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Review Article

Review of Plating Modalities Used in Oral and Maxillofacial Surgery

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Abstract

Management of maxillofacial trauma is one of the mainstay treatment provided by a maxillofacial surgeon. Over the years, a plethora of plating systems has been introduced. The significant advantage of the bone plating is agreed upon as stabilisation of the fracture without immobilization of the jaw- providing the patient a comfortable healing period. Whatever the type of plating system implied, the principles of fracture fixation should remain the same, and the same should be attained post-fracture reduction and fixation. The goal should be to achieve minimum postoperative morbidity and early return to function for the patient.

Keywords: *Maxillofacial Plating System; Miniplate Fixation; 3D Plate Fixation; Bioresorbable Plates*

Introduction

Management of maxillofacial trauma is one of the mainstay treatment provided by a maxillofacial surgeon. It varies from a simple fracture of the mandible to craniomaxillofacial fractures. Restoration of form and function thus becomes the mainstay objective of treatment during these cases. Furthermore, to aid in this, oral and maxillofacial surgeons employs various plating modalities according to their preference.

Over the years, a plethora of plating modalities has been introduced. Each system comes with its baggage, while some do not. So, this article will aim to review the various plating modalities introduced overtime, some still in use, while others have been outdated and some extinct. Although extinct, they have acted as stepping stones for the development of the newer plating techniques and understanding them will aid in understanding the current modalities.

Plating techniques

The significant advantage of the bone plate is agreed upon as stabilisation of the fracture without immobilization of the jaw- providing the patient a comfortable healing period. Plating techniques are broadly classified as compression plating techniques, non-compression plating techniques, and mini-plates. Compression plating systems include the Swiss AO system (Arbeitsgemeinschaft fur osteosynthese) and the ASIF (Association for the Study of Internal Fixation). It is important to differentiate whether the system used is compression or non-compression. For the former, the bones should be in tight contact, while in non-compression, a gap should be present in between the fracture segments. The tight contact in compression osteosynthesis leads to direct bone healing without any intermediary callus formation while the other does. Whichever system is used, they all impart sufficient strength to the fixation, thereby restoring full strength.

Non-compression small plates

Small compression orthopaedic plates have been used in the past. However, they do not provide any additional benefit over the recently developed miniplates, which led to their extinction from oral and maxillofacial surgery.

Compression plates

AO dynamic compression plates

They are the forerunners in the development of miniplates for the maxillofacial region, and the current plating systems are modifications or based on the same principle. They are mainly used in the fixation of mandibular fractures. Anatomical requirements need these plates to be fixed in the lower border of the mandible. Which makes this system a tendency to open up the superior lingual border, along with the opening of the contralateral fracture in bilateral fracture cases, while tightening leading to occlusal discrepancies [1]. Unlike miniplates, these plates engage the lingual cortex making its placement more complex due to the presence of an inferior alveolar nerve.

The speciality of compression plates is the presence of pear-shaped holes that will be at least two in number. They will be placed on either side of the fracture line or ipsilaterally with the widest part of the pear-shaped hole near the fracture line. Pear shape implies that the hole will have a broad and narrow region within the same opening. The margin of the narrow opening will be slanting while the wider part will have a standard countersunk design. Once the fracture is stabilized, and the plate placed, the screw is inserted near the narrow portion of the hole. During tightening, the screw head touches the slanting surface of the narrow side and starts to slide along, and finally comes to rest in the broadest portion of the pear-shaped hole, producing compression at the fracture site (Figure 1). Because of the tendency of these plates to open up the upper border, it is necessary to place a tension band on the upper border which can be in the form either arch bar ligatured or a separate two-holed plate.

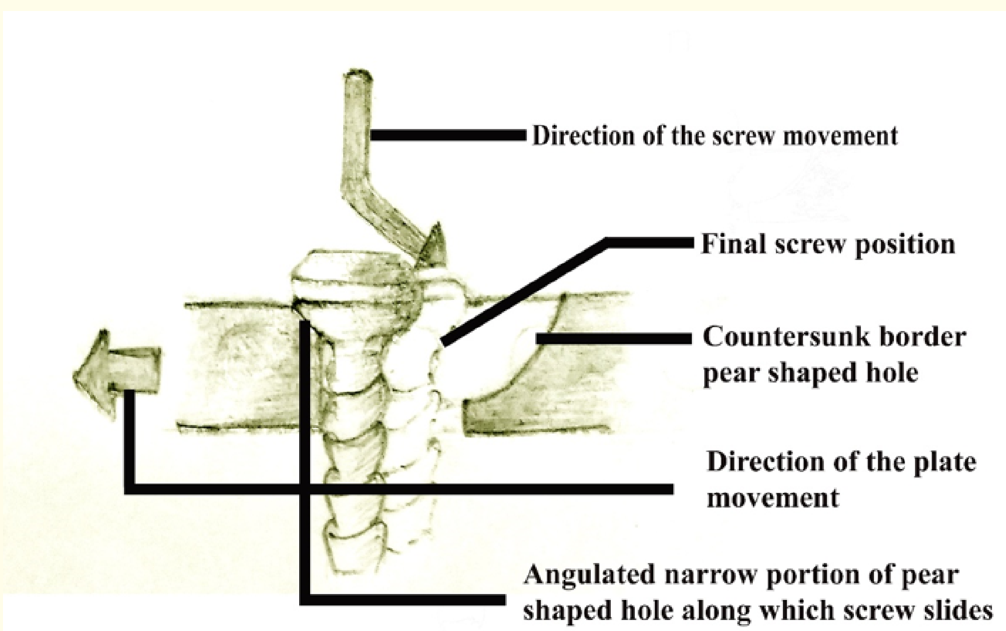

Figure 1: *Dynamic compression plates- screw placement and the path of movement of the plate for compression of the fractured segment.*

The eccentric dynamic compression plate

Was first introduced in 1977 by Schilli [2] to counter the drawbacks of AO dynamic compression plate. Unlike the conventional compression plates of the time, these plates had oblique lateral holes, which made it possible to direct some of the forces applied during fixation to distribute to the superior border-preventing opening up of the fracture. Except for the presence of these oblique lateral holes, rest of the technique remains the same this plates, including the screw plates.

AISI standard plates

These plates had two parts- retention parts and compression parts. The retention part contained normal screw holes which held the plates in place, adapted to the bone contour. The compression half contained an oblong sliding hole and an oval compression hole. These compression holes had a bevel of 27° to 45°, angulation against which the screws were tightened. During the procedure, screws are first placed in the oblong hole but are not fully tightened. Then the compression holes are screwed in like conventional systems. Once it is fully tightened, the oblong hole screw is tightened. Initial placement of the oblong screws prevents lateral dislocation of the fracture segments during tightening of the compression screws. Compression hole with 45° angulation produces more compression resulting in occlusal discrepancies. Hence it is avoided when possible and the 27° angulation plate is preferred.

Because of the unique oblong sliding hole and oval compression holes, this has got much lesser movement during compression than that of other systems. They also have the advantage of having a different plate for the angle region providing the compression, unlike other systems where a change in angulation of the plate is required rather than having a separate design.

Non-compression mini/micro-plates

Mini-plates

Metacarpal plates were the first miniplates to be used for the fixation of fractures in the maxillofacial region, which was reported by Robert WR [3] after treating a series of mandibular fractures. These plates were made of cobalt-chrome alloy and were difficult to manipulate and adapt it to the mandible. Later in 1978, Champy., *et al*. [4] modified the cobalt-chrome alloy miniplates with stainless steel and were the first plates to be made exclusively for mandibular fractures. He also modified the technique of Michelet., *et al*. [5] which led to the introduction of monocortical, small-plate osteosynthesis utilizing malleable plates intraorally (Figure 2). They also postulated the fact that the compression plates exerted stress shielding effect and that a plate with monocortical screws along the natural stress line (Champy's osteosynthesis line) is sufficient to achieve sufficient fixation and stabilization. Lately, titanium mini-plates have been introduced instead of stainless steel plates which have excellent biocompatibility and radiological compatibility.

Figure 2: *Miniplate fixation.*

Champy studied the torsional moments present in the mandible during its function through a mathematical model of the mandible and determined that when a miniplate is placed along the line of osteosynthesis, they have better ability to overcome/neutralize the displacing forces and prevent distraction of the fracture segment. By this model, it was made possible to reduce the thickness of the plates, therefore leading to increased malleability and a perfect adaptation of the plates. It also imparted the miniplates with technical advantages like functional stability and biomechanical favorability-rendering maxilla-mandibular fixation unnecessary. Also, provide them with functional advantages-improved jaw function, reduced weight loss, improved speech and oral hygiene, leading to enhanced social interaction and ability to return to work early.

With all these advantages, it is not spared from the disadvantages. Champy., *et al*. [4] have reported 4.8%, and Cawood et al. [6] reported a 5.7% incidence of occlusal disturbance post-surgery. They have also reported incidences of postsurgical paresthesia, more commonly if the fracture is near the mental foramen.

Mini-plates have always been under scrutiny and were revolving around increased morbidity rates, the difficulty of the procedure, increased operating time, cost of equipment, the necessity for a second procedure to remove the plates and increased the length of hospital stay.

Microplates

Microplates were developed amid growing demand for smaller systems which can provide both superior functional and mechanical properties. Micro-plating systems usually have their diameter < 1.5 mm. Their inherent advantage is that they can be employed in the fixation of small bone pieces which was otherwise impossible. When miniplates are used in the maxillofacial region, especially in the midface region, they are more than often palpable under the skin in the orbital, nasal and frontal regions and also occasionally leads to the development of thermal hypersensitivity necessitating its removal, which is overcome by the microplates. The load-bearing ability of microplates is very less compared to the miniplates. Hence it is limited to the midface or the upper third region. Since their inherent design of thinness, during placement of the plates, drill or screw fracture, bone stripping due to overtightening, reduced holding power leading to fracture displacement post-surgically resulting in unanatomical healing.

One major point of discussion when placing mini-plates and microplates is the adherence to Champy's principle or not. Studies have shown that adherence to the Champy's principle reduces the incidence of postoperative complications [7] and may be attributed to the increased resistance of fracture sites to torsional forces using two plates in the anterior mandible.

Bioresorbable/biodegradable plates

In 1971, Kulkarni et al. [8] initially reported the use of Bioresorbable plates in maxillofacial surgery. Those who piloted the studies using Bioresorbable plates in the 1970s concluded that they were not mechanically adequate, needed maxilla-mandibular fixation and was in excess bulk to be used in the craniomaxillofacial region. The bioresorbable plates were made using polyglycolide, polyglycolic (PGA)/polylactide (PLA), polydioxanone, and PGA/tri-methylene carbonate. The miniplate systems using bioresorbable plates were introduced by Bessho et al. [9] in 1997. In the initial periods, a warm water bath was used to soften the plates and adapt it to the fracture segments. Later Haers., *et al*. [10] showed the use of self-reinforced PLA miniplates which allowed the plated to be adapted with the help of pliers.

During the early period, a single polymer bioresorbable plates were used which either degraded too quickly or ad a slow degradation providing no added benefit over the conventional metal plates [11]. This lead to the development of multi-polymer bioresorbable plates-usually a combination of PLA and PGA. These plates possessed superior properties than their single polymer counterparts. However, for the craniomaxillofacial region, copolymers of lactate with glycolide or L-lactide with D, L-lactide are especially interesting because they possess attractive combinations of strength and resorption profiles. To this combination, the addition of trimethylene carbonate (TMC) into the polymer backbone, further increased its usability in the maxillofacial region with added benefits of strength and malleability.

Once aiding in fracture, healing is complete, these plates harmlessly degrade over time, providing attraction to both patient and the surgeon alike- there is no second surgery required for the removal of plates. Especially useful in cases of pediatric fractures because metal plates impair growth and necessitate removal once placed. They also exonerate the concerns regarding the long-term tissue reactions associated with the metal plates.

3-dimensional plates (3D plates)

3D plates (Figure 3) is a relatively newer technique employed in the maxillofacial fixation and is beginning to gain popularity in the recent times [12]. In 1913, an aluminium-made geometrically closed quadrangular plate was introduced by Lambotte [13]. He secured it to the lower border of the mandible for fracture fixation. He found that if the fracture segments are reduced properly, these plates offered sufficient stability without post-fixation immobilization. Although these plates did not get popularized, Farmand and Dupoirieux [14] developed a titanium plating system based on this principle- 3D stability is achieved by the geometric shapes that form a cuboid compared to the miniplates. The same effect also helped in the reduction of the thickness of these plates to 1 mm.

Figure 3: *Three-dimensional plates.*

The basic form for a 3D plate is quadrangular 2-by-2 hole plate with rectangular or square segments. Other forms include 3-by-2 or 4-by-2. Plates are adapted according to Champy's principles and fixed to the bone with monocortical self-cutting screws. They are also available in various shapes- like triangular plates for the fixation of condylar fractures. Feledy., *et al*. [15] found better bending stability and increased out-of-plane movement restrictions in the 3D plating system. These plates also provide less operating time, a contemporary adaptation of the upper and lower borders, simplified adaptation and ease of application. There are other reports which also states that, in 3D plates, since we are trying to adapt the planes rather than a line like in miniplates, it is much more difficult. However, these may be dictated by the surgeon's experience with these plates. These 3D plates have improved biomechanical stability compared to conventional plates because of their design. While most studies have reported good results in linear fracture fixation of the mandible, but in oblique fracture fixation, there have been complications like infection and segmental mobility [16]. 3D plates also tend to have more material than the conventional plates because of the vertical components attaching the two horizontal components. Farmand and Dupoirieux [14] also treated 95 fractures of the mandibular body using 4-holed square plates; recording complications of one late infection and one plate breakage. Other studies conducted also concluded that unlike the conventional plating system, increased plate fracture is inherent to the 3D plates.

Since it is a newer system, more long-term studies need to be done in to attain definitive results regarding the 3D plating systems.

Conclusion

Whatever the type of plating system implied, the principles of fracture fixation should remain the same, and the same should be attained post-fracture reduction and fixation. The goal should be to achieve minimum postoperative morbidity and early return to function for the patient.

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