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Study of Locked Dynamic Compression Plates in Fracture Management

Dr. S.S.V. Ramana, Dr. M. P. R. Vittal
M.S.(Ortho), I/C Professor of Orthopaedics, Siddhartha Medical College, Vijayawada,
M.S.(Ortho), Associate Professor of Orthopaedics, Siddhartha Medical College, Vijayawada

I. Introduction

The philosophy and techniques of open reduction and internal fixation of fractures have evolved during the past several decades. To achieve functional rehabilitation of limb, anatomic reduction, rigid internal fixation, and early joint motion historically were stressed. Although constructs were quite stable biomechanically, healing often was delayed because of the extent of soft-tissue dissection and bony devascularization required. Indirect reduction was introduced in the 1980's by Mast et al and others in an attempt to decrease surgical dissection by relying on ligamentotaxis, blind re-positioning of fragments, reduction aids such as the femoral distractor, and other methods to maintain the soft-tissue integrity and preserve bony perfusion. Additionally, plates were redesigned to limit contact with the underlying bone and further preserve bony vascularity. In the 1990s, Kretteck et al popoularized minimally invasive percutaneous plate osteosynthesis techniques using conventional implants placed through small incisions and submuscular tunnels. Cadaveric studies demonstrated better preservation of periosteal vasculature with these minimally invasive methods than with standard open exposures for internal fixation. As part of continued development of biologically friendly plating, and to facilitate minimally invasive plating techniques, the use of plates that allow screws to lock into the plate to create a fixed-angle construct is gaining popularity. Understanding the biomechanics of these devices is necessary to appreciate fully the current indications, clinical results, and complications of locking plate technology.

The introduction of much more rigid fixation obtainable with AO implants led to a new set of clinically significant problems: bone loss under the plate, fracture at the ends of the plates, or refracture through the fracture site or screw holes after plate removal. Anderson et al and Hadka and Gustilo had a 22% incidence of refracture after plate removal using the standard, narrow 4.5mm AO plate on fractures of the radius and ulna. Chapman et al were able to eliminate refractures in plate fixation of the radius and ulna by using the AO/ASIF 3.5mm system. Laboratory investigation of this problem has shown two possible cause: stress protection, and devascularization followed by revascularization. Studies by Woo et al, Coutts et al , Uhthoff and Dubus, and others demonstrate that stiff plates, when applied to healing fractures, result in weaker fracture callus and when left in place for prolonged periods, weakening of the bone under the plate due to bone resorption. In accordance with Wolff's law, introducing a rigid member across a fracture site alters the signals influencing the homeostatic mechanisms controlling bone apposition and resorption, so that the fracture heals with weaker callus and bone resorption occurs under the plate and in surrounding cortex.

Swiontkowski and Senft and others have demonstrated devascularization of the cortex secondary to soft-tissue stripping and disturbance of the intrinsic blood supply to bone by the application of the plate and insertion of screws. Newer plate designs have addressed both issues by producing more flexible plates for materials with a lower modulus of elasticity, such as titanium, titanium alloys, carbon fiber, or polymer, and by newer configurations. Only titanium is currently in use clinically, however. Thus the need for the better fracture fixation plate system is required for the osteopenic, intraarticular metaphyseal fractures and comminuted diaphyseal fracture made the way for the evolution of the locking plate system in treating these cases.

Aims & Objectives

1. To study the role of locking plates in fracture management.
2. To study the biomechanics and principles to be followed in various indications of the locking plates.
3. To study the advantages of the locking plate over the normal conventional plating in osteopenic, comminuted and metaphyseal fractures.
4. To follow up the patients till radiological union and study the complications of the locking plate system.

II. Results

In our study of 20 cases, 15 cases were due to RTA, 4 were due to trivial trauma and 1 case was due to fall from height. 11(55%) cases were closed fractures, 2(10%) were grade I compound fractures, 2(10%) were grade II compound fractures, 3(15%) were grade IIIA compound fractures, 2(10%) were grade IIIB compound fractures according to Gustillo-Anderson Classification. In our study, 17 were male and 3 were female.

Principles And Biomechanics

PRINCIPLE USED	NO OF PATIENTS	% OF TOTAL #
COMPRESSION	7	35%
NEUTRALIZATION	2	10%
BRIDGING	4	20%
COMBINATION	7	35%

Post Op Complications

COMPLICATIONS	NO OF CASES	PERCENTAGE
NONUNION	1	5%
INFECTION	1	5%
IMPLANT BENDING & CUTTHROUGH	NIL	NIL
TOTAL	2	10%

Indications: Osteopenic Vs Normal

BONE STOCK	NO OF CASES	PERCENTAGE
OSTEOPENIC	3	15%
NORMAL	17	85%

III. Discussion

The optimal treatment of osteopenic fractures, metaphyseal and intra-articular fractures, highly comminuted fractures, particularly those involving diaphyseal and metaphyseal bone, proximal tibia and distal femur fractures patients are challenging, as they are at a greater risk for delayed union or nonunion following plate fixation because of poor screw purchase or loosening. Inadequate screw purchase in the cortical bone may result in mechanically unstable fracture stabilization, fixation failure, and nonunion. Locking plate systems with screw heads that threaded into the plate and act as fixed-angle devices may facilitate improved stability in such cases. In the present study, we included 20 cases, all were treated with locking plates of different types following 3 biomechanical principles i.e. compression principle, bridging principle, neutralization principle or combination principle. And all cases are studied post operatively till radiological union has occurred.

Out of 20 cases 16 were due to RTA and 4 were due to trivial injury. Among them 11 are closed fractures and 9 were compound fractures. In our study, 7 cases were in the age group of 15-30 yrs, 9 cases were in the age group of 31-45 yrs, 4 cases were in between 46-60 yrs. In our study, 17 cases were male and 3 were female.

Post-op Complications: Of the 20 cases studied 2 cases had complications which were treated later followed by fracture union

1. One diabetic patient had post-op complication of infection, which was treated with antibiotics and the union occurred late i.e. 6 months after the infection was subsided as the case being diabetic, meticulous sugar control and postop antibiotic coverage after culture sensitivity report responded very well and union occurred after 6 months.
2. Another case ended up in nonunion. Apart from this there are no significant complications in the 20 cases studied.

Of the 20 cases studied 3 cases is of osteopenic bone stock constituting 15% of the total cases while the remaining 17 cases are of normal bone. Patients with osteopenic may be at a greater risk for delayed union or nonunion following plate fixation of a diaphyseal or metaphyseal fracture because of poor screw purchase or loosening. Inadequate screw purchase in the cortical bone may result in mechanically unstable fracture stabilization, fixation failure, and nonunion. Locking plate systems with screw heads that thread into the plate and act as fixed-angle devices may facilitate improved stability in such cases. In the present study the 3 cases with osteopenic fractures are treated with the use of both screw types within a single fracture fragment, which potentially mixes different biomechanical fixation principles. Obtaining an initial compression fit between the plate and the bone with an unlocked compression screw, followed by the use of locked screws in the remaining holes, has been recommended for the treatment of fractures in osteopenic bone. These cases showed good union in an average of 16 weeks. Post operatively fracture site was splinted for 6 weeks followed by physiotherapy. Radiological union occurred with good amount of functional outcome in all the 3 cases. Of the 20 cases studied, simple fractures took 12-16 weeks for fracture healing and compound fractures between 16-20 weeks. One case ended in nonunion even after 28 weeks.

Of the 20 cases one case ended up in nonunion. The case which ended up in this complication is simple transverse fracture both bone forearm. In locking plate with adequate compression on either side of the fracture before applying the remaining locking screws aids in fracture union. The locking plate system we used contains combination holes in which either locked or unlocked screws may be placed. The use of unlocked screws allows for compression across the fracture site, and if micromotion is eliminated and absolutre rigidity is achieved, primary healing and direct fracture remodeling may occur. However, this requires friction between the plate and the bone. Locking screws, on the other hand, act as internal splints in which stable and controlled micromotion is preferable, which leads to secondary healing through callus formation. So, obtaining an initial compression fit between the plate and the bone with an unlocked compression screw, followed by the use of locked screws in the remaining holes, has been recommended for the treatment of fractures in osteopenic bone and simple transverse fractures.

IV. Conclusion

Locked plating represents a major advance in fracture care. Locking plate offers improved fixation stability in osteopenic bone and for comminuted and periarticular fractures. The additional stability per screw compared with that of conventional nonlocking fixation is because the locking plates with screw heads thread into the plate and act as fixed-angle devices. The application of locking plates is a little more difficult than placement of conventional plates. Fracture reductions are often done indirectly. The locking screw must be carefully aligned along the axis of the receiving hole to ensure proper tightness, and the length of the plate must be selected carefully. Despite the necessity of mastering these techniques, the use of locking plates will likely increase, particularly with the increasing prevalence of fragility fractures in our aging population which is ever increasing and increase in high energy fractures in younger patients surviving severe trauma as seen in the study where 75% constitutes the RTA.

Theoretically a locking plate could be used anywhere a traditional plate is applied. As the locking plate system has combination holes in which either locked or unlocked screws may be placed. The use of unlocked screws allows for compression across the fracture site, and, if micromotion is eliminated and absolute rigidity is achieved., primary healing and direct fracture remodeling may occur. So, obtaining an initial compression fit between the plate and the bone with an unlocked compression screw, followed by the use of locked screws in the remaining holes, has been recommended for the treatment of fractures in osteopenic bone and simple transverse fractures. But in simple transverse fracture use of normal conventional dynamic compression plates are more appropriate than the locking plate if the bone stock is good. This also implies that if an unlocked screw is used for reduction, it may be unnecessary to replace it with a more expensive locked screw.

Long term problems like implant removal are not studied in these cases due to relatively short term followup and did not need removal of the implant. But it may be relatively difficult for removal than conventional plates. The clinical success of these implants is likely the result of the improved biologic environment provided by minimally invasive plate insertion with no or minimal periosteal stripping as well as the stable mechanical environment thus union rate even in comminuted and osteopenic fractures is satisfactory.

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