DISSERTATION ON

LOCKING COMPRESSION PLATING FOR OSTEOPOROTIC AND PERI-ARTICULAR FRACTURES – A SHORT TERM OUTCOME ANALYSIS

Submitted for
M.S.Degree examination
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CERTIFICATE

This is to certify that this dissertation entitled "**Prospective study on the Locking compression plating for osteoporotic and peri-articular fractures.**" *submitted by* ***Dr.Navin Balasubramanian*** *appearing for Part II, M.S. Branch II - Orthopaedics degree examination in March 2010 is a bonafide record of work done by him under my direct guidance and supervision in partial fulfilment of regulations of The Tamil Nadu Dr. M.G.R. Medical University, Chennai.*

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INTRODUCTION

Peri-articular and osteoporotic fractures of long bones are becoming more common and are very challenging injuries to treat even for a veteran orthopaedician. Peri-articular fractures occur in two different age groups -due to different types of injuries. In young patients peri-articular fractures occur due to high velocity injury such as road traffic accidents, fire arm injuries and sport's injuries while in elderly patients with osteoporosis it occurs usually due to low velocity injury like fall during walking. Also these conditions do result from fractures in the young treated by conservative methods and which in the long term end up in non-unions and further more these conditions are compounded by disuse osteoporosis.

Because of the proximity of peri-articular fractures to the corresponding joints, regaining full motion and function may be difficult. Also achieving full union rates are increasingly difficult because of the lack of availability of good bone stock which is very common in peri-articular fractures because of the cancellous nature of the metaphyseal fragment. The incidences of malunion, nonunion, and infection are relatively high in many reported series. In older patients, treatment may be complicated by coexisting osteoporosis.

There are multiple options for the treatment of these fractures with their associated merits and demerits. Anatomical restoration of the articular surface in cases of peri-articular fractures and good fracture alignment and adequate compression in osteoporotic fractures along with secure fixation of both proximal and distal fragments are the key to achieve good functional outcome in these fractures to prevent early secondary osteoarthritis.

Treatment of these fractures have been a controversial subject over the past two decades. There have been a changing philosophy towards surgical treatment of these complicated fractures. Close management of these fractures was the treatment of choice until 1970. This was due to non availability of appropriate implants and lack of proper techniques. Apart from the usual problems of confining elderly patient to bed, conservative methods at any age may be complicated by joint stiffness, malunion and nonunion.

Early surgical stabilization can facilitate care of the soft tissue, permit early mobility and reduces the complexity of nursing care. Open reduction and internal fixation has been advocated, using implants, including the conventional dynamic compression plates,angle blade plate, fickle devices, Rush roads, Ender nails, dynamic condylar screw, condylar buttress plate and interlocking nails.

The use of fixed angle devices require certain amount of bone stock present, which limits their use in some fracture types. The conventional plates are also associated with their own demerits such as screw pullout, implant failure and unstable fixation needing postoperative immobilisation. Delay in postoperative mobilization results in stiffness of the joint which is an indicator of poor outcome.

A locking plate decreases the screw-plate toggle and motion at the bone-screw interface and provides more rigid fixation. Rigid fixation is felt to be one key to the successful treatment of these fractures. But fixation in osteoporotic and comminuted fractures is difficult to obtain anatomical reduction and adequate purchase.

So now with the evolution of locking compression plating for osteoporotic and peri-articular fractures especially for the comminuted intra – articular fractures many of the older demerits could be addressed which includes the increased stability due to locking compression plating principle, multiple screw options in the distal fragment providing option for fixing the multiple fragments restoring the anatomical congruity and providing stable fixation of the distal fragment with the proximal fragment with resulting increased stability allowing for early mobilization.

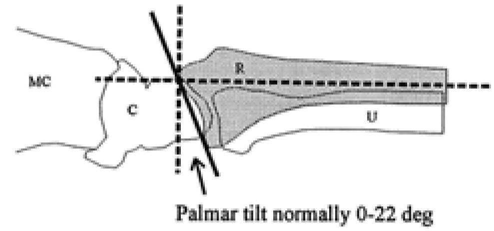
Anatomical considerations:

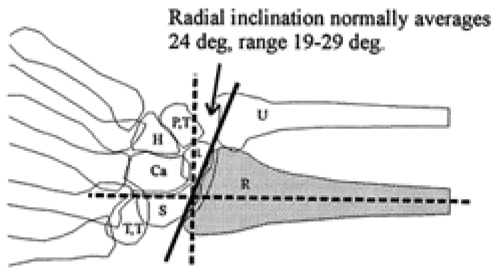
The most commonly encountered regions where peri-articular fractures pose a problem are in order of occurrence distal radius, distal femur, proximal humerus and distal tibia. Hence their relevant anatomy will be discussed in particular with associated radiological assessment of such fractures.

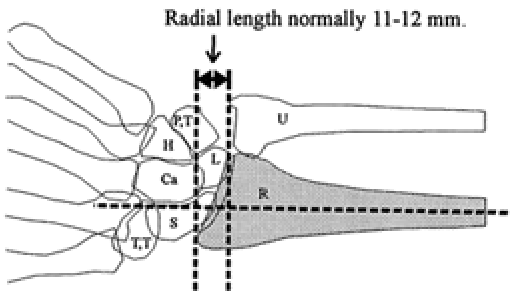
DISTAL RADIUS :

Distal Radius Fracture Anatomy

- Distal radius carries 80% of axial load
- ROM-80°dorsiflexion, 85°palmarflexion, 90°pro\sup,25°radial deviation,35°ulnar deviation
- Distal radius 3 column anatomy: Radial column (strong cortical bone), Intermediate column (contains lunate facet and sigmoid notch); Distal ulna column (contains TFCC)
- Radial inclination=23°,radial length=12mm, volar tilt=11°, ulnar variance -0.6mm, scapholunate angle = 60° +/- 15°







- Sensory branch of radial nerve becomes subcutaneous 5-10cm proximal to radial styloid in interval between brachioradialis and ECRL. It bifurcates before wrist. Dorsal branch 1-3cm radial to Listers. Supplies 1st and 2nd web spaces. Palmar branch passes within 2cm of 1st dorsal compartment provides sensation to dorsolateral thumb after passing directly over EPL.

- Palmar cutaneous branch of the Median nerve arises from the Median nerve @4-6cm proximal to the volar wrist crease and travels between the FCR and median nerve. Supplies sensation to the thenar area.

- Dorsal cutaneous branch of ulnar n arises deep to FCU, becomes SQ 5cm from pisiform-has multiple branches

Distal Radius Fracture Xray

- PA, Lateral wrist films. Normal radiographic parameters: Radial inclination=23°,radial length=12mm, volar tilt=11°, scapholunate angle = 60° +/-15°. Assess ulnar variance, carpal alignment and sigmoid notch conguence

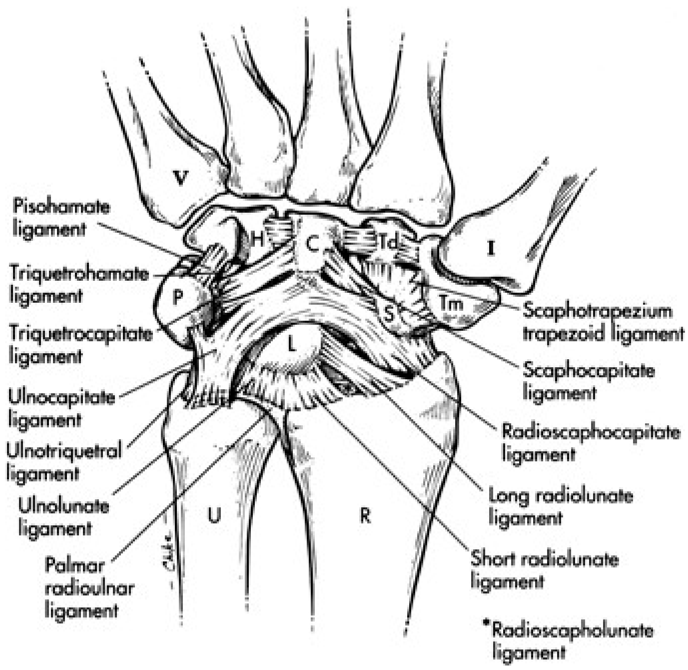
- Signs of DRUJ injury: fracture at the base of the ulnar styloid, widening of the DRUJ space seen on the P/A xray, >20° of dorsal radial angulation, and >5 mm of proximal displacement of the distal part of the radius.

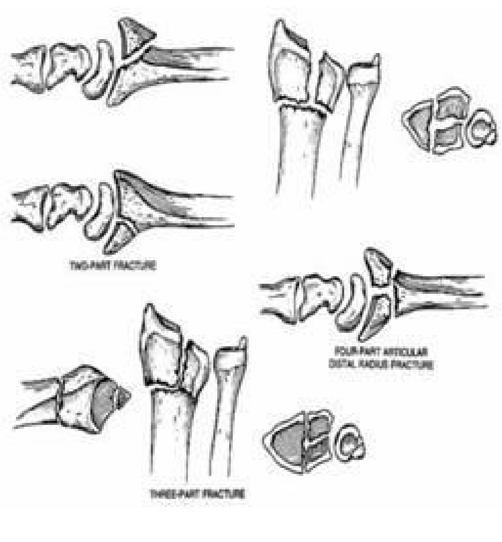
- 1mm-2mm sagital CT best to view articular depression fx

- MRI if TFCC or scapholunate ligment tears suspected

Distal Radius Acceptable Reduction

- <2mm articular stepoff
- <5mm shortening
- <10° dorsal tilt





Distal Radius FractureFx Classification/Treatment

- AO Classification / Treatment: AO Classification

- AO Type A=extra-articular

- AO Type B=partial articular; fx of radial styloid, medial corner, die-punch fracture of central articular surface

- AO Type C=complex articular; high-energy, none of the articular surface remains in continuity with the metaphysic. Involvement of >50% of the diameter of the metaphysic as seen on any radiograph, comminution of at least 2 corticies of the metaphysic, or >2.0mm of shortening of the radius.

DISTAL FEMUR :

Distal Femur Fx Anatomy

- Hoffa Fragment = coronal (frontal) plane fragment associated with comminution in the intercondylar notch. Present in @1/3 of Type C fractures.

Distal Femur Fx Clinical Evaluation

- ATLS resuscitation. These can be high enegery injuries, assessment should begin with the A,B,C's.

- Obvious deformity of knee/thigh often with limb shortening

- Document neurovascular exam before and after any treatment.

Distal Femur Fx Xray

- A/P and lateral views of the knee.

- CT: Ct scan is nearly always indicated for pre-operative planning as there is a high association with coronal plane fractures which are difficult to see on plane films.

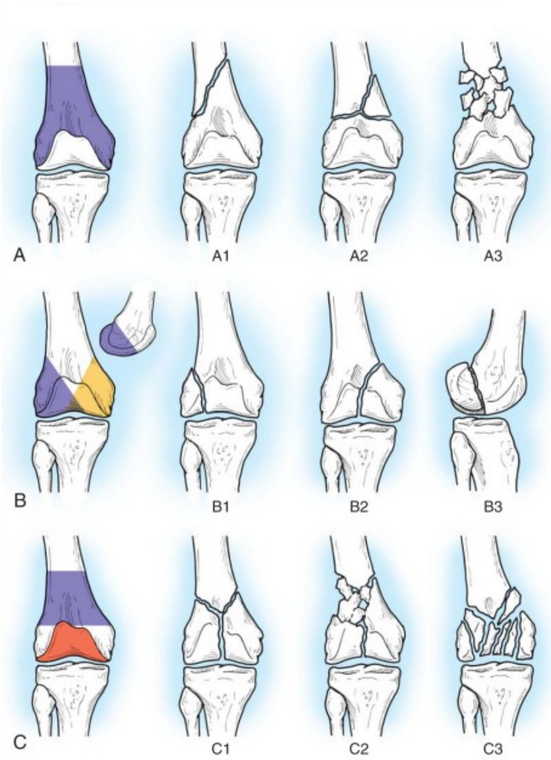
Distal Femur Fx Classification/Treatment

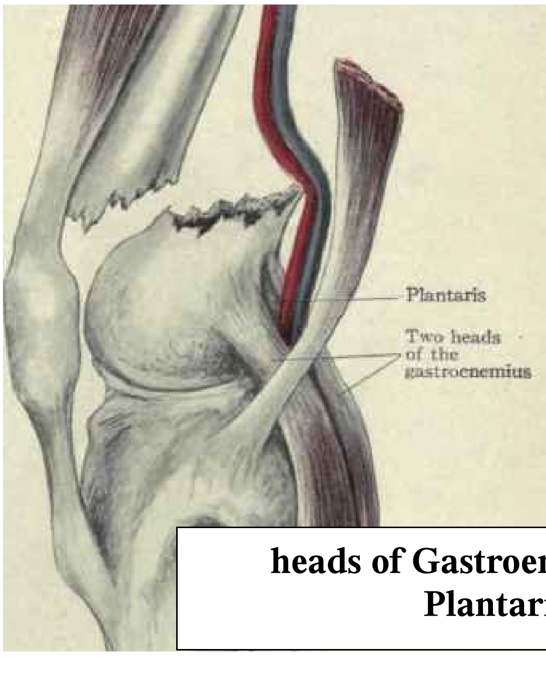
- AO Classification

- Type A=extraarticular

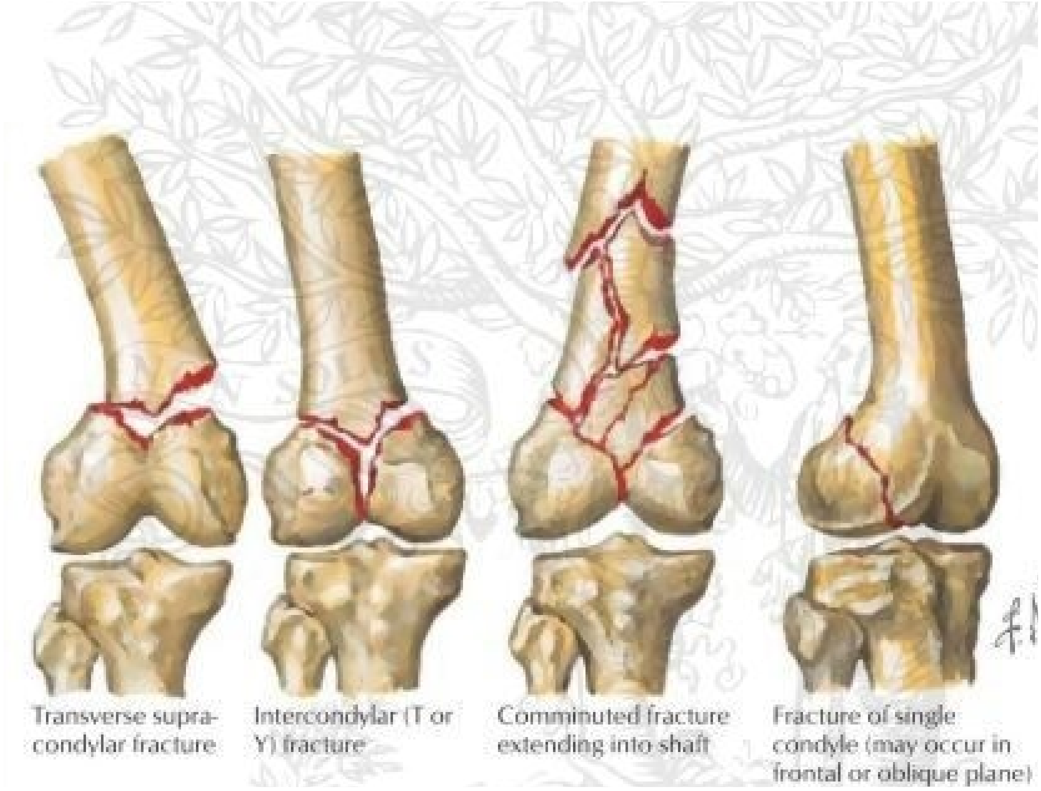
- Type B=unicondylar fractures

- Type C=intrarticular fractures





heads of Gastroenemius and Plantaris



PROXIMAL HUMERUS :

Proximal Humerus Fx Anatomy

- Anatomic Landmarks

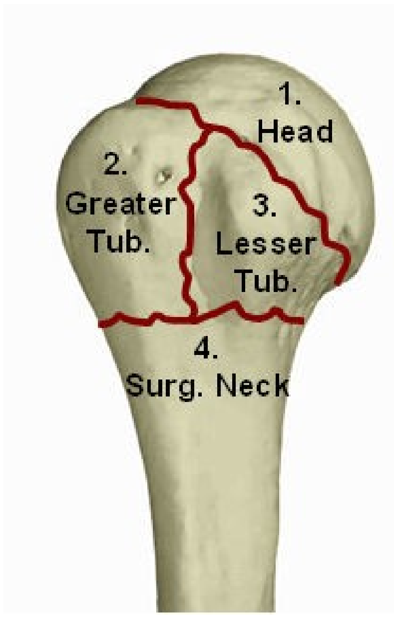
  -Mean distance between the pectoralis major tendon and the top of the humeral articular surface is 5.6cm.

  -Normal distance from the greater tuberosity to the superior protion of the articular surface of the humeral head = 7-8mm.

  -The neck-shaft inclination angle averages 145 degrees. The humeral head is retroveted an average of 30 degrees.

- Greater tuberosity = insertion of supraspinatus, infraspinatus, and teres minor tendons

- Lesser tuberosity = insertion of subscapularis tendon.



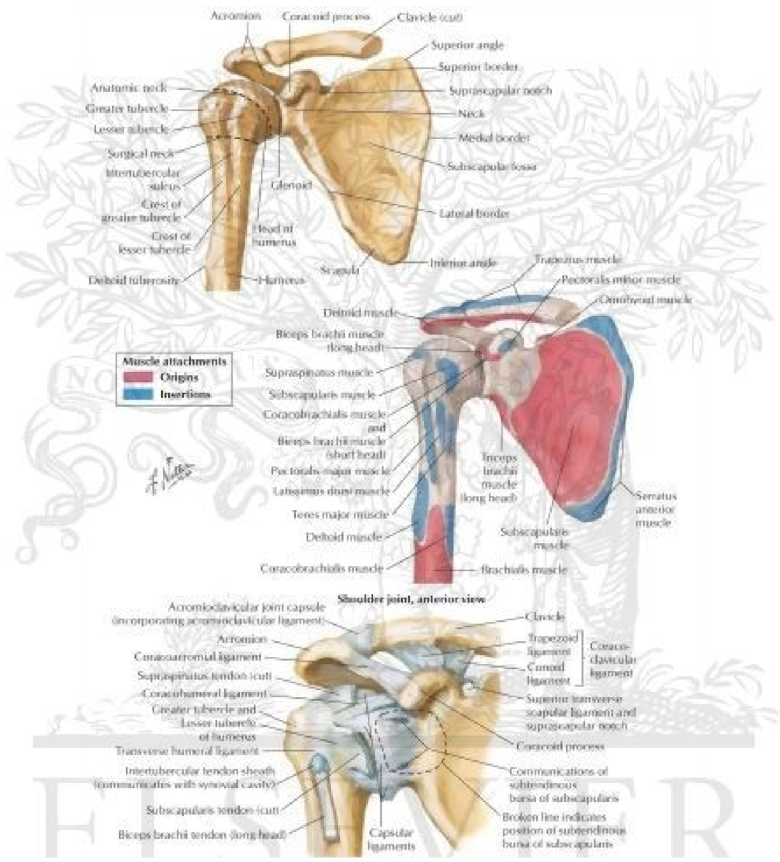
- Displaced greater tuberosity fx is pathognomonic of a longitudinal tear in the rotator cuff at the rotator interval between the supraspinatus and subscapularis tendons.

- Primary blood supply to humeral head is the ascending (arcuate) branch of anterior humeral circumflex artery which runs in the bicipital groove. Less significant supplies include the posterior humeral circumflex artery and small vessels entering through the rotator cuff insertions.

- Humeral head vascularity after fracture can be estimated by the amount of metaphyseal head extension, <8mm is associated with ischemia; Medial hinge disruption >2mm is associated with ischemia. If both indicate ischmia the positive predictive value of ischemia for an anatomic neck fx is 97%.

- Most common site of injury to the axillary artery is in the third part(named in relation to the pec minor) of the artery at the origin of the anterior and posterior humeral circumflex arteries.

- Deforming forces: Pectoralis major pulls the shaft medially, anteriorly and internally rotates. Supraspinatus abducts the head fragment in two part fractures. If greater tuberosity is fractured it is pulled superiorly and posteriorly by the supraspinatus and infraspinatus. Lesser tuberosity fractures are pulled medially.



Proximal Humerus Fx Clinical Evaluation

- Generally complain of shoulder pain after a fall
- Swelling and ecchymosis in shoulder which can expend into chest wall and down arm.
- Document NV exam, especially axillary nerve.
- Assess for head injury, LOC, cardiac/neurologic reasons for fall.

Proximal Humerus Fx Xray / Diagnostic Tests

- AP, scapular lateral and axillary views. Ensure humeral head is not dislocated.

- AP in external rotation best demonstrates greater tuberosity fractures. AP in internal rotation best demonstrates lesser tuberosity fractures.

- CT may be useful in determining fracture type (head splitting) and displacement, especially in greater tuberosity fractures. Helpful for pre-op planning.

- MRI generally not useful.

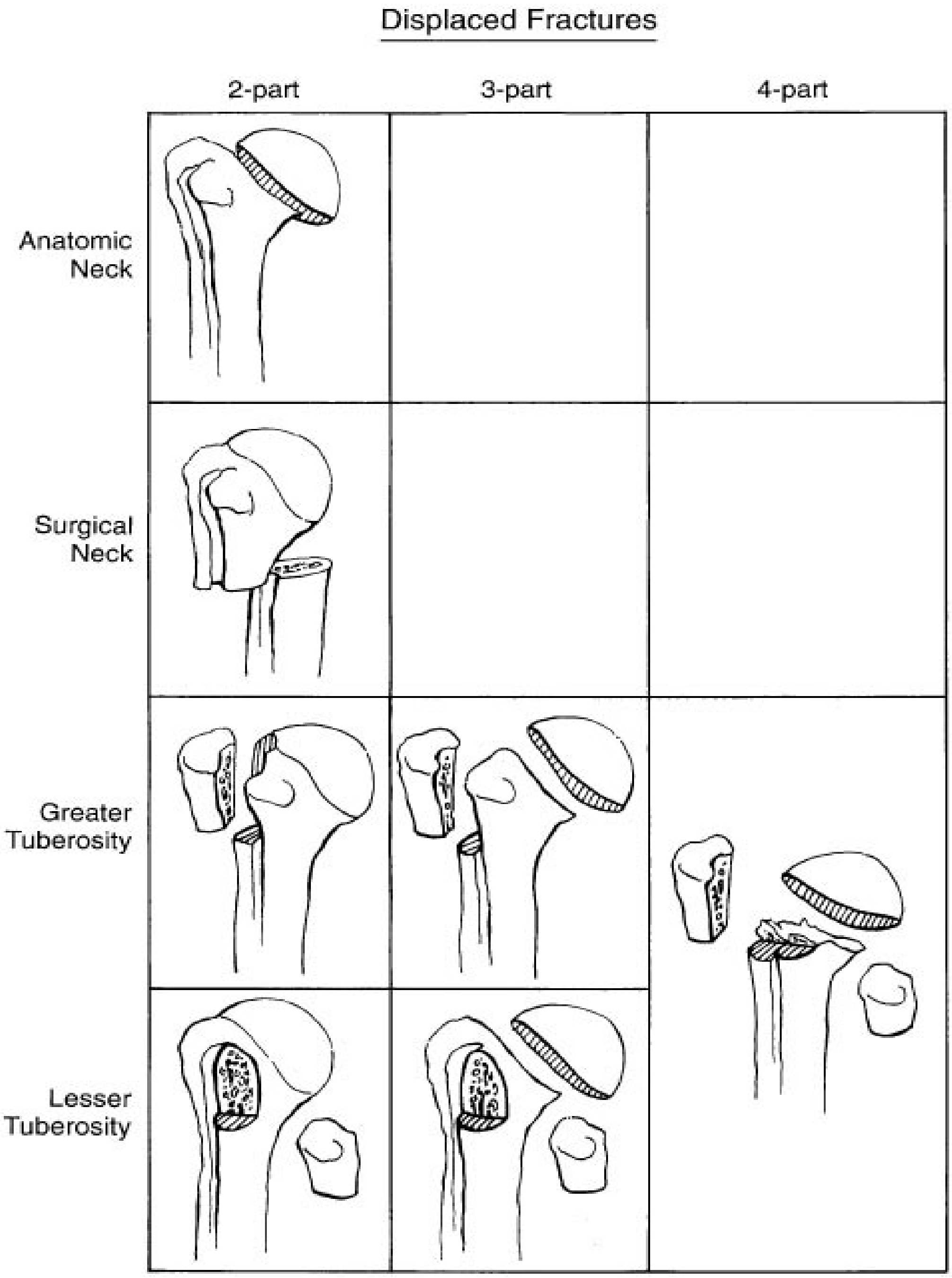
- Consider EMG/NCV if neurologic injury is suspected, occurs in 67% of proximal humerus fractures.

- Angiogram: consider for diminished radial/brachial pulse, expanding hematoma, changing neurologic status.

Proximal Humerus Fx Classification / Treatment

- Neer classification based on parts(shaft, head, GT, LT); displacement = >10mm or >45 degree angulation.. Poor interobserver reliability. CT improves interobserver reliablity.
- Minimally displaced = sling, PT within 2 wks. Functional outcome, ROM and pain are significantly better when PT is started within first two weeks..
- Proximal Humerus Surgical Indications: fx 1cm displaced or have >45 degrees angulation or >10mm tuberosity displacement, open fx, unable to reduce by closed means,
- Greater tuberosity 2-part fracture
- Surgical neck 2-part fracture
- Lesser tuberosity 2-part fracture
- Valgus impacted 4-part fx with good bone: ORIF. Non-op outcomes = 80% adjusted Constant score
- 4-Part Fracture: insufficient evidence is available to determine best treatment option. Increased pain with non-op treatment, equivalent

ROM. Poor results demonstrated with non-op treatment .



DISTAL TIBIA

Pilon Fracture Etiology / Epidemiology / Natural History

- Pilon fractures are fractures involving the articular weight bearing surface of the distal tibia.
- Usually high energy axial load (MVC, fall from height), occasionally low-energy rotation/torsion
- Foot postion determines fracture pattern: if plantar flexed = posterior tibial fragment, neutral = entire articular surface, dorsiflexed=anterior fragments
- 7-10% of tibial fractures

Pilon Fracture Anatomy

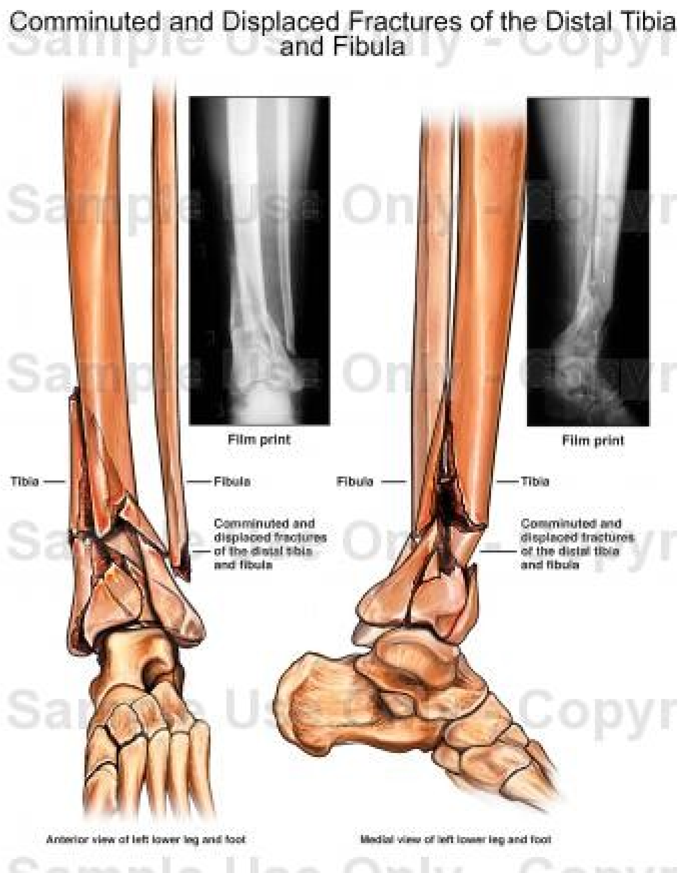
- Distal tibia fractures within 5cm of the ankle

Pilon Fracture Clinical Evaluation

- Assess vascularity by evaluating dorsalis pedis and posterior tibial pulses as well as distal capillary refill
- Evaluate soft tissues.

Pilon Fracture Xray

- A/P, lateral and mortise views of the ankle; A/P, lateral tibia films
- CT scan indicated for pre-op planning, CT scans should be done in traction with 3D reconstructions.



Pilon Fracture Classification/Treatment

- Soft tissues injuries are classified according to Tscherne and Gotzen.
- Open fracture classified per Gustilo and Anderson.

- Principles of Treatment: restoration of fibular length, anatomic reduction of tibial articular surface, bone grafting of metaphyseal defects, medial buttress plating to prevent varus

- Treatment: initial fixation of the fibula with temporary spanning external fixation with delayed conversion to internal fixation when soft tissues permit, generally 14-21 days.

- closed fractures should be placed in calcaneal traction and a Bohler-Braun frame.

- open fractures/compartment syndromes should be taken to OR for 2-pin traveling traction. (one 6mm centrally threaded calcaneal pin and one proximal tibia pin at level of the fibular head with quadrilateral frame.

- AO comprehensive Classification of Fractures of long Bones

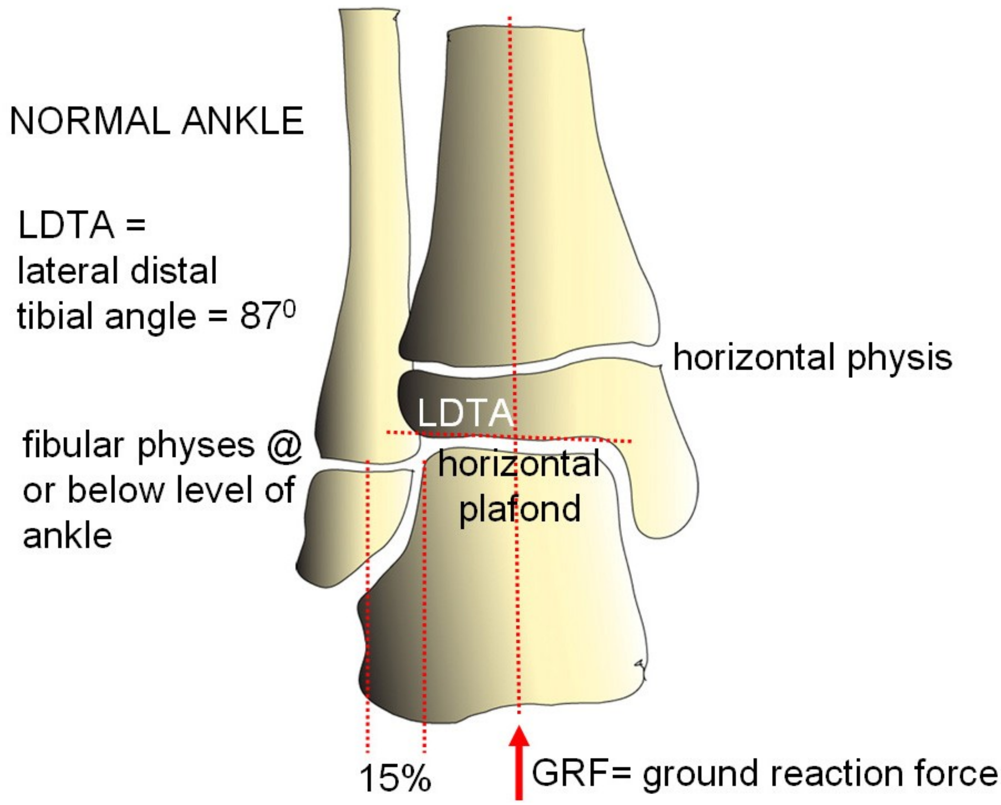
- Ruedi Allgower Classification.

- Type A=extra-articular=@92% good/excellent results,

- Type B=partial articular=@85% good/excellent results,

- Type C=complete articular=@60% good/excellent results

- poor results associated with high-grade soft-tissue injury, >2mm articular incongruency, malalignment of mechanical axis >5degrees



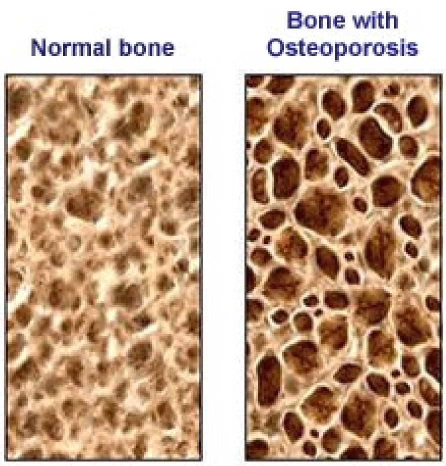
OSTEOPOROSIS

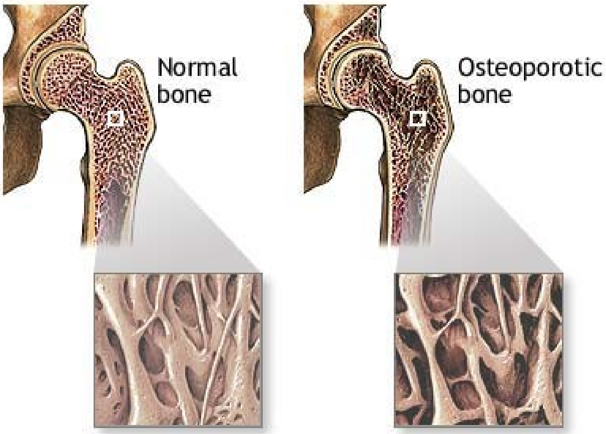
Osteoporosis is a condition marked by reduced bone strength, which can lead to an increased risk of fractured, or broken, bones. Osteoporosis was first observed in Egypt in 990 BC and has therefore been known about for many centuries. The strength of a person's bones is affected by their bone mass (amount of bone) and bone quality. Osteoporosis is the major underlying cause of fractures in postmenopausal and older women. Fractures occur most often in bones of the hip, spine and wrist, but any bone can be affected. Some fractures can be permanently disabling, especially when they occur in the hip. One of the commonest risk factors associated with fracture is a fall .

Approximately one third of community dwellers aged 65 years or more and 50% to 60% of residents of nursing and old people's homes fall each year with women falling more than men . Fractures, dislocations, or serious soft tissue injuries result from about 10% to 15% of the falls in patients living in the community and from about 15% to 20% of falls in institutionalized patients (14,15,16). Fractures occur in 3% to 12% of falls in the elderly being more common in women than men (10). Fragility fractures also impose an enormous cost on society. Hip fracture is a major cause of hospital admission in the elderly.

Osteoporosis usually progresses without symptoms until a fracture occurs. In some cases, bones affected by osteoporosis can become so fragile that fractures occur spontaneously or as the result of minor bumps, falls, or normal stresses and strains such as bending, lifting or even coughing.

Many people think that osteoporosis is a natural and unavoidable part of aging; however, medical experts now believe that osteoporosis is largely preventable. People who already have osteoporosis can take steps to prevent or slow the progression of the disease, and reduce their risk of fractures. Although osteoporosis was once viewed primarily as a disease of old age, it is now recognized as a disease that can stem from less-than-optimal bone growth during childhood and adolescence, as well as from bone loss later in life.





The World Health Organisation defines osteoporosis by comparing the bone mineral density with that of a gender-matched, healthy young adult reference population. A T-score in women of less than -2.5 at any one of three skeletal sites, the femur, the lumbar spine or the distal radius is the WHO 'gold standard' for diagnosing osteoporosis. However, the most common clinical method for assessing the BMD is dual-energy x-ray absorbtiometry of the central skeleton taken at the hip and lumbar spine.

SPECIFIC SURGICAL CONSIDERATIONS FOR TREATING FRACTURES IN AN OSTEOPOROTIC BONE

If an older patient with osteoporosis sustains a fracture there are several important age-related factors to consider when planning treatment. The functional demands in the elderly are different from young healthy people and long-term immobilization in bed must be avoided. Delaying fracture treatment by more than one day has been reported to increase mortality in the elderly . Thus, it is probably even more important in the elderly to achieve a stable fracture fixation that will reduce pain and facilitate mobilization.

Reduced bone mass, increased bone brittleness, and structural changes such as medullary expansion must be taken into account in the osteoporotic patient when deciding the type of surgical method to be used. It must also be understood that the osteoporotic patient usually has low physical demands and a reduced life expectancy when making a decision regarding treatment. For example long-term complications following arthroplasty will not occur in the majority of elderly patients. Thus, joint replacement surgery is a good option after displaced femoral neck fractures as the stability provided by the implant permits immediate weightbearing and mobilization . The major problem in osteoporotic fracture treatment is fixation of the device to the bone as bone failure is much more common than implant breakage. Internal fixation devices such as sliding nail plates, intramedullary nails, and tension band constructs that permit skeletal loading minimize stress at the implant bone interface.

Some osteoporotic fractures are also associated with bone loss. If this occurs it is important to achieve bone contact between the two main fragments even if this results in shortening of the extremity. Good bone contact will improve the chance of healing, reduce the healing period, and also reduce the strains on the fixation device. If plates are used these should be used as tension bands which require cortical contact opposite the plates. In addition long plates, where the spacing of the screws are more important than the number of screws, should be used as they will distribute the forces over a larger area reducing the risk of bone failure .

Several types of fragility fractures such as fractures of the humerus, distal radius, and closed fractures of the tibial diaphysis can be mobilized in a sling, cast, or brace . Immobilization in casts has the disadvantage of immobilizing the joints adjacent to the fracture often leading to joint stiffness. Furthermore, a cast does not control fracture shortening which is often seen in osteoporotic bone; and if the subcutaneous tissue is very mobile, as it often is in the elderly, cast fixation will not provide adequate fracture fixation. External fixators can be used but the main problem with external fixation in osteoporotic bone is the same as for screw fixation, namely loss of fixation. Loosening of the device is often followed by pin infection and local bone resorption sometimes leading to a secondary fracture at the pin site . The introduction of hydroxyapatite coated pins has reduced the complication as fixation is improved compared to using titanium-coated and standard pins .

Another method of improving fixation and avoiding bone resorption is to anchor the screws with polymethylmethacrylate bone cement. This can be inserted into the bone and allowed to harden before drilling or it can be inserted into the screw holes just before the screws are inserted. The screws can then be tightened after the cement hardens . If this method is used it is important that the cement does not penetrate the fracture so as to interfere with fracture healing.

Metaphyseal fractures in osteoporotic bone are associated with specific fixation problems as the metaphyseal fragment is often very small. To improve fixation and resist bending forces a screw and plate construct with a locked angle between the plate and metaphyseal screw is often used. Recently locked plates have been introduced threaded screw holes in the plates, which create angular stability between the screws and the plates.

The LISS system (less invasive stabilization system) and the LCP (locking compression plates) are examples of such plates. The LCP provides 3 times greater stability than a standard lateral condylar buttress plate and about 2.5 times greater stability than a 95-degree condylar plate in axial loading . Biomechanically this is explained by the fact that the LCP also uses multiple screws for metaphyseal fixation. A particular problem that often rules out the use of screws and plates in osteoporotic bone is the periprosthetic fracture. These can be treated with plates using wires for fixation around the femoral shaft

ETIOLOGY

Cancellous metaphyseal regions of bones in many ways behave like osteoporotic bones in that they are the weak link between dense cortical bone and adjoining joint surface. Hence both in the elderly and young alike periarticular fractures and osteoporotic fractures are addressed in similar ways. However the nature of violence in both age groups is different. In the young age groups they mostly occur following high energy violence like Road traffic accidents, fall from heights, fall of heavy objects on them. In the elderly population though these similar fractures do occur following trivial trauma like accidental fall.

TREATMENT

All fractures both in shaft and in particular the metaphyseal cancellous regions need accurate alignment of joint surface and immobilisation. This is of paramount importance as maintaining joint motion is imperative. Also in osteoporotic bones the healing potential of these bones is also altered. These potential hazards must be addressed if we are to provide a normal mobile stable joint to the patients.

Non operative Treatment:

Earlier till 1970's most of the fractures were treated with closed reduction methods and immobilized in plaster cast . They were followed primarily because of the lack of appropriate implants and adequate surgical constraints. For non displaced and stable fractures, bracing can provide enough stability to control pain and allow healing; however, bracing cannot control alignment or length because immobilizing the joint above and below is impossible. Hence the fallacies of plaster casting techniques were instrumental in the new age of operative fixation techniques.

Surgical Treatment:

Surgical treatment requires reduction followed by fixation to maintain alignment. Options include external fixation or internal fixation. Internal fixation is with intramedullary devices (eg, flexible rods, more rigid retrograde or antegrade rods) or extramedullary plates and screws.

Distal Radius fractures treated with External Fixator and ligamentotaxsis :

This device allows distraction of the fracture fragment and prevents collapse of the cancellous bone. The drawbacks of this are poor patient compliance in that this requires atleast 6 weeks of application, cannot correct three dimensional deformities and leads to wrist stiffness.

Proximal humeral fractures treated with tension band principle and intramedullary devices :

These devices are used in simple Neer's two part fractures but comminuted fractures and fractures involving head of the humerus cannot be satisfactorily managed.

Supracondylar femur fracture treated with a dynamic condylar screw plate:

This device allows fixed-angle stabilization of the fracture, which usually prevents late loss of reduction, but it is technically limited because it cannot be used to fix multiple fragments.

Supracondylar femur fracture treated with a blade plate:

This device allows fixed-angle stabilization of the fracture, which usually prevents late loss of reduction, but it is technically limited because it cannot be used to fix multiple fragments.

Supracondylar femur fracture treated with a supracondylar buttress plate:

This device provides multiple holes for screw fixation of multiple fragments, but it is not a fixed-angle implant so it may cause late deformity.

Supracondylar femur fracture treated by retrograde intramedullary nail:

Intramedullary devices are mechanically stronger than plates but have limited ability to control multiple fragments and require exposure through the knee joint.

Supracondylar femur fracture treated with Zickel flexible intramedullary rods:

These devices act as an internal splint and can be placed rapidly with minimal blood loss and surgical exposure but do not control length and alignment.

Supracondylar femur fracture treated with external fixation and minimal internal fixation:

This technique allows immediate restoration of length and alignment with minimal surgical exposure, but it often cannot hold the alignment in the long term and has associated problems with pin care.

Supracondylar femur fracture treated with a tibial buttress plate:

This type of plate is rarely used for these fractures but can allow low-profile fixation of stable fracture patterns.

Distal tibial fractures treated with interlocking nails, K wire fixation, External fixator :

These implants do not provide adequate stable fixation also they do not conform to the anatomic shape of the tibial plafond. Hence their use in distal tibial fractures is limited.

History of plating

The date that a bone plate was first used on bone is reported to be 1565 (300 years before general anesthesia). That plate was used to repair a cleft palate and was made out of molded gold. The late 1880's brought the next major change in bone plating; surgeons began burying the bone screws below the skin. There were many designs and ideas that developed over the next 70 years. Unfortunately, malunions, nonunions and bone infections were issues due to lack of sterile techniques, and bone plates that were biomechanically unable to provide rigid fixation. Robert Danis (1880-1962) developed the ideas of compression plating and experimented with many different designs during his lifetime.

Modern bone plating started in the 1950's when a group of 15 surgeons lead by Maurice Muller formed AO/ASIF (Albeitgemeinshaft fur osteosynthenfragen/ Association for the study of internal fixation) to improve the principles of bone plating. AO remains purely a medical organization to advance the study of fracture treatment while Synthes is the commercial arm of the AO.

The original plates had round holes. If compression was needed for the fracture, a separate device was needed to accomplish this. The Dynamic Compression Plate (DCP was introduced in 1969 and was the standard AO plate until a few years ago. The holes are shaped like an inclined and transverse cylinder. The screw head can slide down the incline when tightened in a vertical direction. The horizontal force of the screw head as it impacts the side of the angled hole results in movement of the bone fragment.

In an effort to balance rigid fixation and preservation of blood supply to the bone, the Limited Contact Dynamic Compression Plate (LC-DCP) was developed and released in 1990. The plate had many design features that improved the biomechanics and use of the plate such as, thinner design while maintaining equal stiffness at the screw hole s and between them, better hole design, no middle of the plate and of course the ability not to contact the periosteum in between the holes. At the same time this plate was released, surgeons were looking for methods to place plates that did not require large muscle dissection and therefore destruction of the blood supply to bone (MIPO -minimally invasive plate osteosynthesis). Systems such as the Less Invasive Stabilization System (LISS) , Point Contact Fixator (PC-Fix) and Schuhlis systems used principles of external fixation, internally and locking technology theory. What resulted in 2000 was the Locking Compression Plate (LCP) with a Combi hole so that the techniques of conventional and locked screw technology could be used in one plate.

The original AO principles were:

- Anatomic fracture reduction & fixation (as we know not always possible).
- Rigid fracture stability (not always possible).
- Preservation of blood supply through careful soft tissue approaches and fracture reduction techniques (sometimes the blood supply is damaged from the injury).
- Early return to function of the plated limb (difficult in veterinary patients to control the amount of use).

With the understanding that not all fractures can be reconstructed, the "rules" have been somewhat modified to:

- Long bong bones must have axial re-alignment but not necessarily anatomic perfection. Anatomic reduction is still necessary for joints.
- Appropriate construct stability to ensure fracture healing via direct or indirect healing.
- Atraumatic approaches and fracture reduction or minimally invasive approaches.
- Early return to mobility.

Fractures can and will heal under both conditions but that is if the appropriate condition is chosen for the appropriate fracture situation!

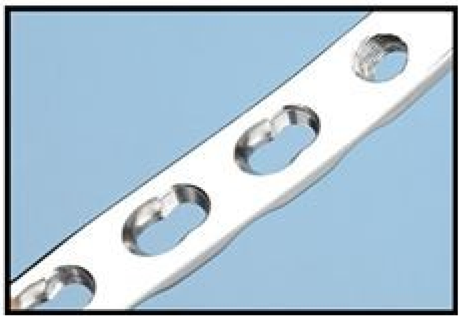
The dynamic compression plate (DCP):

DCP

Limited contact dynamic compression plate (LC-DCP):

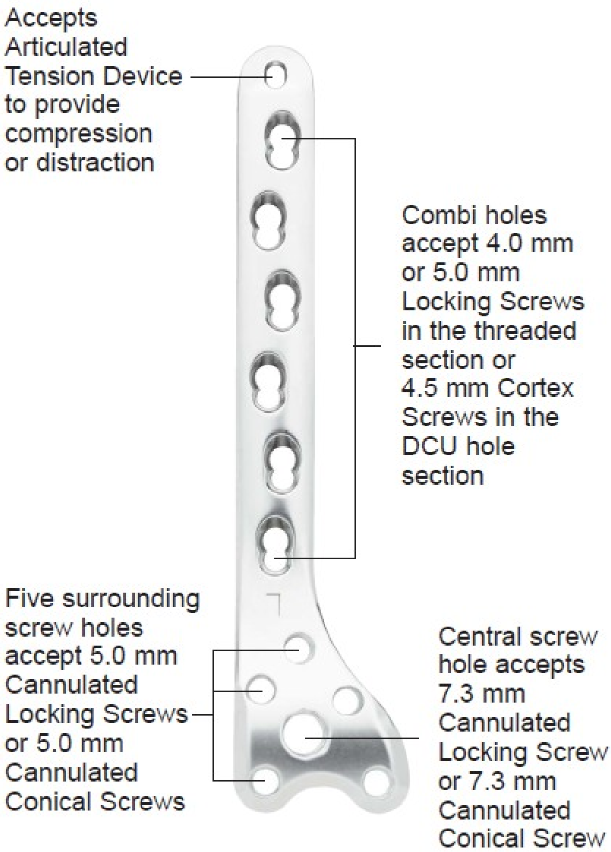
LC-DCP

The locked compression plate (LCP):



A cortical screw, a locked screw and the StarDrive head on the locked screw:

4.5mm Distal Femur Locking compression Plate:



The plate system has many similarities to traditional plate fixation methods with few improvements such as

Locking screws provides fixed angle construct and improved fixation in osteoporotic bones

1. The screws do not rely on plate bone compression

2. Multiple screw fixation in distal fragment allows improved fixation

3. Anatomically shaped plates is contoured to match the contour of the bone and hence intra-operative contouring is not required.

4. Combi - holes have additional dynamic compression holes providing options for axial compression in addition to locking mechanism.

Conventional Bone Plating versus Locked Compression Plating

Conventional bone plates depend on direct plate to bone and screw to bone friction to maintain fracture fixation. Therefore the plates must be perfectly contoured prior to application to the bone. Fracture reduction can be lost from axial loads causing excessive shear forces on the construct that are greater than the frictional loads between the bone-plate-screw construct. The cortical screws can toggle which leads to screw loosening and loss of plate-bone fixation. Each screw works independently; the construct depends on a single screw's stiffness or pullout strength.

The biomechanical goals of the LCPs are to increase the stiffness of the construct in a biological environment. The LCP is a fixed angle construct that does not rely on screw purchase in bone. Once the screw is locked into the plate, the fixed-angle converts shear stress into compressive stress at the screw-bone interface. The load is now perpendicular to the screw axis. In order for the construct to fail under an axial load, the bone must collapse in compression. Therefore, the strength in the LCP is the sum of all the screw and plate interfaces.

Locking screws are designed with smaller threads because they are not used to generate compression between the plate and the bone. They have a larger core diameter that ensures greater bending and shear strength and dissipate the load over a larger area of bone. They have the new Star Drive head that allows 65% greater insertion torque than conventional hexagonal drivers. The Star Drive is self- retaining (stays on the screw driver without a holding device). The locked screw has a conical, double-lead thread design that facilitates alignment with the threaded plate hole.

To date, there are no randomized clinical trials in human or animals comparing the LCP plate to conventional plates (DCP and LC-DCP) in patients with similar fractures. The plates are studied and compared *in vitro* (human and animal) and in case series' and are where the information on LCP principles and indications come from. The purported indications for LCPs include:

1. Patients with poor quality bone (osteoporosis, osteomyelitis)
2. Complex periarticular fracture (especially when contouring may be difficult in the metaphyseal area)
3. Inability to get minimal number of conventional screw cortices,
4. Periprosthetic fractures
5. Nonunions from failed fixations (cortex or cancellous screw stripping or screw back-out)

6. Polytrauma cases (especially when the fractures cannot be anatomically reconstructed).

In vitro studies in bone models do show that locked screw constructs fail at higher loads than cortex screws and their advantage is magnified in osteoporotic bone.

Technical and biological LCP aspects that are not known when used in veterinary patients are: the ideal number of locked screws on either side of the fracture, the number of unicortical versus bicortical screws necessary for success, indications for some plate contouring (although not exact contouring), the effects of combining conventional screws and locked screws in the same construct, indications for double plating or adding additional implants (such as plate rod constructs), if there are additive biological effects on fracture healing when LCPs are placed minimally invasively. It is technically possible to place locking plates and screws minimally invasively with proper fluoroscopic equipment. In human studies there is little mechanical advantage in placing more than 2 locked screws on either side of the fracture. This may be quite different in animal patients that cannot be strictly confined or have multiple limbs fractured. Fracture fixation failures with LCPs do occur; the clinical case application will address some of the reasons for this.

AIM OF THE STUDY

The aim of the study is to analyze the short term results in terms of union and functional outcome for osteoporotic and periarticular fractures treated with locking compression plating.

MATERIALS & METHODS

This is a study conducted in the Department of Orthopaedics, Madras Medical College, Government General Hospital, Chennai.

This study is a prospective study Conducted in the Department of Orthopaedics from September 2007 to September 2009 with a sample size of 21 cases.

Patients:

Patients were randomly selected from among the admissions to the Orthopaedic ward in the Department of Orthopaedics, Government General Hospital, Chennai and recruited into the study prospectively based on the following criteria:

Inclusion criteria:

1. Age more than 16 years.
2. Osteoporotic bones either disuse or pathological bones.
3. Fractures occurring at or near joints namely distal femur, proximal humerus, distal radius, distal tibia, proximal tibia.
4. Osteoporotic non-unions

5. Patients who consents to be included in the study.

Exclusion criteria:

1. Exclusion criteria were skeletal immaturity
2. Patients with tumourous conditions.
3. Severe articular comminution not possible to be reconstructed with internal fixation.
4. Undisplaced fracture patterns needing only conservative management.
5. Patients not willing for internal fixation.

Study protocol:

A total of 21 patients with osteoporotic and periarticular fractures were included in the study as per the criteria outlined previously.

On admission detailed examination of the patients was carried out after hemodynamic stabilization. Patients were then immobilized on a plaster of Paris

Then standard Antero – Posterior and Lateral view X – Rays are taken and the fracture configuration noted. Computerized Tomography is also taken when needed to assess the exact alignment of the fragments. The fracture is classified using the various classification systems earlier described.

Then after the assessment for anesthetic fitness open reduction and internal fixation of the fracture is done using locking compression plate.

POST OPERATIVE ASSESSMENT USING HHS and DASH Scoring systems :

HSS (hospital for special surgery) score

Pain
Walking (none to severe): points 15–0
At rest (none to severe): points 15–0
Function
Walking (unlimited to unable): points 12–0
Stairs (normal to with support): points 5–2
Transfer (normal to with support): points 5–2
RoM (80°–120°): points 10–15
Muscle strength (grade 5–0): points 15–0

Flexion deformity (none to >20°):points 10–0
Instability (none to >15°): points 5–0
Subtractions
One cane: 1 point
One crutch: 2 points
Two crutches: 3 points
Extension lag (5°–15°): 2–5 points
Deformity (every 5°): 1 point

Excellent = 85 points or more, good = 70–84 points, fair = 60–69 points, poor = less than 60 points.

CASE : 1

35 years old female

Road Traffic Accident

Closed Muller's Type C2# Right side

Open Reduction and internal fixation with 7 holed distal femur locking compression plate.

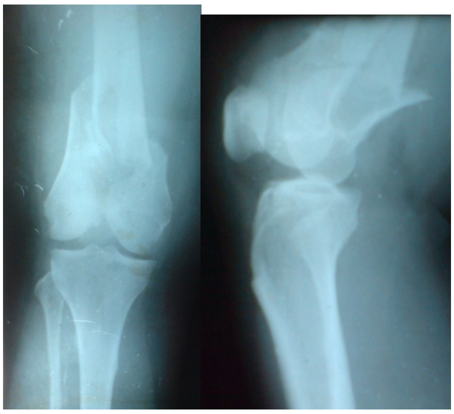
Radiological fracture union: 12 weeks

Range of Motion: 0 – 135^{0}

HSS: Excellent (91)

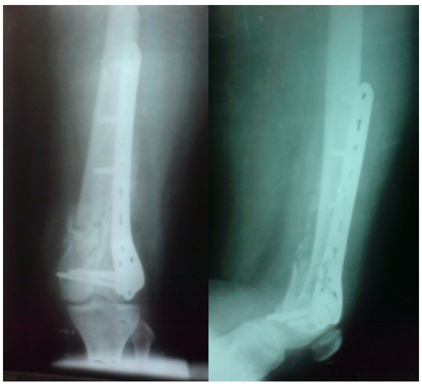
CASE 1

Pre Operative



Immediate Post Operative

6 months post operative



Clinical Outcome Knee Flexion and Extension

CASE 2

22 years old male

Sustained RTA and fall

Comminuted fracture Distal Radius – Right

Open Reduction and Internal Fixation using Distal Radius Locking Compression Plate

Radiological union : 12 weeks

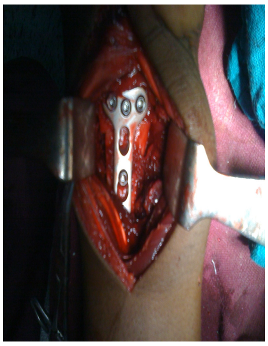
Range of motion : Dorsiflexion 35 deg palmar flexion 50 deg

DASH score : 5.0 (Good)

CASE 2

Pre-op X-rays

Per-op picture



Immediate post-op X-ray

CASE 2

6 months follow-up

CASE 3

40 year old Female

Sustained accidental fall from two wheeler and sustained injury to Right leg

Had a Pilon fracture Right

Treated by Open Reduction and Internal Fixation with Distal Tibial Locking plate and Fibular plating

Radiological union : 12 weeks

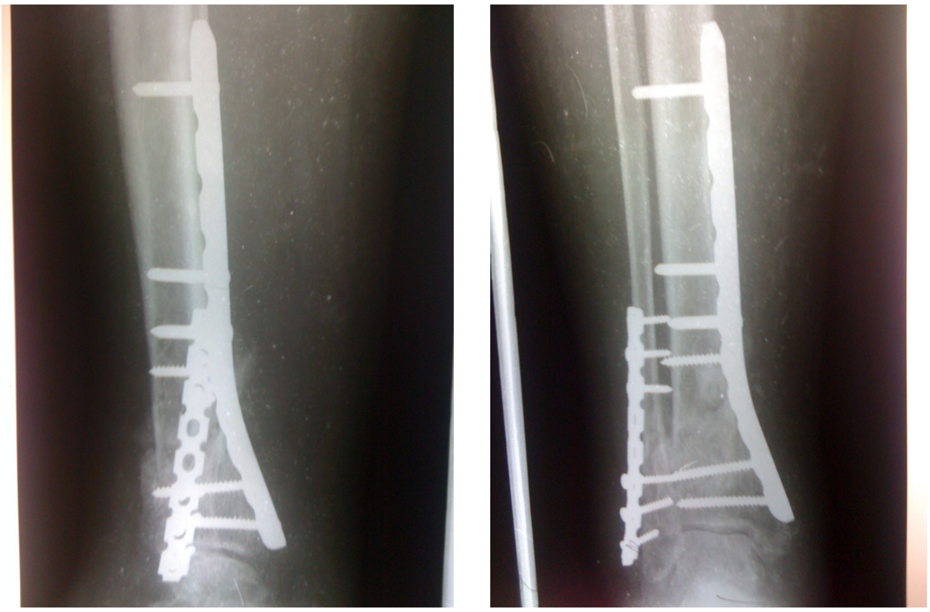
Functional outcome : Excellent with full weight bearing walking with no secondary osteoarthrosis of the ankle

CASE 3

Tibial Pilon # pre-op

Immediate Post-Operative X-Ray

CASE 3



12 months follow-up

CASE 4

32 year old Male

Sustained RTA and had a Grade II compound fracture of Both Bone Leg Left side

Initially treated with Wound Debridement and External Fixator followed by flap cover

At 5 months he developed non-union at fracture site

Treated with Open Reduction and Narrow Dynamic Locking Compression Plate with Bone Grafting

Radiological union : 14 weeks

Functional Outcome : Excellent outcome. Full weight bearing walking with full range of motion

CASE 4

Immediate pre-op

Immediate post-operative X-Ray

CASE 4

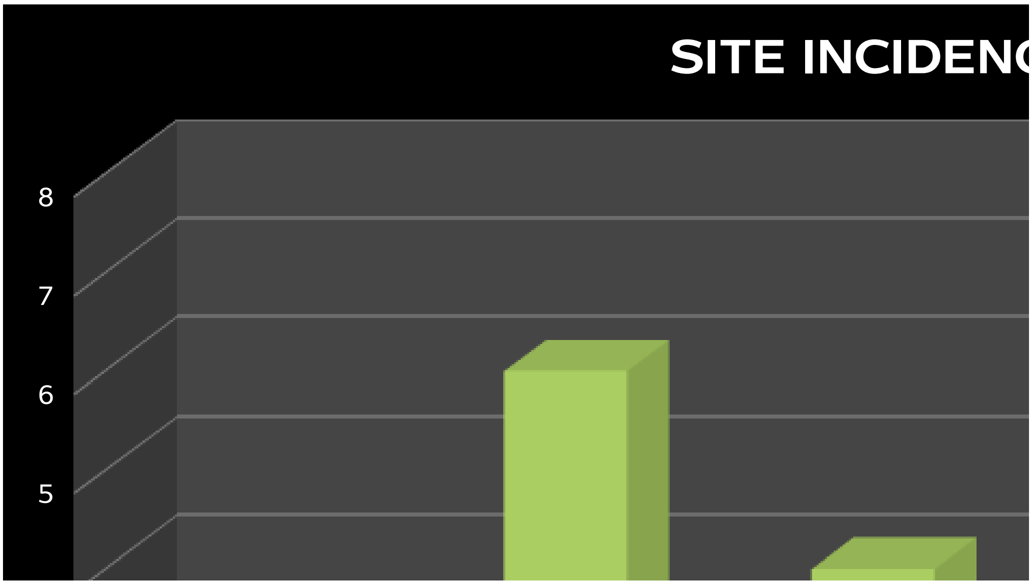
13 months follow-up

OBSERVATION & RESULTS

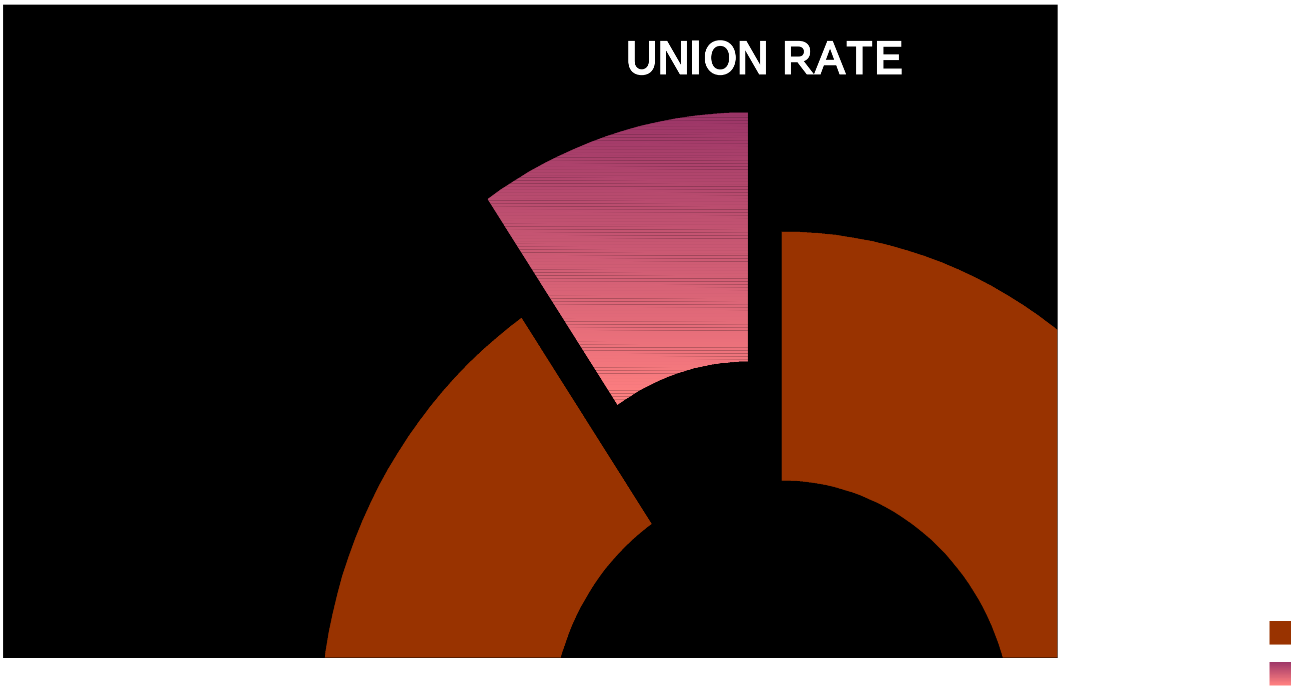
There were a total of 3 complications in two patients, two were infections(one case of superficial and one case of deep infection) the infection rate which was 0.01% and is similar to other reported series [11,14].They were treated with thorough wound debridement and i.v antibiotics for six weeks which soon resolved. There was one case of non-union which was due to the infection. Solid union was observed in 21 out of the 24 cases (88 %) which are similar to other studies[4,5,8,11,14]. The range of movements attained at an average follow-up of 15.5 months was 87 % of which 17 had excellent results, 4 had good outcome, 2 had fair outcome and 1 case had poor functional results according to the respective scoring systems like DASH, Harris hip score and HSS (Hospital Severity Score) knee score.

There were no evidence of early secondary osteoarthrosis in none of the 14 cases of juxta-articular fractures treated with locking compression plates. 21 patients were satisfied with the functional outcome following plating with locking compression plates. There were 10 patients who had either revision plating or primary plating done for osteoporotic fractures. Nine out of the 10 fractures united without any need for further surgeries. One patient had infection and this was attributed to the poor skin condition and soft tissue condition due to multiple failed procedures in him.

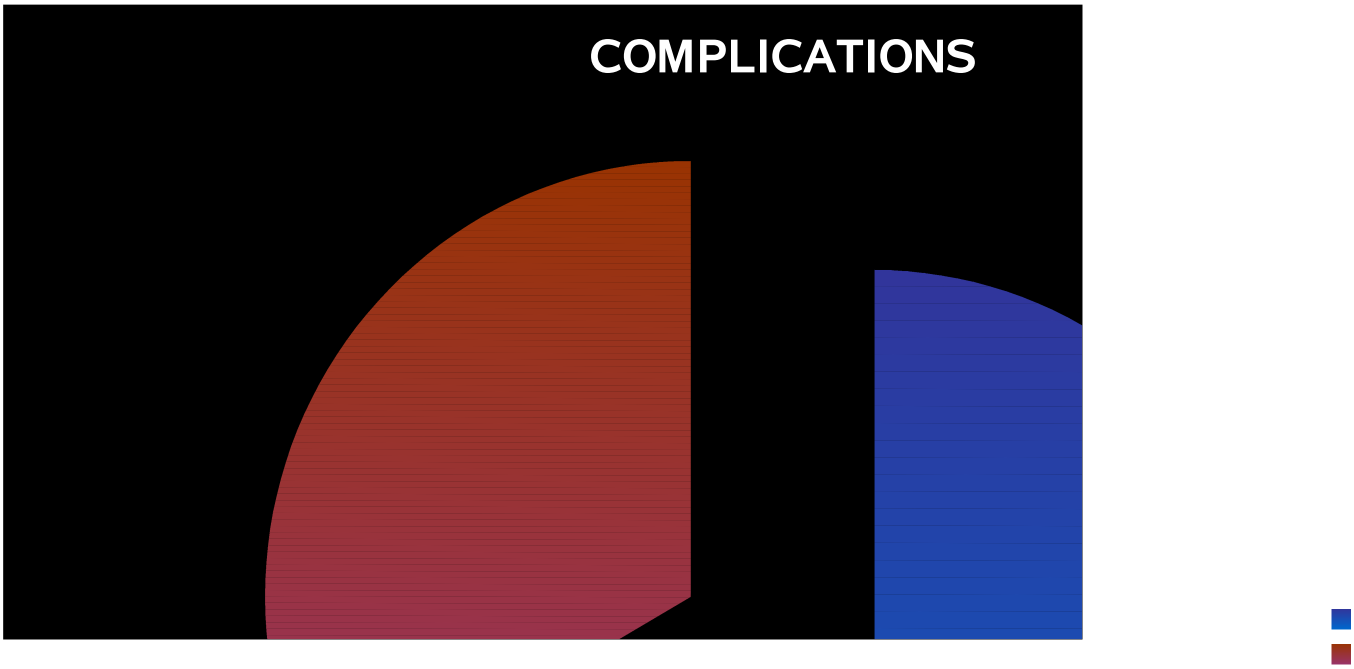
SEX INCIDENE	MALE	FEMALE
	17	**4**



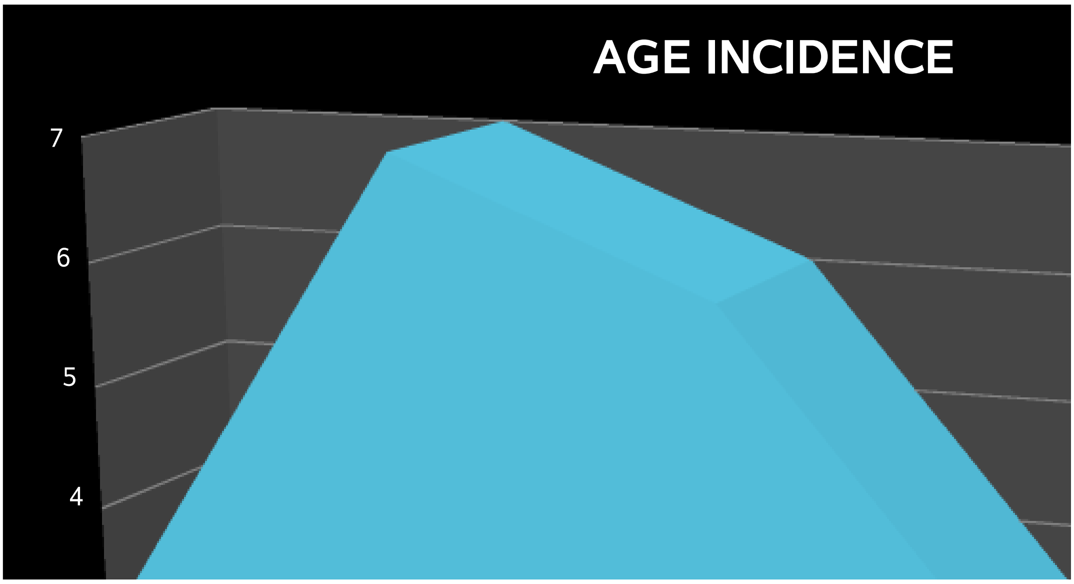
DISTAL FEMUR	PROXIMAL HUMERUS	DISTAL RADIUS	DISTAL TIBIA	DIAPHYSEAL OSTEOPOROTI C
2	6	4	1	8



UNION	19
NON-UNION	2



INFECTION	1
NON-UNION	2



11-20 years	3
21-30 years	6
31-40 years	6
41-50 years	4
51-60 years	1

DISCUSSION

The recent evolution in reduction and internal fixation of fractures is based on an improved understanding of the biology of bone, of the biomechanics of fracture fixation and fracture healing and on the analysis of previous failures. Improvements in implant designs play an important role in avoiding possible complications and in achieving the primary goals of operative fracture treatment.

The evolution of locking compression plates in the fixation of specific fracture characteristics has revolutionized the treatment of complicated and failed previous internal fixation procedures. Our study was done to analyse the usefulness of such locking plates in osteoporotic and periarticular fractures and results were computed and compared with similar studies done by other surgeons.

Gardner et al. in 2002 reported his series of 36 cases of proximal humeral fractures treated with proximal humeral LCP and reported two cases of humeral necrosis which was not seen in our study. Breakage of implant was seen in one patient which was also not encountered in our study. The DASH score reported was 18.0 which was similar to the DASH score of 19.0 in our study.

Bjorkenheim et al (2004) reported a series of 72 patients with proximal humeral fractures treated with PHILOS plate and reported a union rate of 94 %. There were three cases of non-union (0.04 %). Our series also had similar results.

Sommer et al. (2004) reported four cases of implant failure with locking plates and attributed this to poor technical application and also poor choice of appropriate implant rather than to the features of locking plate itself. His experience highlights the importance of detailed understanding of the biomechanical principles of plate fixation as well as meticulous pre-operative planning.

Ring et al. (2004) reported his series of 24 cases of osteoporotic non-unions of diaphyseal fractures treated with locking compression plates and reported a union rate of 97 % with two cases requiring additional bone grafting to achieve union.

Kassab et al. (1998) in his series of 44 patients with diaphyseal osteoporotic non-unions and achieved solid union in 40 cases (90 %). In our series it was 88 % which was comparable. There were three cases of persistent non-unions which required secondary bone grafting and revision internal fixation.

CONCLUSION

This study highlights the role of locking compression plating in complex osteoporotic and peri-articular fractures in which conventional dynamic compression plates and reconstruction plates would fail prematurely. The correct application of locking compression plates requires a long learning curve and spurious use will negate the advantages of the locking plates.

The results of our study have confirmed earlier reports that locking compression plates provide better fixation in osteoporotic fractures. The chances of implant failure are less as the screws are firmly position inside the bone. Also since these plates are limited contact plates there is less contact between plate and the bone and hence there is minimal disruption of sub-periosteal blood supply to the fracture ends and this aids in fracture union. The locked nuts prevent further tightening of the screws and hence reduction is maintained and secondary angular deformities are prevented.

In periarticular fractures when the required cortical purchases are not possible on either side of the fracture site, these specially designed plates allow adequate cortical purchases. Also metaphyseal fractures behave like osteoporotic fractures since they are primarily cancellous bone stable rigid fixation is not possible in all cases with conventional plates.

We have used locking compression plates in both osteooporotic and juxta-articular fractures and have found to be implant of choice in these fractures. The union rates achieved by us is 88 % which is comparable to other studies. Also the low infection in our study and the non-union rate are also comparable to similar studies done by other groups.

Hence locking compression plates are special implants which have been specifically designed for clinical application in osteoporotic and juxta-articular fractures.

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PROFORMA

TOPIC : Locking Compression Plate in Osteoporotic and Juxta-articular fractures

Dr. Navin Balasubramanian P.G M.S (Orth)

CASE :

NAME : AGE / SEX :

ADDRESS : D.O.A :

D.O.S :

D.O.D :

Presenting complaints :

If female whether Pre- / Post-menopausal

Examination :

X-Ray :

Diagnosis :

Treatment :

Procedure done :

Post-op protocol :

Advice on discharge :

FOLLOW-UP NOTES

Time since surgery	X-Ray Findings	Range of Movements	Functional Assessment	Any complications

Special Points :