence of mobility and/or devitalization of bone with microorganisms results in infection of the fracture ***(Perez and Ellis, 2020)***.

Iatrogenic Complications

The most common iatrogenic complication that can occur when rigid internal fixation of mandibular fractures is used is placement of a screw or screw hole through a normal anatomical structure such as a tooth root or the mandibular neurovascular bundle. Because the mandible contains tooth roots above and the inferior alveolar neurovascular canal in the middle, the only place where bicortical bone plates can be applied safely on the lateral cortex is along the inferior border ***(Florescu et al., 2016)***.

Complications Related to the Surgical Approach

The most common anatomical injury when treating mandibular fractures is damage to the trigeminal nerve (CN V). The mandibular canal must be avoided when placing rigid internal fixation devices. Injuries usually occur when placing a bicortical screw in the posterior body/angle region through an intraoral approach using transbuccal instrumentation. Inadequate access and visibility and/or inadequate familiarity with mandibular anatomy is usually the reason. The other area is the region of the mental nerve. Parasymphyseal fractures often require exposure of the mental nerve and skeletonization of the nerve bundle to allow for better retraction. It is paramount to perform an excellent presurgical examination to document the degree of any preexisting injury to the nerve ***(Zuniga et al., 2017)***.

Most injuries to CN V heal and patients recover their sensation. Visualized transections can be repaired using a direct approximation technique if the fascicles are intact or by using a nerve graft and connector-assisted techniques ***(Yampolsky et al., 2017)***.

Timing of Open Reduction and Internal Fixation

Although closed reduction of mandible fractures via mandibulomaxillary fixation (MMF) has therapeutic value, open reduction internal fixation (ORIF) has become the standard of care for achieving anatomic reduction for a wide variety of mandibular fractures, including condylar head fractures. However, mandible ORIF is considered to have a higher risk of postoperative infectious complications, as compared with MMF, given the introduction of hardware in a grossly contaminated oral cavity. Intuitively, earlier ORIF should reduce the open fracture contamination exposure, though delayed ORIF allows for soft-tissue edema to subside and wound closure under reduced tension, which may theoretically decrease the risk of subsequent wound dehiscence and hardware exposure ***(Domingo et al., 2016)***.

Early expert opinion suggested that ORIF for mandibular fractures should be performed within 6 hours of injury to reduce complication rates. This time threshold was later extended to 24 hours, and by the 1990s to within 48–72 hours. To date, there remains no consensus on the optimal ORIF treatment delay or whether delayed treatment increases complication rates. At our center, this poses a scheduling challenge for booking mandible ORIF cases as a "Priority 2" (to be completed within 24 hours), or a "Priority 3" (to be completed within 72 hours) ***(Zhang et al., 2016)***.

Previous reviews have addressed, at least in part, the topic of mandible fracture ORIF treatment delay. However, earlier reviews analyzed heterogeneous populations of patients with various facial fractures, included patients treated exclusively with closed surgical techniques, and were either outdated, or not truly systematic in nature ***(Hurrell and Batstone, 2014)***.

An established time for repair of mandible fractures as a standard of care has not been firmly established by the treating specialties. Treatment practices related to the timing of repair seem to be associated with patient compliance, the doctor's clinical judgment, and logistics. This has been, in part, because the published data are without a study specified to the matter. In general, the findings of complications associated with the timing of fracture repair have been elaborated within the research of other associated topics. Thus, topics such as early immobilization, infection incidence, patient compliance, substance abuse, problems associated with teeth within the line of fracture, and compound injuries have been studied as isolated variables, within the context of postoperative complications ***(Stacey et al., 2006)***.

fixation was advocated to reduce the chance of infection. A systematic review by Hermund et al, however, showed no difference between early or delayed treatment, and other studies have shown little evidence that a delay, even of several days, is associated with increased morbidity in most patients. It is therefore difficult to argue that treatment should be urgent, from a surgical point of view particularly when continued improvementsin care have allowed surgeons to delay treatment when necessary and avoid negative outcomes ***(Katsarelis et al., 2016)***.

In terms of postoperative complications, prior studies have shown an association between prior treatment and diminished disease. Anderson and Alpert displayed a 16% overall postoperative infection rate in a study of 75 mandible fractures, but no infections occurred in patients treated within 24 h of injury. An alternate study by Maloney et al. reported 204 fractures in 131 patients with overall infection rate of 4.4%. In any case, consistent patients treated within 72 h of injury and or trauma had no contaminations and infections ***(Alshahhat et al., 2018)***.

Regarding other post-operative complications as TMJ dysfunction, numbness and malocclusion ,earlier studies reported a non-significant increase in cases of numbness and TMJ dysfunction in delayed treatment group ***(Webb et al., 2009)***. There is no consensus on whether ORIF treatment delay is an independent risk factor for the development of postoperative complications in patients with traumatic mandible fractures ***(Stone et al., 2018)***.

Another important consideration in managing patients with a mandible fracture is determining a cost-effective treatment algorithm. Stable patients with mandible fractures who can feed orally and who display no airway compromise can be managed as outpatients and scheduled as elective cases ***(Alshahhat et al., 2018)***.

It should be possible to treat most patients with mandibular fractures by the end of the day after admission. This would allow enough time for the resolution of any other medical problems such as acute intoxication, the optimisation of a pre-existing medical condition, and a period of observation for a suspected head injury. It would also allow the surgical team to organise the necessary resources and personnel ***(Malanchuk and Kopchak, 2007)***.

Quality of life and duration of stay

Despite the apparent lack of morbidity associated with delayed treatment, patients naturally prefer to wait for as short a time as possible, as factors such as fasting, pain, confinement to the ward, and time off work, have detrimental effects on their quality of life. The NHS tariff system means that the "fee" payable for this injury is fixed, and the opportunity to reduce costs per patient episode comes from a reduction in the duration of stay. Delays lengthen the stay, increase the cost, and potentially displace elective operations, which can incur further financial penalties. Although the NHS is facing the tightest financial constraints, substantial improvements in productivity are required to avoid a reduction in quality and cuts in the service ***(Katsarelis et al., 2016)***.

Conclusion: The treating disciplines have not firmly established an established period for mandible fracture repair as a standard of care. Treatment methods about the time of repair appear to be linked to patient compliance, the doctor's clinical judgement, and practicalities. In most patients, even a few days' delay is associated with higher morbidity. It is thus difficult to claim that treatment should be urgent from a surgical standpoint, especially when continuous advances in care have permitted surgeons to postpone treatment when necessary and avoid unfavourable outcomes. However, Most patients with mandibular fractures should be able to be treated by the end of the day after admission. This would give enough time for any other medical issues, such as acute intoxication, to be resolved.

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