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Management of Extra Articular Distal Tibial FractureUsing Minimally Invasive Percutaneous Technique.

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Abstract

Background:Distal tibia fractures are challenging injuries. They are often caused by high energy axial compressive, direct bending or low energy rotation forces. These fractures constitute less than 10% of all tibial fractures. The aim of treating the fracture is to preserve normal mechanical axis, ensure joint stability and restore a near full range of motion. This is a difficult task to accomplish in each and every case due to compromised soft tissue condition, variable bone quality and associated medical conditions. Distal tibia fractures are devastating injuries that are usually due to high-energy mechanisms such as falling from heights or motor vehicle accidents. They may also occur from low-energy mechanisms, which are seen in rotational injuries around the ankle. Results of conventional osteosynthesis with plates have been suboptimal with reported complications of wound infection, skin breakdown and delayed union or non-union, requiring secondary surgical intervention. Locking compression plating has gained popularity and is being used frequently for fixation of distal tibia fractures. With the use of minimal invasive techniques excellent results are obtained in complex fractures.

Keywords:Distal Tibial Fracture,Minimally Invasive Percutaneous (MIPPO).

1. Introduction:

1.1 ANATOMY OF DISTAL TIBIA:

The tibia has proximal and distal metaphyses and a diaphysis spanning between them. The slightly expanded distal end of the tibia has anterior, medial, posterior, lateral and distal surfaces. It projects inferomedially as the medial malleolus. The distal end of the tibia, when compared to the proximal end, is laterally rotated (tibial torsion) **(1.2)**.

The distal end of the tibia is much smaller than the proximal end and presents five surfaces; it is prolonged downward on its medial side as a strong pyramidal process, the medial malleolus. The lower extremity of the tibia together with the fibula and talus forms the ankle joint **(3)**.

The smooth anterior surface projects beyond the distal surface, it is smooth and rounded above, and covered by the tendons of the Extensor muscles; its lower margin presents a rough transverse depression for the attachment of the articular capsule of the ankle-joint. The medial surface is smooth and continuous above and below with the medial surfaces of the shaft and medial malleolus, respectively; it is subcutaneous and visible. The posterior surface is smooth except where it is crossed near its medial end by a nearly vertical groove, which is usually obvious and extends to the posterior surface of the malleolus. The groove is adapted to the tendon of tibialis posterior **(3).**

More laterally, the posterior tibial vessels, tibial nerve and flexor hallucis longus contact this surface. The lateral surface of tibia presents a triangular rough depression the lower part of this depression is smooth, covered with cartilage in the fresh state, and articulates with the fibula the triangular fibular notch; its anterior and posterior edges project and converge proximally to the interosseous border. The floor of the notch isroughened proximally by a substantial interosseous ligament but is smooth distally and is sometimes covered by articular cartilage. The anterior and posterior tibiofibular ligaments are attached to the corresponding edges of the notch **(3).**

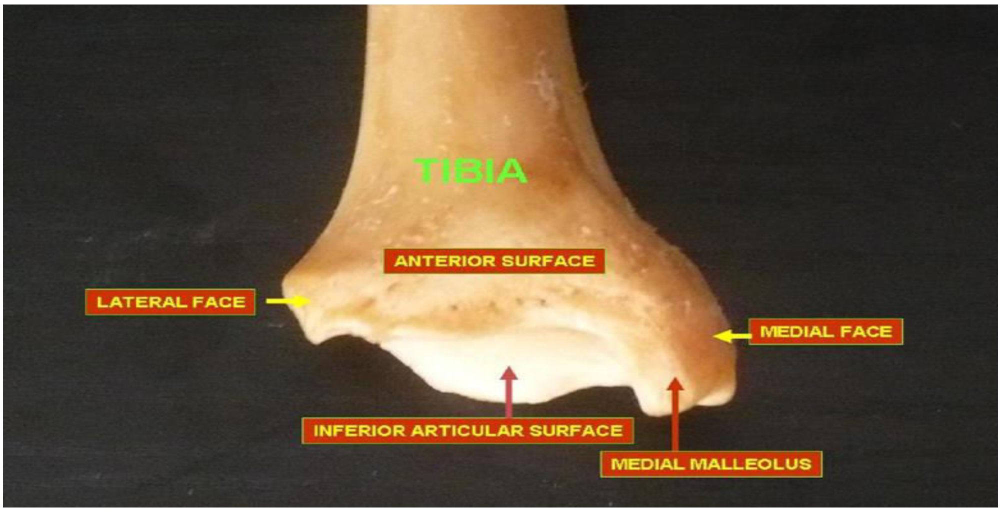

Figure (1): Lower extremity of tibia seen from the front (3).

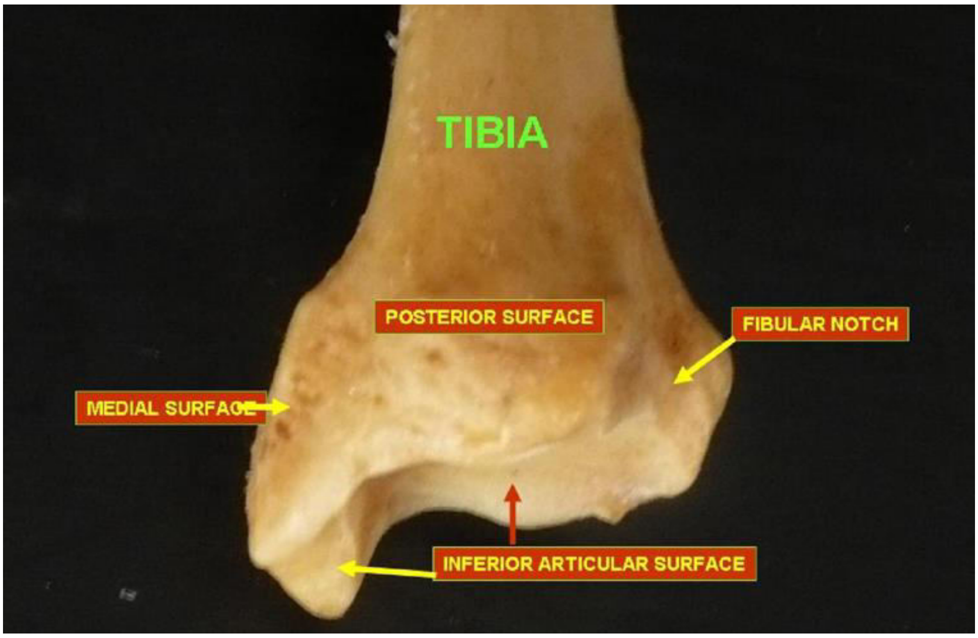

Figure (2): Lower extremity of tibia seen from the back (3).

2.Incidence of Distal Tibial Fractures:

The incidence of distal tibial fractures is 3% to 10% of all tibial fractures or 1% of lower extremity fractures. In 70% to 85% of cases, a fibular fracture is also seen, which occurs in more complex

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injuries **(4).**

As these fractures are often the result of high-energy trauma, up to 50% of patients may have additional lower extremity injuries, most often ipsilateral calcaneal or tibial fractures. about 80% of injuries there will be concomitant distal fibular fracture. About 6% of patients may also have multiple system injuries **(4).**

2.1 Classification of Distal Tibial Fractures

Distal tibial fractures are often associated with high-energy injuries and classification of the state of the soft tissues is useful for communication, research and prognosis. The state of the soft tissues can be assessed by means of the Gustilo–Anderson **(5)** or Tscherne– Gotzen **(6)** systems for open or closed fractures respectively. Extensive soft-tissue injury disrupts the vascular supply to the fracture site and increases the risk of infection and delayed or nonunion **(7).**

In clinical practice, the classification of the morphology of distal tibial fractures is descriptive, stating the position, orientation of the fracture, degree of translation, angulation, shortening and rotation as well as the extent of comminution. Robinson et al. developed a classification based on their study of 63 patients with distal tibial metaphyseal fractures treated with intramedullary nailing. They reported two distinct patterns of injury, fractures resulted from a direct deforming force producing a transverse fracture pattern (type I). Alternatively, a helical fracture was formed as a consequence of a torsional force (type II). Type I fractureswere associated with a slower union compared to the type II fractures. This is likely to be a consequence of the increased soft-tissue injury associated with the transverse fractures as well as the relatively reduced exposed bone surface area **(8).**

According to the AO Classification of Müller and Nazarian fractures of the distal tibia are defined as extra-, partially intra-, and completely intra-articular, the Müller classification should reflect the severity of injury, the prognosis and possible treatment modalities **(9).**

Fractures of the distal tibia have been given the number 43 in the AO Classification. Fractures of types 43 B3 and C1-C3 are the severest fracture patterns of the distal tibia with involvement of the distal tibial articular surface, thus corresponding to the classical tibial pilon fracture **(9).**

Apart from the AO Classification one of the best-known classifications is the one compiled by Ruedi and Allgöwer. It divided distal tibial fractures into 3 groups and formed the basis for the AOClassification, which is in widespread use today **(10).**

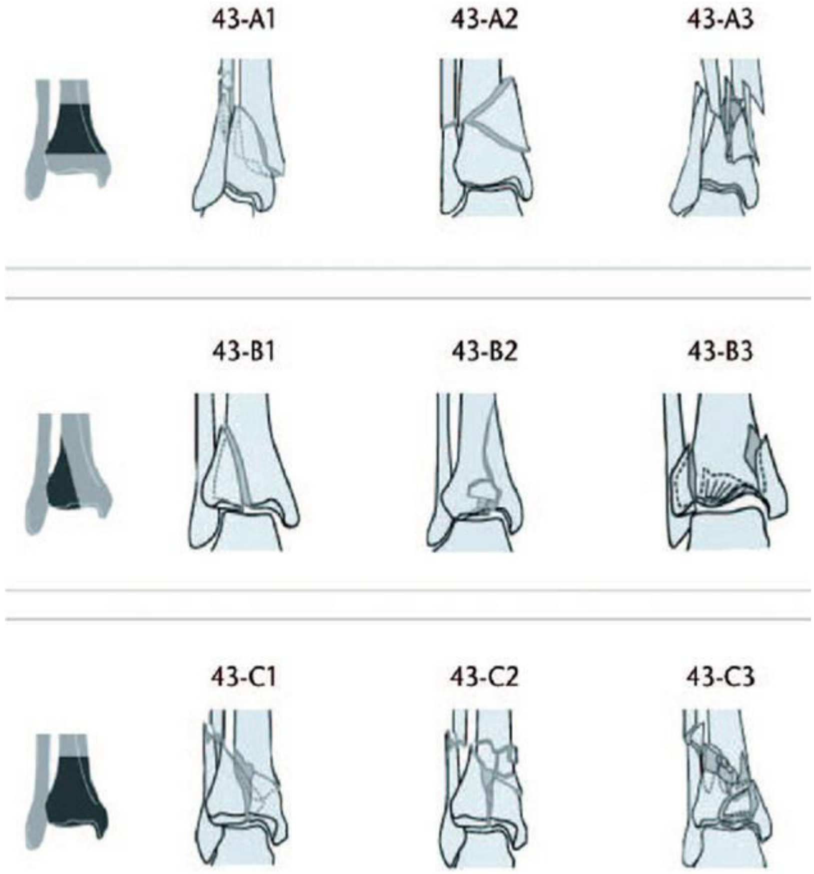

Figure (3): AO/OTA classification of distal tibial fractures. Adapted with kind permission from AO Foundation, Switzerland. 43-A extra-articular fracture. 43-A1 simple; 43-A2 wedge; 43-A3 complex. 43-B partial articular fracture. 43-B1 pure split; 43- B2 split depression; 43-B3 multifragmentary depression. 43-C complete articular fracture. 43-C1 articular simple, metaphyseal simple; 43-C2 articular simple, metaphyseal multifragmentary; 43-C3 articular multifragmentary (9).

3. Management of Distal Tibial Fractures:

3.1 Conservative management

Conservative management of distal tibial fractures can only be considered for the non-displaced closed fractures that can be exactly reduced and retained in stable fixation (Type 43-A1–3, B1) or in situations of desolate vascularity or general inoperability (**11, 12**).

The indications for nonoperative treatment as closed injury, no other major fractures, initial shortening 15 mm, and angular deformity after initial manipulation 50 in any plane **(13)** Failure to achieve an adequate initial reduction, as defined in Table, is an indication for operative treatment or further attempts at closed reduction **(14).**

Fracture of the distal tibia, especially in classical tibial pilon fractures with involvement of the distal tibial plafond and the distal metaphysis, is an injury that generally requires surgical intervention. Lengthy periods of immobilization of an extremity are associated with the usual risks of thrombosis, embolism, reflex dystrophy and contractures with subsequent per immobilization of complex distal tibial fractures, on the other hand, can lead to secondary reduction loss. The manifestation of secondary compartment syndrome or nonunion or consolidation in varus malalignment are additional risks of conservative management. Varus malalignment of the lower leg is generally less well tolerated than valgus malalignment. In cases of leg shortening, special raised shoes will help**(15).**

3.2 Surgical management

Surgical intervention aims to achieve anatomical reduction with restoration of axes, length and joint constellations, and early functional mobility. The main objective, as for every other joint fracture and especially for a load-bearing extremity, is the restoration of the articular surface. Treatment procedure should be tailored in accordance with the concomitant soft tissue injuries and the fracture pattern **(16, 17).**

A primary one-stage procedure with definitive fracture fixation and single-shot antibiosis is only relevant to simple fractures that present within 6–8 hours of trauma. A two-stage procedure with initial retention by external fixator followed by a conversion procedure be the treatment of choice for open fractures, fractures with extensive soft tissue injury, status after compartment release, vasomotor injuries or in patients with compromising comorbidities **(18).**

In these cases of bad perfusion of thelower leg or severe soft tissue damage even definitive stabilization with external fixator is recommended as a good alternative (**19**).
It may be advantageous to stabilize simultaneous fibular fractures with a plate combined with a joint-bridging external fixator as a primary intervention **(20,21).**

Anatomical reduction of the fibula will restore the lateral column of the upper ankle joint as well as length and rotational alignment of the lower leg. Possibly, anatomical reduction of the tibial metaphysis and the articular surface and restoration of the malleolar mortise can be simplified by ligamentotaxis. In open fractures with significant soft tissue injury, radical wound debridement is essential to decrease the risk of wound infection. Temporary vacuum-assisted wound closure can be achieved by insertion of a foam in appropriate technique. The same procedure also facilitates application of dressings and wound drainage after compartment release **(22).**

The course of treatment focuses on reduction of swelling by elevation of the extremity, cold sponge and sufficient analgesic therapy. Regular evaluation of the soft tissues is important for the early recognition of imminent compartment syndrome. Early mobilization of the patient with partial weight bearing of the affected limb is a priority **(11).**

If primary treatment of a concomitant fibular fracture was not possible, the fibula should now be reduced and stabilized by fixation. Stabilization of the fibula is performed as usual through a posterolateral skin incision. Generally, a one-third tubular plate as a neutralization plate is adequate for fibula fixation or a bridging plate if there are bone defects **(23).**

The routine approach to the distal tibia is through an anteromedial skin incision. Surgery should be preceded by preoperative single-shot antibiotic administration, for example of a cephalosporin **(24).**

A variety of locking plates are applied depending on the size of the fragments, fracture geometry and the condition of the soft tissues. To minimize surgical insult to the damaged tissue, these plates may be positioned in minimal ivasive technique. The proximal screws can then be inserted

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through stab incisions to preserve the soft tissues. If internal fixation does not achieve sufficient stability for exercises, the external fixator may have to be left in situ. However, in many cases, the external fixator can be removed to permit functional rehabilitation of the adjacent joints. Loading capacity for the plated lower leg generally remains clearly restricted to around 20 kg for 6– 8 weeks postoperatively **(25, 26).**

If the soft tissue injury, course of infection, patient specific circumstances or the fracture geometry do not favor two-stage internal fixation, the external fixator will remain as the definitive solution. If the fracture pattern is highly complex, alternatives include stabilization by means of a ring fixator combined with a tubular rod fixator as a hybrid or an Ilizarov fixator **(27, 29).**

Alternatively, simple extraarticular fractures (Type 43-A) may be stabilized by plate osteosynthesis or intramedullary nails. Both procedures have advantages and disadvantages and should be discussed and evaluated for each individual case **(28, 29).**

Intramedullary nailing of metaphyseal fractures may be associated with deformity as a result of instability after fixation, unlike intramedullary fixation of diaphyseal fractures of the tibia, nailing of metaphyseal fractures with a short proximal or distal fragment is associated with an increase in malalignment, particularly in the coronal plane. The cause has been attributed both to displacing muscular forces and residual instability. As there is a large difference between the size of the implant and the metaphyseal diameter with no nail-cortex contact, the nail may translate laterally along coronally placed locking screws. Poller screws acting as blocking screws were placed on the concave side of the deformity between the cortex and nail have been proposed as a possible solution by preventing translation in the tibia (Fig 10). These Poller screws decrease the width of the medullary cavity, physically block the nail, and increase the mechanical stiffness of the bone-implant construct **(30).**

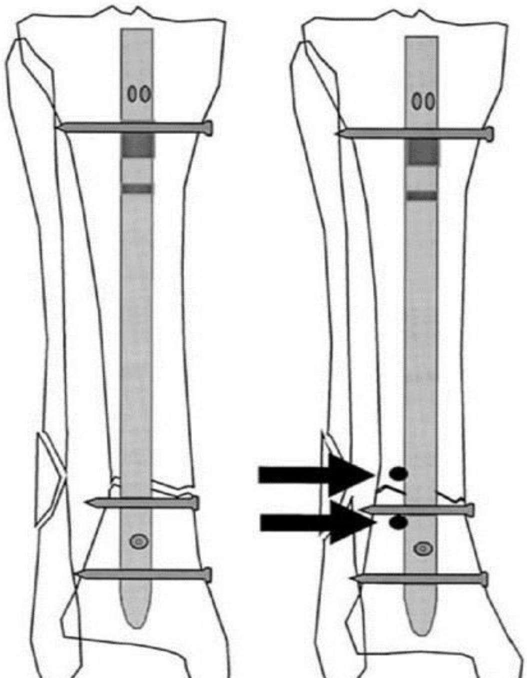

Fig. (4): Schematic drawing of distal fracture of the tibia stablized with an intramedullary nail of small diameter before (left) and after insertion of Poller screws (arrows, right)(30)

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Nail fixation has the advantage that it is less invasive, and the approach is away from the fracture site, but it is often difficult to perform distal locking in a small metaphyseal fragment. Furthermore, cases of postoperative, approach-related knee pain have been described. Closed reduction is more prone to malalignment and occasionally ends in rotational deformity **(28, 25, 29).**

An osteosynthesis plate is most likely to ensure better reduction and is generally easier to anchor in the distal fragment. However, some studies have reported higher rates of infection and disordered wound healing, perhaps partly because the approach to the distal tibia lies close to the fracture site in the area of greatest soft tissue injury. Soft tissue irritation due to the implanted plate has also been described as well as the need for a longer period of partial weight bearing and a possible risk of implant failure as loading increases **(31).**

Amputation need only be considered when faced with the severest combinations of bone and soft tissue injury and, possibly, for patients whose survival is threatened **(11).**

Depending on the soft tissue insult and the possible course of infections, especially if implanted material is exposed, reconstruction of soft tissue structures by plastic surgery will complement the therapeutic strategy. In these cases, adequate radical debridement should not be compromised by concerns that soft tissue closure will not be possible later on. The presence of contaminated or necrotic tissue leads to a much higher risk of infection which, in turn, may retard the healing process and compromise the final outcome **(24).**

3. From ORIF to MIPPO and Advantages of MIPPO

ORIF is frequently used method of treatment of distal tibia fractures. ORIF can be performed with many different incisional approaches. The anterolateral approach is more frequently used. The anterolateral incision is performed at the anterior ankle, which is an area historically known to have poor healing. The extensive dissection required for visualization and reduction of the fracture disrupts the surrounding soft tissue and extraosseous vascular supply. Often, the dissection devitalizes the fracture fragments **(32).**

This has been known to delay healing and, ultimately, may contribute to the development of nonunion. The extensive dissection involved with ORIF, especially with the anterolateral approach, has displayed increased results of wound complications, including dehiscence;full-thickness necrosis; and, ultimately, infection (Fig. 5).

Figure (5): Anterior ankle full-thickness necrotic wound following ORIF of a pilon fracture (33)

These complications are of significant gravity because they may require use of long-term intravenous antibiotics, multiple visits to the operating room for debridement, and may lead to eventual limb loss **(34).**

Open reduction and internal fixation of distal tibial fractures initially appears to offer significant benefits over intramedullary nailing. It allows near anatomic reduction with stable fixation preventing malunion and there are no restrictions on the length of distal fragment as may be imposed by the need for distal locking of intramedullary nails **(35).**

However, open reduction and internal fixation is not a popular method of fixation of these fractures due to the risk of wound dehiscence and infection which occurs as a consequence of the minimal soft-tissue cover over the anteromedial tibia. A number of small studies have challenged this viewpoint, citing no or minimal infective complications following open reduction and internal fixation **(36).**

Alternative approaches to the distal tibia via a posterolateral or anterolateral approach have been proposed to improve the soft tissue cover of plates, but it is the development of minimally invasive percutaneous plate osteosynthesis (MIPPO) techniques for distal tibial fractures that has attracted the greatest interest in recent years. MIPPO has meant that plate fixation can be performed with less disturbance of the soft tissues, reducing the risk of wound complications and helping preserve the blood supply to the medial distal tibia **(34).**

MIPPO is undertaken following initial resuscitation and after the resolution of significant soft-tissue swelling that would prevent wound closure; this may require a period of temporary immobilization in a back slab or external fixator. The protocol for MIPPO requires initial closed reduction of the fracture. This may be achieved directly with percutaneously positioned pointed reduction forceps or indirectly through manual traction, an AO femoral distractor, concurrent fibular fracture fixation or a spanning external fixator **(37).**

A 3 cm curvilinear incision is made over the medial malleolus and a plane developed under the subcutaneous border of the tibia with Mayo scissors. Plates that have been used for MIPPO include dynamic compression plates (DCP), limited contact dynamic compression plates (LC-DCP) and more recently the anatomically contoured locking compression plates (LCP). The LCP is preferable as the locked fixed angle construct means the plate can sit off the bone, preserving periosteal blood supply. Anatomical contouring reduces the prominence of the plate, helps restore the normal anatomy and reduces varus/valgus or rotational deformity **(38).**
Temporary stabilisation with K-wires may be performed whilst the plate position is confirmed with fluoroscopy. With the LCP, a conventional screw can initially be used near the fracture site to draw the bone and plate closer together, to reduce the prominence of the plate and increase construct stability. Locking screws are inserted through stab incisions, with attention being paid to ensure that distal screws do not encroach on the distal tibiofibular joint. Care should be taken during the dissection of the stab incisions to prevent damage to the great saphenous vein and saphenous nerve **(39).**

MIPPO for distal tibia fractures is better suited for patients who have a less than optimal soft tissue envelope where extensive dissection would carry high risk for wound complications. The

MIPO technique is more reserved for fractures to the distal tibia in which the plafond does not present with severe comminution. In cases in which significant disruption and comminution of the tibial plafond is involved, MIPO may not be able to adequately restore the articular surface. These fractures would be better served with either ORIF through the anterolateral approach; alternative incisional approaches that give direct exposure to the articular surface; or, ultimately, primary fusion Fracture pattern and deformity also plays a role in selection of plating technique. Distal tibia fractures with varus deformity are better treated with medial buttress plating. Medial buttress plating will better counter the deforming forces and provide an overall stronger construct **(34)** (Fig. 6).

Figure (6): (A) Distal tibia fracture with varus deformity. (B) Postreduction of distal tibia fracture with use of delta external fixator along with fibular ORIF. (C) Anteroposterior (AP) radiograph of MIPPO technique for distal tibia fracture. (D) Lateral radiograph of MIPPO technique for distal tibia fracture (33).

3.1 Mippo advantages:

MIPPO is simpler technique, no need of extensive surgical exposure, Improved rates of fracture union high, Decreased infection rate, Decreased need for bone grafting, Early mobilization of extremity possible, Ideal technique for dealing with multiple injuries, Decreased incidence of refracture after plate removal **(40).**

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