REVIEW ARTICLE

History and Recent Developments in Internal Plate Fixation of Fractures

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ABSTRACT

Since more than a century ago, metal plates have been utilized to internally treat fractures. Even while early issues like corrosion and insufficient strength have been fixed, more contemporary designs still have some issues. To create a plate that speeds up fracture healing without affecting bone physiology, more study is required. The biggest change to plate-fixation of fractures came with the invention of rigid plates. However, after the plate was removed, it caused cortical porosis, delayed bridging, and refractures. These unintended consequences were allegedly brought on by bone-plate contact obstructing cortical perfusion. Further plate improvements, therefore, sought to prevent necrosis and eventual porosis by reducing this contact area. The biggest change to plate-fixation of fractures came with the invention of rigid plates. However, after the plate was removed, it caused cortical porosis, delayed bridging, and refractures. These unintended consequences were allegedly brought on by bone-plate contact obstructing cortical perfusion. Further plate improvements, therefore, sought to prevent necrosis and eventual porosis by reducing this contact area. The treatment of bone fractures, particularly refractory fractures, should be improved by further advancements in bio metals and their design for orthopedic bone plates.

Key words: Bimetals, bone fracture, bone plates, internal fixation

INTRODUCTION

Internal organs are primarily protected by bones, which also bear the weight of the body. When the applied load exceeds the sustainable limit, bones can fracture, and the type of fracture varies on the loading circumstances. Every fracture results in a complicated tissue injury that affects both the surrounding soft tissue and the bone, impairing local blood flow and causing pain and reflex immobility. Rapid healing without severe deformity and restoring the patient's bone to a level of function similar to that of the bone before the fracture are the clinical goals of an effective treatment. Since there are multiple methods that can successfully heal most fractures, disagreement over particular approaches is unavoidable. Regardless of the method's theoretical viability, revision surgery to the treated bones is the result of poor technique or an improper choice of the therapy.[1]

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Wires, pins, plates, and screws are the most often used implant devices for fracture fixation, and they are typically made of 316L stainless steel, titanium alloy (Ti-6Al-4V), cobaltchromium alloy, or biodegradable polymers. Fixing through plate is one of the internal fixation therapy options for a broken long bone. To hold bone fragments together and transfer load between the bones and the plate such that the plate bears the majority of the applied loading during the healing process before transferring it to the bone as the fracture heals, screws are used to secure the plate to the bone. Fixing a fractured bone with a plate encourages remodeling of the bone as a response to the increased stress.[2]

FRACTURE HEALING STAGES

1. Tissue degeneration and hemorrhage: Lack of blood flow causes bone to fracture at the fracture surface
2. Cellular proliferation: Cellular tissue surrounds the fragment ends, filling up the spaces between the fracture sites

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3. Callus development: When the conditions are right, the cell population transforms into osteoblasts and osteoclasts. Mopped-up dead bone and braided bone can be seen in the callus
4. Consolidation: The replacement of woven bone by lame bone and the firm fusion of fractures
5. Remodeling: Fresh bone is changed to resemble healthy bone.[3]

To avoid tensile strains at the fracture interface, it is critical to start with a high plate stiffness. The fixation plate should gradually transfer some stress to the bone as the healing process advances; for this reason, the plate stiffness should gradually decrease. Use of a bone plate constructed of biodegradable material can accomplish this. To ensure that the stiffening callus formation keeps pace with the rate of material degradation of the plate, care must be taken while designing the rate of material degradation.[4]

OBJECTIVES AND INDICATIONS OF INTERNAL FIXATION

Goals

- Restore skeletal structure while protecting soft tissues
- Enduring fixation
- Speedier recovery
- More predictability and may be quicker recovery.

Indications

- Intra-articular fractures that have moved
- Open wound
- Polytrauma
- Neurovascular damage that is associated
- Closed therapy failure.

Fixation Construct

- Fixation construct is determined by the patient's variables and fractured personality
- Simple fracture patterns and articular injuries are treated with immediate reduction and absolute stabilization
- Fracture personality includes elements including anatomic location, soft tissue, bone quality, and fracture pattern state
- Relative stability and indirect reduction are used to treat complicated and comminuted fracture patterns.[5]

FRACTURE STABILITY

Absolute stability: Involves anatomic reduction, stable fixation, and direct viewing. Compression plating, lag screws.

RELATIVE STABILITY

It involves fixing and indirect reduction. The objective is to maintain the biological environment of the fracture while restoring axial, angular, and rotational alignment using IM rods, bridge plating, Ex-fix, and casting.

HYBRID FIXATION

This type of fixation combines absolute and relative stability principles. A periarticular fracture with significant meta-diaphyseal comminution is an example.[6]

SCREWS AND ITS FUNCTION IN INTERNAL FIXATION

Screw types include cortical, cancellous, solid, and cannulated as well as locking and non-locking. Locking screws "lock" into the plate to create a fixed angle device; other screw types include cortical, cancellous, solid, and cannulated. IMNs are redirected with the help of a poller or blocking screw, which has a core diameter that is slightly larger than the diameter of the pilot hole in a positional screw. Non-locking plate screws cause friction between the plate and bone because of compression, while locking ones provide angular stability.[7]

LAG SCREW METHOD

100% threaded (example: 3.5 mm cortex screw)

1. Drill perpendicular to the obliquity of the fracture line and reduce the fracture
2. Gliding hole: Only the fracture line should be drilled with the 3.5 mm screw's outer diameter.
3. Using a drill sleeve, center the drill for the screw's core diameter (2.5 mm) inside the gliding hole, and drill the far cortex
4. Proximal cortex countersinking enhances screw-bone load transfer (measure screw length after countersinking).[8]

PLATE FUNCTION

It can be either a locking or a non-locking plate.

Neutralization

It neutralizes/protects lag screws against shear, bending, or torsional stresses across the fracture.

Buttress/Anti-glide

When used in metaphyseal fractures to hold intra-articular fragments in place. It is important to precisely contour a rigid plate to the local anatomy; alternatively, pre-contoured anatomical plates can be employed.

Anti-glide Plate

It is used in diaphyseal fractures. With axial loading, the anti-glide effect causes compression within the crack. Another method for creating a buttress effect is to carefully position a screw and washer near the fracture's apex.[9]

PLATINGPURPOSE:COMPRESSION

- Absolute stability and rigid fixation are provided by compression
- beneficial, especially in transverse fractures where lag screw placement is not an option
- Compression plating can be carried out using
- Plate layout (dynamic compression principle)
- exceedingly bending the plate
- Device for external tension
- A mix of the aforementioned
- Either by itself or in conjunction with lag screws
- Alone – When lag screw insertion is challenging, such as in transverse or short oblique fractures
- Compress the plate and the plate together before inserting the lag screws.[10]

PLATE FUNCTION: BRIDGE

This procedure is appropriate for severely comminuted metaphyseal or diaphyseal fractures or when a direct route to the fracture is prevented by the surrounding soft tissues. The aim is to "bypass" the fracture zone to maintain the fracture biology. Indirect reduction and relative stability rather than anatomic reduction and absolute stability (internal splint).[11]

PLATE FUNCTION- LOCKING

A locking plate provides axial and angular stability when the screw head locks into the plate. A locking construct transfers the load through the complete structure (bone, screw, plate, screw, and bone), and their failure is often caused by plate fatigue fracture.

In contrast to conventional plates, where construct stability depends on bi-cortical screw fixation, a locking construct does not require bi-cortical fixation. However, bi-cortical screws enhance the construct's torsional stability and fixation in osteoporotic and metaphyseal bone. Before locking, fracture reduction, and compression should be done; hence, conventional screws should be installed before locking screws. When treating comminuted meta-diaphyseal fractures and osteoporotic bone with bridging, the use of a locking plate is beneficial.[12]

RECENT DEVELOPMENTS AND TECHNOLOGIES FOR NEWER PLATES

To address bone loss under plates and delayed union, a fundamentally fresh strategy must be sought. Rigid plates support a significant portion of the stresses, alleviating the plated bony segment of the stimuli required for post-traumatic osteogenesis (the production of new bone to fill the fracture gap) and for maintaining bone mass. Rigid plates carry a higher percentage of stress than bone, as seen by the endosteal bone development at both ends of the fracture plate, where load is transferred from bone to plate proximally and from plate to bone distally. Bone has to be dynamically loaded to stay strong. In addition, for a fracture to mend, nature needs to recognize the loss of bone continuity. Under rigorous fixation, primary bone repair is similar to physiologic remodeling. It is a slow procedure that heals fractures beneath less stiff plates much more slowly.

In our perspective, a build that permits micromotion through the fracture site is the only way to improve fracture healing under plates. In addition, micromotion must be restricted to the axial direction, requiring that the build be built to withstand bending, torsion, and shear forces.

We know the significance of dynamic stresses conveyed in the axial direction for post-traumatic osteogenesis from the clinical results of the Ilizarov approach.[8]

Combination holes in more recent plate designs allow for the insertion of both standard and locking screws through the same plate. This enables "hybrid fixation," whereby absolute and relative stability can be attained using a single implant, depending on the fracture pattern.[13]

ADVANCES IN METALLURGY

For use in internal fixation for orthopedic surgery, new materials are constantly being developed by researchers. The metal tantalum, which has been utilized to make superalloys and exhibits remarkable corrosion resistance, is the subject of research at the moment. The use of tantalum in the production of implants has shown promise in studies. The creation of biomaterials has garnered interest recently as well. These substances are not only harmless to bodily tissues, but many of them also disintegrate or reabsorb once the bone has recovered. In this field, poly-L-lactic acid, polyether-etherketone, and hydroxylapatite are now being studied and used as implants. One of the most used surgical tools in foot and ankle surgery continues to be plates and screws. For the distinct foot architecture, plating systems have evolved to be more anatomically specialized, and specialty plates with opening wedges are advancing technique.[9]

Additional technological advancements such as locking plates are also enhancing patient outcomes in high-risk individuals with conditions such as diabetes and osteoporosis. These developments are a part of the growing implantable orthopedic device market.

The majority of conventional bone plates are made of bio-inert substances. Hench *et al*. proposed the idea of the third generation of biomaterials, which highlighted the idea that these biomaterials should be made to trigger particular biological responses at the molecular level. The advancement of material science as a fundamental discipline might encourage a qualitative leap in many domains. Bone plates, the most often utilized implant in the field of orthopedics, are likewise going through a crucial development stage. Here, we envision a novel notion of bone plate, which ought to include the following features: Providing dependable attachment for the fracture ends, avoiding stress shielding, and removing the need for a second operation because the implant would have degraded otherwise.[14]

CONCLUSION

Internal fixation of bone fractures still mostly uses stainless steel and bone plates made of titanium. Although these alloys are sufficiently hard to guarantee the fixing reliability for the fracture fragments, a second procedure for implant removal and an undesirable stress shielding effect are inevitable. In addition, these traditional bone plates perform quite poorly when treating refractory fractures. Tissue engineering, a possible medical technique to replace injured tissues and organs, has grown quickly during the past three decades. Its use in orthopedics, where TE is primarily employed for the repair and regeneration of bone deformities, is one of the fastest expanding disciplines in the field.

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