European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 08, Issue 03, 2021

Evaluation of Role ofBlocking Screws in the Treatment of Non-diaphysealTibial Fractures

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Abstract

Background:Distal tibial fractures can be divided by mechanism into injuries caused by torsion trauma or by compression trauma. The latter ones are often associated with a complete destruction of the tibial joint surface, so-called tibial plafond fractures. Another group of fractures are the distal metaphyseal fractures of the tibia with only minimal involvement of the ankle as a result of low energy torsion trauma. Multiple factors can be held responsible for posttraumatic complications and poor outcome: malalignment, nonanatomic reduction of the joint surface or bone defects, and severe soft tissue injury. Therefore, a sophisticated therapeutic regime of distal tibial fractures is necessary, which we present in detail in this article. In cases with only minor soft tissue injury a primary definitive open reduction internal fixation (ORIF) of the tibial fracture is possible. Fractures with severe soft tissue injury should be initially fixed with an external fixator. Definitive fixation and reconstruction should here be performed in subsequent operations. Early functional therapy can be attempted if fractures are reliably stabilized.Blocking or "Poller" screws are a particularly useful technique to help guide the nail correctly. This technique involves placing a blocking screw, drill bit, or K-wire to force the reamer and then the nail into the proper path.The screw can be left in place to increase stability which may be particularly useful in geriatric fractures with wider tibiae and poorer bone quality.

Keywords:Non-diaphyseal Tibial Fractures, Blocking Screws.

1.Anatomy

The leg is the part of lower limb between knee and ankle. The leg consists of two parallel bones, the tibia and fibula. The fibula is the smallest, articulating with lateral condyle of proximal tibia and not sharing in knee joint formation & distally anchoring in distal tibia forming lateral malleolus of ankle. The leg is divided into anterior, lateral&posterior compartments **(1).**

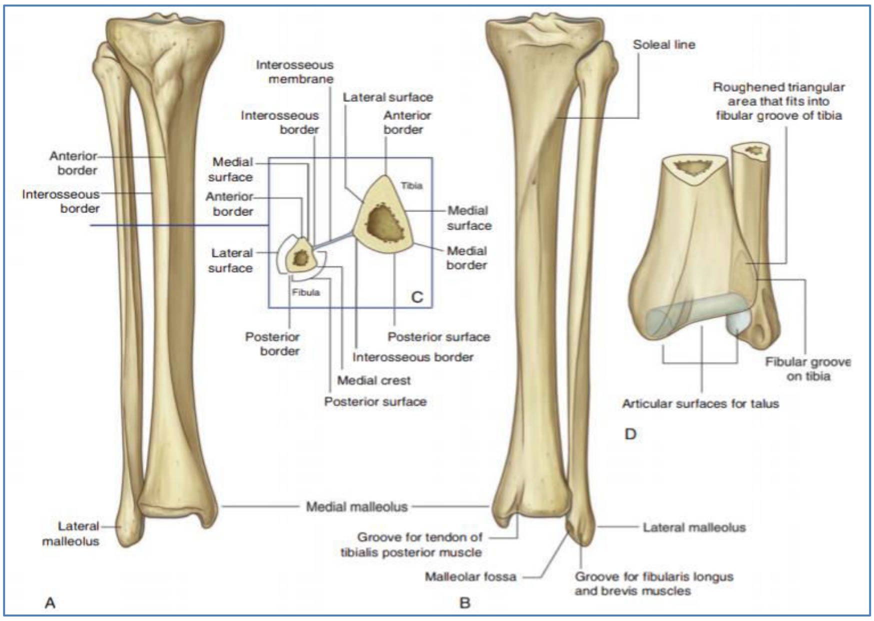

Figure (1) Shows bones of the leg A.anterior view B. posterior view C. Cross setion view D. distal BBL(**1**).

Bones of leg:

The mechanical axis of the lower extremity runs from the center of the femoral head to the center of the distal tibia at the ankle and should pass just medial to the center of the knee. The normal proximal and distal tibial articular surfaces are not quite parallel. The distal articular surface is perpendicular to the mechanical axis of the tibia (lateral distal tibial angle LDTA about 90 degrees), whereas the proximal articular surface is tilted slightly medial (medial proximal tibial angle [MPTA] about 87 degrees)**(2).**

Tibial shaft is triangular in cross section with three borders, anterior, interosseous & lateral and three surfaces, medial, lateral & posterior. Posterior surface has oblique line called soleal line which descends from lateral to medial. It expands proximally & distally to support body weight at knee & ankle joints. Interosseous membrane is thick fibrous band of collagen fibers descending obliquely from tibia to fibula except proximally fibers ascend from tibia to fibula, it has proximal and distal aperatures for passing blood vessels between anterior & posterior compartments. It is reinforced inferiorly at ankle joint by anterior &posterior tibiofibularligament **(1).**

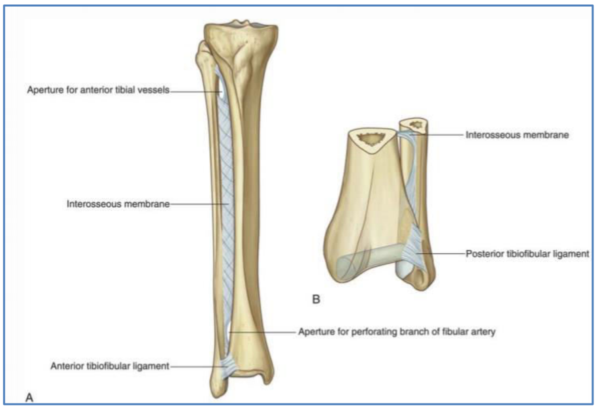

Figure (2): Shows A.Interosseous membrane between tibia and fibula , its collagen fibers directions, apertures in interosseous membrane and ATFL .B. Interosseous membrane, Aperture and PTFL**(1).**

Proximal tibia:
Consists of medial (the largest) & lateral condyles with superior articular surface for articulation with distal femur at knee joint Thereis also rough area for nutrient arteries perforation & infra patellar pad of fat above tibia tuberosity.
The medial surface has rough elevation proximally for attachment of Sartorius, gracillis& semitendinosus (pes anserinus). The lateral surface has tubercle for attachment of iliotibial band **(1).**
Non articular surface, posteriorly contains groove for attachment of semimembranosus muscle medially and head fibula postero- laterally at inferior aspect of lateral condyle.Tibial tuberosity is inverted triangle at anterior aspect of tibia below inter condylar region, containing attachment for patellar tendon.**(1).**

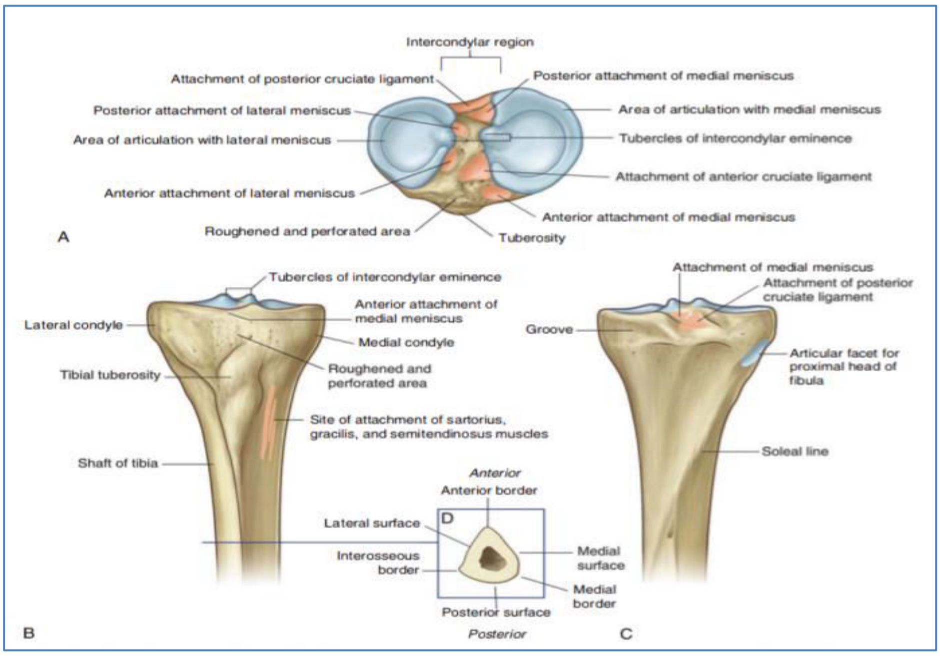

Figure (3): Shows A. Proximal tibia articular surface B. Proximal tibia anterior view and its attachments C. Proximal tibia posterior view and its attachments **(1).**

Compartments & musculature:
The musculature of the leg is divided into four compartments. The anterior compartment musculature originates predominantly from the anterolateral aspect of the proximal tibia and includes the main dorsiflexors of the ankle and toes. The anterior compartment also contains the deep peroneal nerve and anterior tibial artery which supply the muscles in the compartment .The anterior compartment structures are dissected off the tibial surface and retracted laterally during an anterolateral surgical approach to the tibia, this being required for plate osteosynthesis.**(3)**

There are two posterior leg compartments, superficial and deep. The superficial posterior compartment contains the gastrocnemius soleus muscle complex, which is the primary ankle plantar flexor, and the plantaris muscle. The posterior deep compartment is bordered anteriorly by the posterior surface of the tibia and the interosseous membrane. It contains tibialis posterior which inverts the foot, flexor hallucis longus and flexor digitorum longus, which plantar flex the toes, in addition to popliteus, and the peroneal artery, posterior tibial artery, and tibial nerve. The posterolateral surgical approach to the distal tibia utilizes the plane between muscles of the lateral and deep posterior compartments.**(3)**

The lateral compartment muscles evert the foot and take origin from the lateral and posterior aspects of the fibula diaphysis. The lateral compartment also contains the superficial peroneal nerve which exits the fascia approximately 10 to 12 cm proximal to the tip of the distal fibula. The superficial peroneal nerve is at risk during lateral fasciotomy, distal fibular fixation, and placement of distal screws during percutaneous plating of the tibia**(2).**

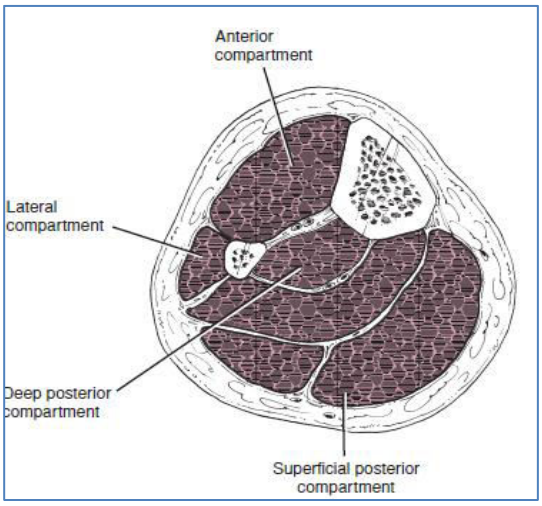

Figure (4): Shows cross sectional view of compartments of the leg**(2).**

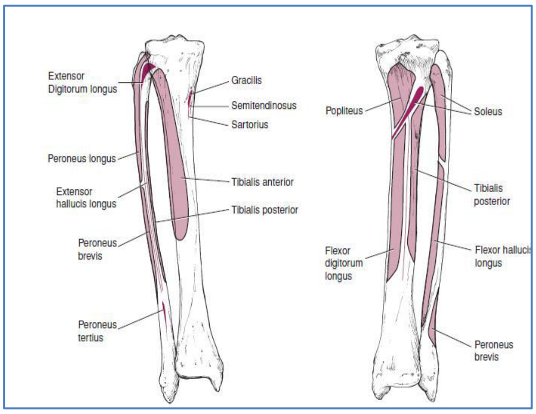

Figure (5): Show A. Muscles that originate or insert in the leg anteriorly B. Muscles that originate or insert in the leg posteriorly**(2).**

Vasculariy:

Blood supply of the tibia is dervied from posterior tibial artery and anteriortibial artery where the posterior one gives nutrient artery that enters into the posterior tibial cortex, distal to the soleal line at the middle 1/3; enters posterolateral cortex of the tibial at the origin of the soleus muscle;artery may transverse distance of 5.5 cm before entering its oblique nutrient canal;artery divides into three ascending branches & a single descending branch, which gives off smaller brances to the endosteal surface; provides the endosteal blood supply to the inner tibial cortex that may be damaged after reaming of an IMN during its insertion where this medullary nutrient artery provides bloodsupply to most of uninjured diahysis through its interosseeous distribution because the combined devascularization caused by both the fracture and reaming produces a layer of necrotic bone through much of the diaphysisthis makes bone dependent on soft tissue envelope for blood supply & stripping of soft tissues may render the bone avascular but the medullary arterial circulation regenerates in a few weeks in the space that exists around a medullary nail. This arterial regeneration permits revascularization of the inner cortical bone, which is also supported by recruitment of periosteal collateral circulation if the surrounding soft tissues are healthy enough.

After a fracture, the tibial blood supply changes dramatically; peripheral vessels are recruited to take over much of the arterial supply of the cortex and revascularize necrotic areas, as well as provide nourishment for the metabolically active peripheral callus.

This process requires healthy surrounding tissues and is most effective in areas with muscles closely applied to the tibia. Surfaces that are covered only with periosteum, subcutaneous tissue, and skin are less able to benefit from this temporary extraosseous blood supply.

While anterior tibial artery which is may be vulnerable to injury after its division from popliteal artery, where it passes thru hiatus in upper interosseous membrane gives periosteal vessels that supply the outer tibial cortexwhere periosteum has abundant blood supply as it courses down interosseous membrane **(2).**

Venous drainage of the tibia

Blood from the tibia is drained by both superficial and deep veins. The superficial veins often anastomose with one another and with deep veins along their length.

All veins of the leg have valves, which are more numerous than in veins of the upper limbs. Deep veins have the same names as corresponding arteries. Blood from the tibia is drained by both superficial and deep veins where great saphenous veins and small saphenous veins are superficial veins that drains mainly the medial side of the leg and thigh, the groin, external genital and abdominal wall and drain the foot and posterior aspect of the leg respectively. They receive tributaries from superficial tissues and connect with the deep veins as well where deep veins are posterior tibial vein and anterior tibial veins where the posterior one drains the foot and posterior compartment muscles also drain blood from the fibular (peroneal) veins which drain the lateral and posterior leg muscles where anterior tibial veins drains the ankle joint, knee joint, tibiofibular joint and anterior portion of the leg. The two veins unite with each other just inferior to the popliteal fossa to form the popliteal veins which drains into femoral vein till venous drainage ends into inferior vena cava.**(2).**

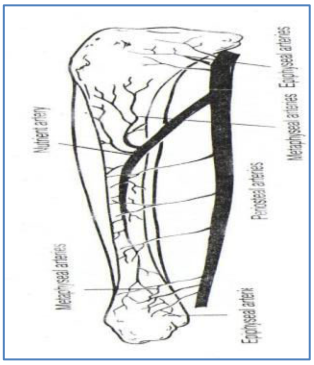

Figure (6): Shows blood supply of tibia**(2).**

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Operative treatment for diaphyseo metaphyseal tibial fractures:

Operative treatment is currently the preferred treatment for displaced diaphyseo metaphyseal tibial fractures, with intramedullary nailing is the safest, noninvasive preferred treatment**(4).**

Mechanics of interlocking intramedullary nailing: there are multiple advantages of using interloking nail in treatment of metaphyseo - diahysealtibial fractures as:

- Structural analysis of interlocking nails depends on screws bind the nail. which prevent any kind of motion.
- Efficiency of a nail depends on the material used for its construction (imparts strength) and the design geometry (imparts rigidity/stiffness) Choice is guided by above two considerations
- Strength of nail bone construct depends on working length and gripping strength. Working length is that part of the nail which is not covered by the bone after completion of the surgery. Part which underlies residual fracture gap stiffness of the nail against bending force is inversely proportional to the square of working length where the rigidity of nail against torsional forces is also inversely related to working length Shorter the working length, greater is the bending and torsional rigidity of the nail bone construct.
- Gripping strength magnitude of force by which slipping of nail axially at the bone nail interface at the time of transmission of forces between the fracture fragments is prevented. Bone tissue exerts an equal and opposite force on the nail which is designated as hoop stress also slotted hollow nails have a distinct advantage in this regard, compression during entry exerts elastic force on the canal wall which mantains acceptable magnitude of gripping strength in the post-operative period.

Disadvantages of interloking nail as having residual interfragmentary gap is always there since the nail is locked increases due to necrosis at the bone metal interface. Fall in hoop stress not seen in gliding nails fragments glide along surface of nail, reduction in fracture gap leading to healing can be avoided in interlocking nails with the help of dynamisation.

Working length of the locked nail spans between the locking screws leading to less resistance to bending and torsional forces; This can only be averted by using nails of increased thickness which can be achieved by keeping the inner diameter constant.

Holes or gaps within the nail act as stress raisers since lower limbs undergo cantilever bending the stress is maximum at the distal end of the nail. The lower the fracture is, the lesser is the supporting effect of the bone.

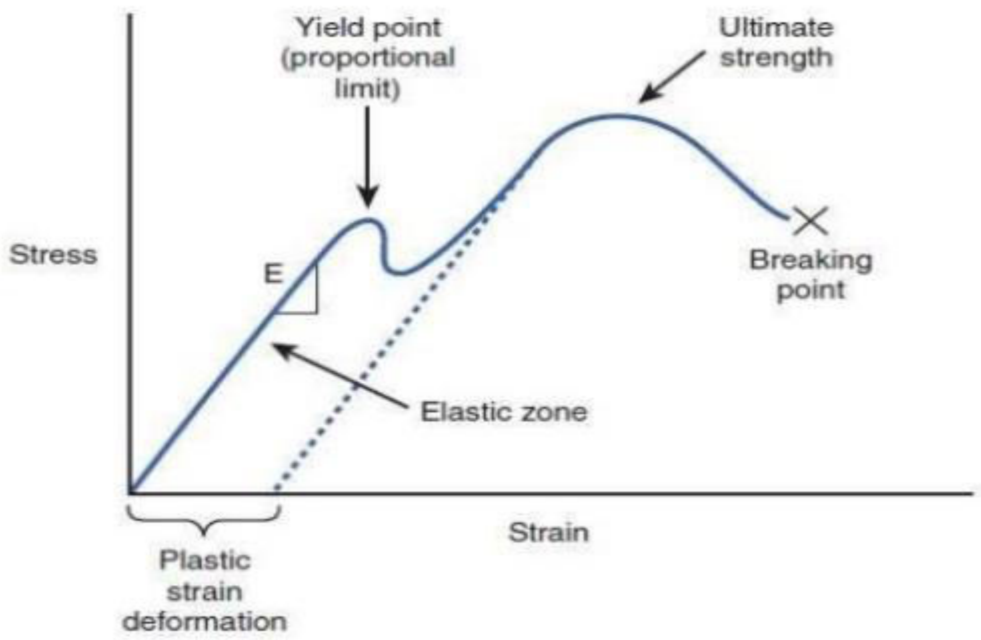

Figure (7): shows stress strain curve of the material of the interlocking nail (5)

There are several surgical approaches(**6). **utilized when performing intramedullary tibial nailing, each with distinct advantages and disadvantages

1. Medial tendon parapatellar: This is the most common starting point and is used for the majority of fractures in the middle and distal thirds of the tibia. However, it can lead to valgus mal alignment when used to treat proximal tibial fractures.

2. Lateral tendon parapatellar: This approach aids in maintaining fracture reduction when nailing proximal one third of fractures but requires mobilization of the patellar tendon.

3. Patellar tendon splitting: This gives direct access to starting point but can inadvertently damage the patellar tendon or lead to patella Baja and is used less commonly.

4.supra patellar nailing approach: It is recently used for proximal tibial fractures to improve alignment as it is done in semi extended position for accurate entry & resistance of patellar tendon deforming force that leads to apex anterior angulation.

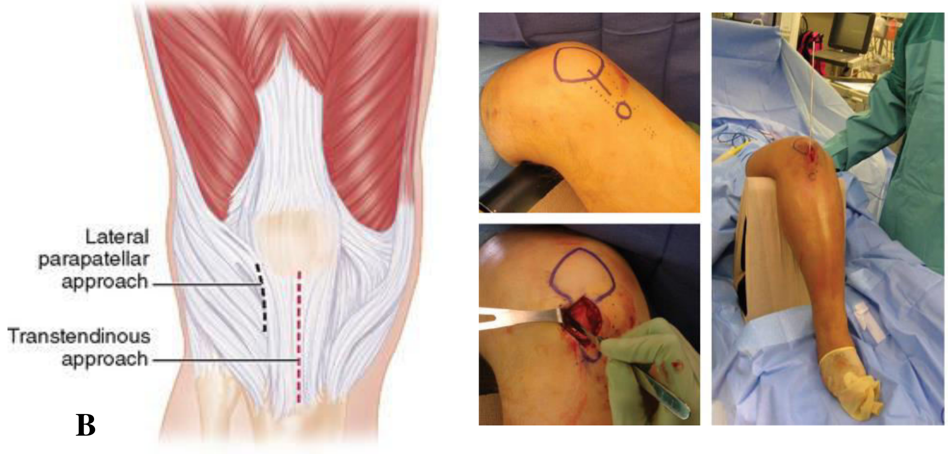

Figure (8): Shows different approaches of intramedullary nailing. A. Medial parapatellar B. Lateral parapatellar and transtendinous approaches(6).

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Figure (9) Suprapatellar nailing approach(6).

There is high rate of malreduction& malalignment while fixation of diaphysio metaphyseal tibial fractures by interlocking intramedullary nail**(7) .**

There are multiple techniques to avoid malreduction. Clamp-assisted reduction, provisional unicortical plating (plate assisted reduction), Blocking screw & Universal Distractor are techniques used to assist the reduction of diaphyseo metaphyseal tibial fractures.

1) Provisional unicortical plate (plate assisted reduction):

The most invasive approach involves reducing the fracture in an extended position and applying a unicortical plate that does not impede the passage of an IM nail. The plate can then be removed or left in place**(8).**

This often requires open exposure of the fracture and release of the fracture hematoma as well as periosteum stripping, which may compromise the healing potential, especially in the setting of an IM implant in open fractures, additional exposure may not be necessary **(8).**

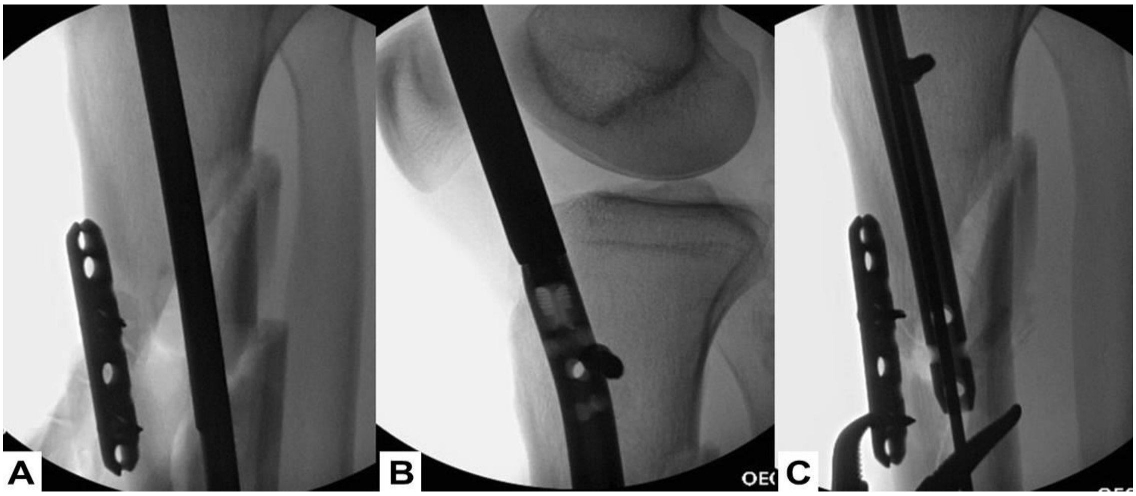


Figure (10) Shows intra operative fluoroscopic view for plate assisted reduction technique for proximal tibial fracture and fixation by ILN(8).

2) Clamp-assisted Reduction:

Less invasive options may also allow for the provisional reduction of the fracture and temporarily resist deforming forces during the insertion of the.Alignment can be achieved and secured using percutaneously applied reduction forceps. This technique requires careful attention to soft-tissue compromise and the location of neurovascular structures**(9) .**

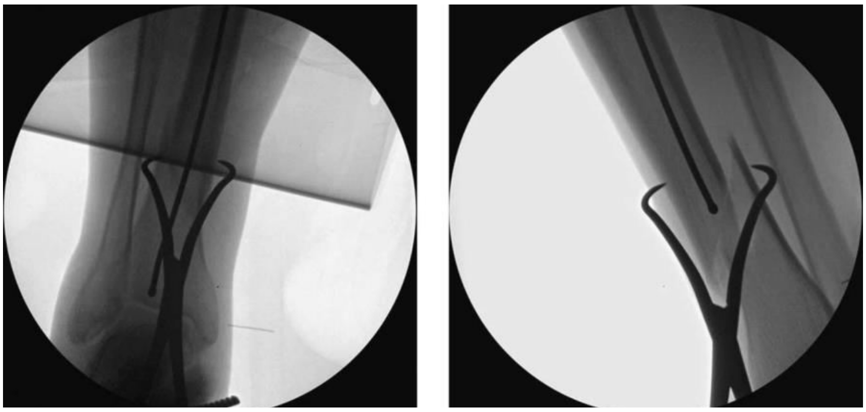


Figure (11) : Shows percutaneous assisted reduction technique in ILN(9) .

2) **Universal distractor:**

A medially based universal distractor can be used to correct multiplanar deformity. Consider placing the proximal Schanz pin in a manner that would act as a blocking screw to prevent an apex anterior deformity. Ensure placement of distal Schanz pin is out of (or distal to) the anticipated trajectory of the nail**(10).**

Figure (12) Shows universal distractor assisting in reduction(10).

5) Blocking screw:

Terminology:The concept of Poller screw was first popularized by Krettek et al **(11).** They called the screws “Poller screws” because the screws guided the nail like the “Poller” (retractable bollard) traffic control devices guide traffic in Europe.

Blocking screws are another option to help prevent displacement and to direct the nail. It also improves the mechanical stability, Screws placed adjacent to the nail from anterior to posterior help prevent coronal plane deformity Screws placed posterior to the nail in the coronal plane help prevent procurvatum or flexion

These screws must be accurately placed to be effective and must have sufficiently secure placement to resist the forces of nail insertion.

Figure (13): Shows A blocking screw in sagittal plane from medial to lateral B blocking screw in coronal plane from anterior to posterior(11).

Common complications following tibial fractures:
1) Compartment syndrome
2) Symptomatic hardware
3) Malunion
4) Nonunion
5) Deep infection
6) Complex regional pain syndrome

1) Compartment syndrome:
Definition:
Elevation of intra compartmental pressure within confined closed space for a duration that if it is not decompreesed will lead to tissue ischaemia, necrosis & functional impairment**(2).**
Irreversible tissue necrosis will lead to local Volkmanischaemic contracture & systemic crush syndrome. Critical tissue pressure thresholds are 10 to 20 mm Hg below diastolic blood pressure or 25 to 30 mm Hg below mean arterial pressure**(12).**

2) Symptomatic hardware:
Implant itself may be asymptomatic. Symptomatic hardware may be due to prominent screws. Implant removal is not usually needed except if there is infection**(13).**

3) Malunion:
Malunion leads to malalignment which cause stresses on articular cartilage of knee &ankle in fractures proximal &distal tibia respectively. Stress on articular cartilage cause arthritis of the joint with limitation in function**(14).**

4) Nonunion:
Delayed union means lack of signs of healing after 3 to 6 months. Nonunion means lack signs of healing after 6 months. Signs of nonunion include pain while weight bearing, absence of visible fracture callus or lack of visible consolidation. An increased risk of delayed union or nonunion has been reportedwith open fractures, deep infection, a postoperative fracture gap, distal fractures and smoking **(2).**

Nonunion can be classified:
According to presence of infection or not: septic and aseptic nonunion. According to occurrence of biological tissue formation: Atrophic, Oligotrophic & Hypertrophic. Treatment strategy is according to the cause: debridement of non-viable tissues, treatment of infection, increasing the stability of the fracture &osteoinductive or osteoconductive materials.

5) Deep infection:
Deep infection rates after internal fixation are rare in closed fracture and open fracture grade 1 but it is common in open fracture grade 3. The most commonly organism is Staphylococcus aureus. Deep infection after IM nailing has been related to thermal necrosis, exchange nailing, primary external fixation & the severity of the open fracture**(15).**

Treatment of deep infection following IM nailing can be performed with or without nail removal depending on the stage of fracture healing**(16).** However, the presence of a contaminated implant with a biofilm can make clearance of infection significantly more challenging. The use of temporary or permanent antibiotic nails has been described by multiple authors for IM infections of the tibia**(17)**.Antibiotic nails are associated with improved fracture stability compared to other antibiotic delivery methods such as spacers and beads **(17).**

The rate of clearance of infection is high**(18)** , but the rate appears to be lower when the nail is retained than for retention of plates**(16).** Patients can present with recurrent infection years after an apparent cure. Severe or recalcitrant infections may be an indication for late amputation**(19).**

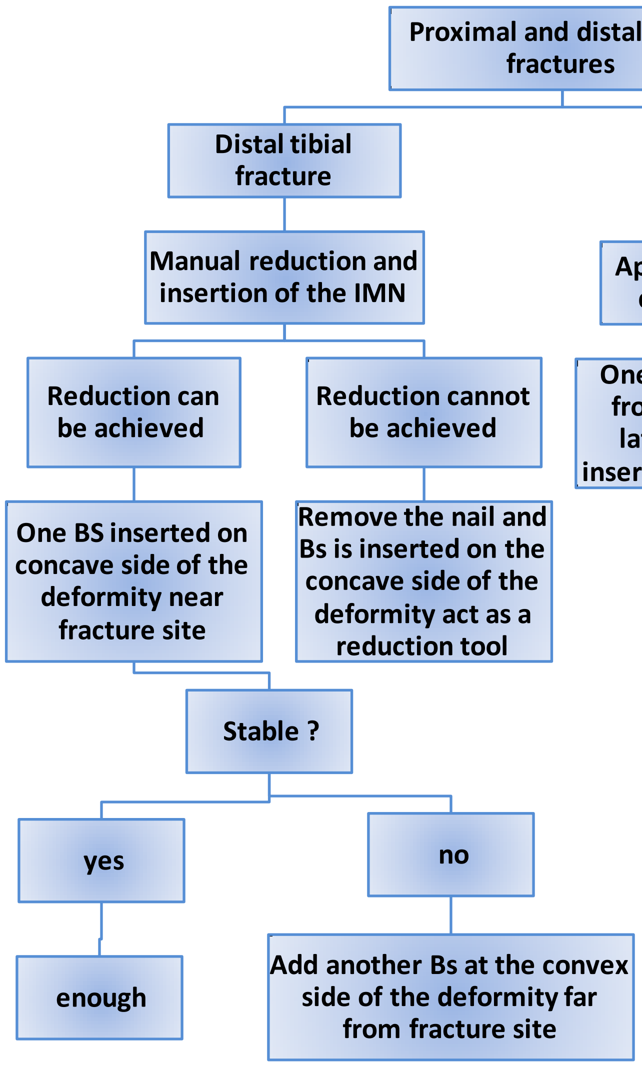
6) Complexregional pain syndrome (CRPS) :

Definition:
Complex regional pain syndrome (CRPS) is an inappropriate pain response to a tissue injury. The pathophysiology of the condition is incompletely understood.

Clinical features:
There is often burning pain and characterized by hyperesthesia (excessive sensitivity) and allodynia (the perception of pain following a non-painful stimulus such as stroking). There are associated objective abnormal signs involving edema, sweating, skin texture and colour, hair growth and nail appearance. These are accompanied by objective radiographic features of periarticular osteoporosis. There are often psychological features associated with the development of chronic pain. CRPS is most common in middle-aged women and smokers **(20).**

Management of CRPS:
Eighty-five per cent of patients will experience a substantial improvement in their symptoms over a period of 2 years with treatment. There are four principles for treatment **(20)**.
1. Analgesia: A spectrum of drugs is used, including simple paracetamol, NSAIDs, Opiates, analogues of gamma- aminobutyric acid (GABA, the principal inhibitory central nervous system transmitter) such as gabapentin, and antidepressants.
2. Physiotherapy: This will maintain and improve the range of movement.
3. Psychological techniques: Patients are advised to stay as active as possible, and to use the affected limb and joints as normally as possible.
4. Spinal cord stimulation: An implanted stimulator can be effective in refractory cases.

Algorithm of the guidelines for treatment of proximal and distal tibial fractures



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