Recent Advances in Treatment of Mandibular Fractures

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Introduction

Fracture of the mandible occurs more frequently than any other fracture of the facial skeleton due to its prominent position. Its one of the serious facial injuries that an average practicing dental surgeon may expect to encounter, though rarely. Management of mandibular fractures has evolved as early as 1650 BC, when an Egyptian Papyrus described the examination, diagnosis, and treatment of mandible fractures. Many patients either were not treated properly or received no treatment and subsequently died.

Hippocrates was the first to describe reapproximation and immobilization through the use of circumdental wires and external bandaging to immobilize the fracture. The importance of establishing proper occlusion first was described in a textbook written in Salerno, Italy, in 1180. Maxillomandibular fixation first was mentioned in 1492, in an edition of the book Cyrugia printed in Lyons. Chopart and Desault used dental prosthetic devices to immobilize fracture segments.

Most fracture treatment involved some form of external bandage or wrap occasionally used in conjunction with a bridle wire throughout the 19th century.

Guglielmo Salicetti first accomplished the use of intermaxillary fixation. Orthodontic bands and arches were used for intermaxillary fixation. However, Gilmer reformed the treatment of fractures when he fixated full arch bars on both the mandible and the maxilla.

In the last five decades these advances have been primarily on the various techniques & materials used in internal fixation of these fractures which will favour an ideal osteosynthesis enviorment . Right from the time of Luhr (1968) who introduced the use of compression plates in the treatment of fractures of the edentulous mandible and Champy et al., (1978) who developed, modified and improvised the technique of miniplate bone osteosynthesis in maxillofacial region these techniques have revolutionized the management of facial & mandibular fractures.

Treatment of Fractures of the Mandible

No matter how much these techniques have evolved, the main goal of treatment of any facial fracture must be to bring the ends of the fracture in their anatomically correct position with as much precision as possible and to make sure, by appropriate fixation that bony consolidation can takes place in that position.

Basic fundamentals in a facture treatment is always involves three stages or steps:

1. **Reduction:** Restoration of the fragments to their normal/premorbid anatomical alignment.
2. **Fixation:** Use of materials to hold the fragments in their reduced position.
3. **Immobilization:** Involves restriction of the movement of the fractured bone and/or fragments to promote healing

Closed reduction

Technique of reducing the fractured segments without exposure and visualization of the fracture site.

With reference to mandibular fractures it usually means maxillomandibular fixation.

Techniques of closed reduction

1. Direct interdental wiring outdated associated with extrusion of teeth.
2. Eyelet or Ivy wiring rapid, extremely useful, does not address dentoalveolar injuries.
3. Continuous or multiple loop wiring not in use
4. Arch bar extremely useful also manages concomitant dentoalveolar injuries
5. Cap splint good technique but requires good laboratory back up time consuming
6. Gunning type splints used in fractures of the edentulous mandible
7. Pin fixation

Open reduction

Open reduction requires a surgical approach to the fracture site. On approaching the fracture site the fragments are reduced (anatomic realignment) and are held in place using wires, bone plates & screws, clamps, lag screws etc.

Approach / access to the fracture site may be made through an existing wound or through a surgically created incision. Most fractures in the anterior mandible, body and angle are best approached through an intraoral approach whereas the fractures of the condylar region are usually approached through an extraoral approach.

Techniques of open reduction and internal fixation:

A] Those requiring post reduction MMF:

1. Transosseous wiring
2. Circumferential wiring
3. External pin fixation
4. Bone clamps
5. K-Wires

B] Those not requiring post reduction MMF (in most cases)

1. Non compression small plates

2. Compression plates
3. Mini plates
4. Lag screws

CHAMPY'S LINES OF OSTEOSYNTHESIS (Conventional system):

Champy et al., (1978) developed, modified and improvised the technique of miniplate bone osteosynthesis in maxillofacial region. This consisted of monocortical, juxta-alveolar and subapical osteosynthesis without compression inserted through an intra-oral approach with intermaxillary fixation. They advocated this technique as a routine treatment procedure for any mandibular fractures. Taking into consideration all the bio-mechanical forces they used photoelastic method and described ideal lines of ostesynthesis . Monocortical screws were sufficient and were placed below the roots and either above or below the inferior alveolar canal.

At the angle of the jaw the plate was fixed on the vestibular flat osseous area located besides the third molar. Anterior to mental foramen in addition to subapical plate, another plate near the lower border of the mandible was fixed.

They documented that, compression osteosynthesis was not advantageous as their existed a natural compression along the lower border of the mandible and it is impossible to measure this force of compression which if excessive could lead to bone necrosis.

Current conventional system of osteosynthesis of mandibular fractures with miniplates is based on this principle.

CURRENT ADVANCES IN OPEN REDUCTION PLATING SYSTEM

Plating systems have evolved along with the time with respect to designs and materials. Material of bone plates evolved from iron to stainless steel to titanium, vitallium and recently the bio resorbable poly-lactide. While material changed, so did the design from compression plates to rectangular plates, miniature plates, x-plates and more recently the 3D plates and locking plates.

3 D PLATES

A three dimensional miniplate is formed by joining two miniplates with interconnecting vertical cross-bars. The name "three dimensional plate" suggest that the plate stabilizes the fractured segments in all three dimensions. The fundamental idea of three dimensional bone plates is based on principal of quadrangle as a geometrically stable configuration for support. Increased stability is achieved by the geometrical shape of quadrangular plate rather than by its thickness or length.

DESIGN

When mandible is in function, primarily three forces are of concern, namely bending, vertical displacement and shearing. In 3 dimensional plates, since two horizontally placed miniplates are further joined by using vertical cross bars at 90 degrees these acts as vertical struts and further minimize bending. Since the entire plate acts as one single unit because of the inter connections and the quadrangular shape (it acts as a tetragon), the vertical displacement and the shearing of the bone is also reduced to minimal thus holding the bone fragment in three dimensions.

A 3-D Plate Fixed For a Mandibular Parasymphysis Fracture

ADVANTAGES OVER CONVENTIONAL PLATING SYSTEM

3 Dimensional stability: As discussed earlier, the 3-Dimensional plate system provides stability against all three directions of forces viz. shearing, bending and vertical displacement due to its unique design giving it an upper edge over conventional plating system which is 2 Dimensional.

A three dimensional miniplate is formed by joining two miniplates with interconnecting vertical cross-bars so providing better resistance to vertical displacement of fractured segments. The fundamental idea of three dimensional bone plates is based on principal of quadrangle as a geometrically stable configuration for support. Bending resistance is also seems to be increased (100% against 84%) when compared with conventional plates. Theoretically, increased stability is achieved by the geometrical shape of quadrangular plate rather than by its thickness or length.

Easy adaptation: 3 Dimensional plate being a single unit makes the adaptation easier compared to double miniplate system

Less operating time: 3 Dimensional miniplate takes around 65 minutes (range 45 minutes to 110 minutes) of mean operation time from incision to suturing of the site.

Operation time is decreased due to:

a. Single unit adaptation (compared to double miniplates)
b. Less exposure required (as superior and inferior border od mandible need not be exposed)
c. Easy adaptation (as it is a single unit plate)
d. Less screw requirement when 3 X 2/ 2 X 2 plate is used (compared to 8 screws required for double miniplates)
e. Extraoral approach is not mandatory in angle fractures

(unlike double miniplates)

Less Infection rate: Infection rate is found out to b 0% to 5% in studies compared to average infection rate of 7% observed in conventional plating systems.

Cost effective: 3- Dimensional titanium plates cost same as two titanium miniplates. As the screws required for 3 Dimensional system are less, total system becomes more cost effective compared to conventional one.

DRAWBACKS OF THE 3 D PLATING SYSTEM:

Inability to fix at mental foramen region: When fracture line passes through or in near proximity to mental foramen, 3 Dimensional plate cannot be used as mental nerve would be sacrificed. When conventional system is used, a miniplate can be fixed one above the mental foramen and second below it. While 3 Dimensional plate is a single unit, cannot b used due to presence of mental nerve.

More quantity of implant: Due to presence of vertical struts, 3 Dimensional plating system has more quantity of implants compared to conventional one.

LOCKING PLATES

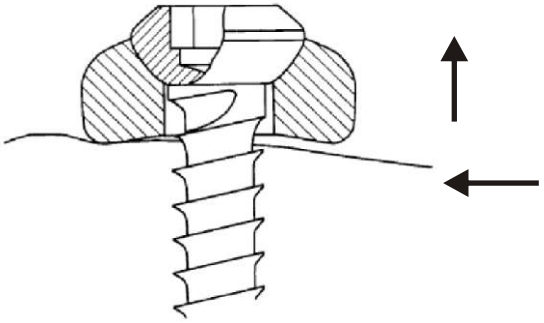
The introduction of locking plate/screw reconstruction plating systems for treatment of mandibular fractures and continuity defects offers certain advantages over other plating systems. These plates function as internal fixators, achieving stability by locking the screw to the plate.

Design of a locking plate system. Note the threads present in the plate holes which are absent in miniplates thus allowing the plate & the screw to "lock" with each other

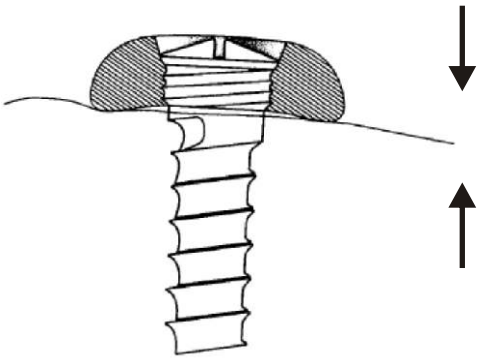
DESIGN

Locking plates resemble mini plates in almost all details except one. In locking plate the screw heads as well as the plate holes are threaded so as to "lock" with each other.

Screw once passed through bone, not only locks with it but also with the plate. Thus screw and plate forms a single unit and with both it acts as two unit fixation i.e. locking plate with screws act as "internal fixators" giving more stability to implants theoretically. On the other side in conventional system as screw, plate and bone form individual unit, they form three unit fixations thus having more movement of units compared to locking plates.



Conventional System



Locking Plate System

ADVANTAGES OVER CONVENTIONAL SYSTEM:

1. Intimate contact of plate with bone is unnecessary in locking plates as when screws are tightened they get "locked" to plate thus stabilizing the fractured segments,
2. More stability of fractured segments is achieved as compared to conventional miniplate system.
3. Locking plates do not disrupt cortical bone perfusion as compared to conventional plate which compresses the undersurface of bone plate to cortical bone.
4. Less time consuming as absolute adaptation is not mandatory
5. Incidents of resorption of buccal and lingual cortices are very few when compared with that of conventional system (approximately 50%)
6. Screws are unlikely to loosen from plate which proves useful:
   - If screw is inserted into fracture gap
   - If bone graft is screwed to plate
   - As it decreases incidence of inflammation

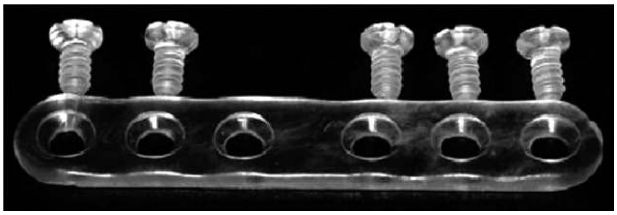
DRAWBACKS OF LOCKING PLATE SYSTEM:

1. Incidence of breakage of these plates and screw is slightly more(5%) compared to conventional plates.
2. Locking plates are relatively more expensive.

BIO RESORBABLE PLATES

Bioresorbable polymeric plates and screws can be a good alternative for metallic plates and screws. The materials used for biodegradable fracture fixation devices

are high-molecular weight polymers. Today, the materials used are poly-oc-hydroxyl acids: polymers and copolymers of Polylactic acids (PLA), Polyglycolic acid (PGA), Poly L Lactide (PLLA), and PDS. These materials degrade in aqueous media to monomers, which are metabolized and excreted by the lungs as carbon dioxide and water. Degradation is faster in vivo than in vitro, partly because cellular enzymes enhance it.



A Typical Resorbable Plate and Resorbable Screws (Inion Plating System, Finland).

TECHNIQUE

Incision site is dissected as same manner as that of conventional technique. The selected bio-resorbable plate is then placed in water bath of 55 degree Celsius for 1 to 2 minutes, allowing the plate to become malleable. Fracture is reduced and plate is then adapted as per required. After adequate adaptation, plate is secured with resorbable screws (minimum two on each side) with lengths ranging from 6 to 12 mm. during placement of screws, adequate tapping is required.

ADVANTAGES OVER CONVENTIONAL PLATING SYSTEM

Bioresorbable property: These plates provide stable fixation in the early healing of fracture and then harmlessly degrades over time, until load can be safely transferred to the healed bone. Biodegradable plate maintains 70% of its initial strength at 9 to 14 weeks, with 42% bulk resorption by 40 weeks and is completely resorbed by 2 to 4 years.

Elimination of need for postoperative plate removal: As bio-resorbable plates resorbs by itself, there is no need of plate removal in future. While in conventional non resorbable plating system plate removal is required in almost 12% cases postoperatively.

Reduced impact on growing mandible: Bio-degradable plates resorbs completely in 2 to 4 years thus it does not affect the growth of the mandible unlike metal implants and hence can be safely use in growing patients

Reduced postoperative pain: Metal implants may cause a post-operative pain due to galvanism or on palpation. Non metallic bio-resorbable plates do not create galvanic current and resorbs and hence reducing the post-operative pain.

Reduced operative time: When placed in hot water bath, BRP softens and becomes malleable. It can be adapted according to bone contouring on bone itself. Thus it saves the operating time required for adaptation of plate.

Reduced toxicity: In some of the studies it is stated that a metallic implants releases metallic ions and they r deposited heavily in liver and kidneys. This matter of toxicity is not a question in terms of bioresorbable plates.

Postoperative fracture visualization: Titanium plates do not allow full visualization of the fractures on postoperative radiographs. Resorbable plates are radiolucent, thus full visibility of the fracture site is available to the clinician.

Intraoperative view of a plate used on the symphysis region

DRAWBACKS OF BIO RESORBABLE PLATES:

Low strength of implant: Unlike metallic implants BRP shows low tensile and compressive strength. Studies showed that BRP can successfully take upto 50 N of load which is very less compared to titanium i.e. 400 N.

Movements of fractured segments: Rigidity of BRP is questionable when comes to mandibular fractures where reduction requires high rigidity.

Orocutaneous fistula formation (higher inflammatory reactions) : BRP implant rejection was found in some individuals for some BRP materials leading to orocutaneus fistula formation exposing the implant.

Expensive: BRP still is the most expensive plating system requiring expensive implants as well as instruments.

Technique sensitive

Conclusion

The concepts and philosphies of the different systems used in the Mandibular fracture management is varying from time to time. But the ultimate treatment goal remains the same, that is anatomical reduction of fragments, functionally stable fixation of the fragments, preservation of blood supply to the fragments and early, active pain free immobilisation.

The operative treatment of mandibular fractures has been influenced and hence modified by several experimental studies. Although rigid fixation is not a new concept in the treatment of fractures in oral and maxillofacial surgery, but has recently gained renewed interest. Advocates have stressed patient comfort as well as enhanced bone healing among the advantages of this kind of treatment.