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Treatment of Extra Articular Distal Tibial Fractures Using Plating and Intramedullary Nailing

Abde lrahim Elmabrouk Muftah Salem1,Elsayed Abdelmoty Mohammed 2, Mohamed Elsadik Attia 3,and Sameh Mohamed Holyl4

1M.B; B.CH.; Sert University- Libya.

2Professor of Orthopedic Surgery,Faculty of MedicineZagazigUniversity.

3Ass. Professor of Orthopedic Surgery,Faculty of Medicine Zagazig University.

4 Lecturer of Orthopedic Surgery, Faculty of Medicine Zagazig University.

Correspondingauthor:AbdelrahimElmabrouk Muftah Salem

Email:abdulraheemortho687@gmail.com

Abstract

Background:Distal tibial fractures are the most common long bone fractures. An incidence of 17 per 100 000 person-years, although more recent data indicate that the incidence may be declining.The tibia is the second largest bone in the body. There are two concave condyles at the proximal aspect of the tibia. The medial condyle is larger, deeper, and narrower than the lateral condyle. An elevated process, the tibial tubercle, located between the two condyles is the site of attachment of the patellar tendon. The shaft of the tibia is prismoid, with a broad proximal extent that decreases in size until the distal third, where it gradually increases in size. The tibial crest is prominent medially from the tibial tubercle to the tibial plafond and is subcutaneous without any overlying muscles.The slightly expanded distal end of the tibia has anterior, medial, posterior, lateral and distal surfaces. The distal end of the tibia, when compared to the proximal end, is laterally rotated (tibial torsion). The torsion begins to develop in utero and progresses throughout childhood and adolescence till skeletal maturity is attained.minimal invasive plate fixation (MIPO) is recommended to limit this complication and given more stability. The basic principles of this technique include in direct closed reduction, extra periosteal dissection, anatomic alignment. Plate length and screw density are key factors for the stability of fixation.Comminuted fibular fractures fixed with MIPO technique using a long bridging plate, or intramedullary fixation of the fibula with a small diameter flexible nail

Keywords:Extra Articular Distal Tibial Fractures, Intramedullary Nailing, Plating.

Anatomy of The Tibia

The tibia is the second largest bone in the body. There are two concave condyles at the proximal aspect of the tibia. The medial condyle is larger, deeper, and narrower than the lateral condyle. An elevated process, the tibial tubercle, located between the two condyles is the site of attachment of the patellar tendon. The shaft of the tibia is prismoid, with a broad proximal extent that decreases in size until the distal third, where it gradually increases in size. The tibial crest is prominent medially from the tibial tubercle to the tibial plafond and is subcutaneous without any overlying muscles **(1).**

The tibia develops from three ossification centers one in the shaft and one in each epiphysis. The tibial diaphysis ossifies at 7 weeks of gestation and expands both proximally and distally. The proximal epiphyseal center appears shortly after birth and unites with the shaft between 14 and 16 years of age. The distal epiphyseal ossification center appears in the second year of life, and the distal tibial physis closes between 14 and 15 years of age. Additional ossification centers are

occasionally found in the medial malleolus and in the tibial tubercle .The tibia articulates with the condyles of the femur proximally, with the fibula at the knee and the ankle, and with the talus distally. Twelve muscles have either their origin or insertion on the tibia**(1).**

The fibula articulates with the tibia and the talus. The fibular diaphysis ossifies at about 8 weeks of gestation. The distal epiphysis is visible at 2 years of age, and the proximal secondary ossification center at 4 years. The distal fibular physis closes at approximately 16 years the proximal physis closes later, between the age of 15 and 18 years. Nine muscles have either their origin or insertion on the fibula**(1).**

The distal tibia:

The slightly expanded distal end of the tibia has anterior, medial, posterior, lateral and distal surfaces. The distal end of the tibia, when compared to the proximal end, is laterally rotated (tibial torsion). The torsion begins to develop in utero and progresses throughout childhood and adolescence till skeletal maturity is attained **(2).**

The anterior surface is smooth, projects beyond the distal surface, from which it is separated by a narrow groove. The capsule of the ankle joint is attached to an anterior groove near the articular surface. The anterior surface is covered by the extensor tendons above and a rough surface below for attachment of the anterior ligament of the ankle joint. The medial surface is smooth and continuous above and below with the medial surfaces of the shaft and medial malleolus **(3).**

The posterior surface is smooth except where it is crossed near its medial end by a slightly oblique groove. This groove is adapted to the tendon of tibialis posterior, which usually separates the tendon of flexor digitorum longus from the bone. More laterally, the posterior tibial vessels and nerve and flexor hallucis longus contact this surface.

The lateral surface is the triangular fibular notch; its anterior and posterior edges project and converge proximally to the interosseous border. The floor of the notch is roughened proximally by interosseous ligament but is smooth distally and sometimes covered by articular cartilage. The anterior and posterior tibiofibular ligaments are attached to the corresponding edges of the notch **(4)**.

The distal surface articulates with the talus and is wider in front, concave sagittally and slightly convex transversely, i.e.it is saddle shaped. The medial malleolus has a smooth lateral surface with a crescentic facet that articulates with the medial surface of the talus. Its anterior aspect is rough and its posterior aspect features the continuation of the groove from the posterior surface of the tibial shaft for the tendon of tibialis posterior. The medial malleolus divides into anterior colliculus and a posterior colliculus, which serve as attachments for superficial and deep deltoid ligaments **(3).**

Nerves:

The posterior tibial nerve runs adjacent and posterior to the popliteal artery in the popliteal fossa. The common peroneal nerve passes around the proximal neck of the fibula. It divides into the deep and superficial branches, passing into the anterior and the lateral compartments of the lower leg respectively. Each branch innervates the muscles within its compartment. The deep peroneal nerve provides sensation to the first web space. The superficial branch is responsible for sensation across the dorsal surface of the foot **(5).**

The muscular attachments:

No muscle is attached to the distal tibia (only crossing anterior and posterior of the lower third of the tibia), so the distal third of the tibia is poor blood supply (the fracture of the distal tibia easily suffers from delayed union) **(6).**

The muscles of the leg consist of an anterior group of extensor muscles which produce

dorsiflexion (extension) of the ankle, a posterior group of flexor muscles which produce plantar flexion (flexion) and a lateral group of muscles (the fibulares)**(4).**

The anterior compartment contains muscles that dorsiflex the ankle when acting from above. When acting from below they pull the body forward on the fixed foot during walking. Two of the muscles (extensor digitorum longus and extensor hallucis longus), also extend the toes, and two muscles, tibialis anterior and fibularis tertius, have the additional actions of inversion and eversion **(figure 1)(7).**

The lateral compartment of the leg contains fibularis (peroneus) longus and fibularis (peroneus) brevis. Both muscles evert the foot and are plantar flexors of the ankle, and both play a part inbalancing the leg on the foot in standing and walking**(4).**

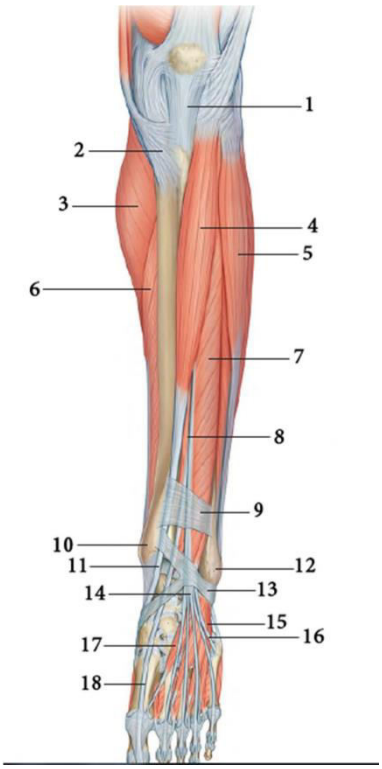

Figure (1): Muscles of the leg (anterior aspect).1-patellar tendon.2-insertion of Sartorius.3-gastrocenemius.4-tibialis anterior.5-fibularis longus.6-soleus7-extensor digitorum longus.8-extensor hallucis longus. 9-superior extensor retiniculum.10- medial malleolus.11-tibialis anterior.12-lateral malleolus.13-inferior extensor retiniculum.14-extensor digitorum longus.15-extensor digitorum brevis. 16-fibularis tertius. 17-extensor hallucis brevis.18-extensor hallucis longus **(6).**

The muscles in the posterior compartment of the lower leg form superficial and deep groups, separated by the deep transverse fascia. The superficial flexors group (gastrocnemius, plantaris and soleus) form the bulk of the calf. Gastrocnemius and soleus, collectively known as the triceps surae, constituting a powerful muscular mass whose main function is plantar flexion of the foot. Gastrocnemius and plantaris act both on the knee and ankle joints; soleus on the ankle alone **(figure 2) (7).**

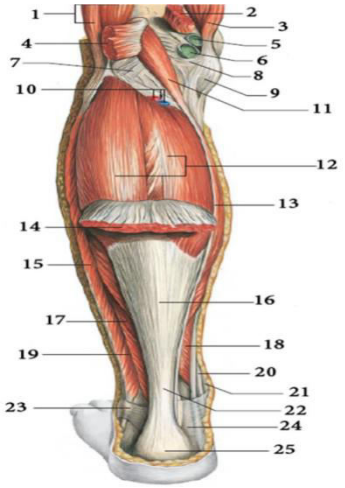

Figure (2): Muscles of the left leg, posterior aspect Gastrocnemius partially removed.1- biceps femoris.2-gastrocenemius medial end. 3-semimembranous.4-gastrocenemius lateral end.5-medial subtendinous bursa of gastrocenemius.6-semimembranous bursa. 7-arcuate popliteal ligament.8-oblique popliteal ligament.9-tibia, medial condyle.10- popliteal vessels.11-plantaris.12-soleus.13-tendons of plantaris.14-gastrocenemius.15- fibularis longus.16-tendon of gastrocenemius.17-flexor hallucis longus.18-flexor digitorum longus. 19-posterior intermuscular septumof leg.20-tendon of tibialis posterior.21-medial malleolus.22-calceneal tendon.23-superior fibular retiniculum.24- flexor retiniculum.25-calceneal tuberosity **(6).**

The deep flexor group, lies beneath anterior to the deep transverse fascia, and consists of popliteus, which acts on the knee joint, and flexor digitorum longus, flexor hallucis longus, and tibialis posterior **(figure3) (4).**

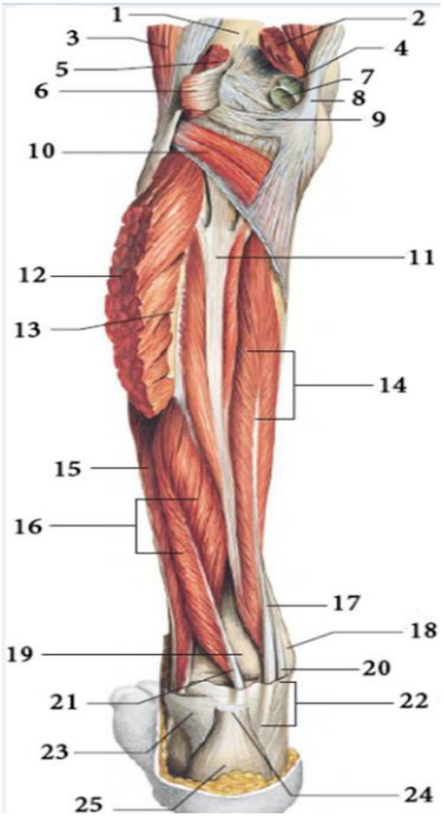

Figure (3): Muscles of the left leg, posterior aspect Superficial muscles extensively removed.1-femur, popliteal surface.2-gastrocenemius medial head.3-biceps femoris. 4- medial subtendinious

bursa of gastrocenemius. 5-gastrocenemius lateral head.6-plantaris.7-bursa of semi membranous.8-tendon of semimembranous. 9-oblique popliteal ligament. 10-popliteus. 11-tibialis posterior. 12-soleus. 13-fibula, interosseous border. 14-flexor digitorum longus.15-fibularis longus.16-flexor hallucislongus.17- tendon of flexor digitorumlongus.18-medial malleolus.19-tibia.20-tendon of tibialis posterior.21-tendon of flexor hallucis longus.22-flexor retiniculum.23-superior flexor retiniculum.24-calceneal tendon.25-calceneal tuberosity **(6).**

Treatment of displaced extra articular Distal Tibiafracture

1-Minimal Invasive Plate Osteosynthesis (MIPO):

Indication:

Fractures of the lower third tibia resulted from low energy trauma or high energy trauma with good skin condition. In this method can access anatomical reduction but may result in extensive soft tissue dissection, disruption of blood supply, nonunion, delayed union and wound complication and infection. So, minimal invasive plate fixation (MIPO) is recommended to limit this complication and given more stability. The basic principles of this technique include in direct closed reduction, extra periosteal dissection, anatomic alignment. Plate length and screw density are key factors for the stability of fixation. **(8).**

Contraindication:

Any soft tissue injury at fracture site or patient liable to incidence of infection.

Complication:

The risk of wound dehiscence and infection which occurs as a consequence of the minimal soft-tissue cover over the anteromedial side of the tibia.

Figure (4): Fracture of distal tibia treated by MIPO technique **(8).**

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2-Intramedullary nailing:

Indication:

Fractures of lower third tibia resulted from low energy trauma or high energy trauma with distal fragment allowing to insert distal locking screws, no severe soft tissue damage, or no bone exposed. In this method can limit the soft tissue damage, protect blood supply through minimal invasive technique but may result in difficulty in distal nail fixation, mal union, breakage of locking distal screws and risk of nail propagation into the ankle joint. So, Expert nail is recommended to limit this complication and given more stability **(9).**

Figure (5): Distal tibial fracture treated by ILN **(9).**

Contraindication:

Difficult fracture reduction, fracture propagation into the ankle joint, and inadequate distal locking options **(9).**

Complication:

Mal union, nail propagated into ankle joint, and breakage of distal locking screws. **(10)**

2-Fixation of fracture fibula:

The need for fibular fixation is unclear in extra-articular fractures of the distal tibial metaphysis, especially if the concomitant fibular fracture occurs above the level of the distal tibio-fibular syndesmosis. **(11).**

Fibula is fixed first when the fracture is simple (not comminuted) by open anatomic reduction and plate fixation using 1/3rd tubular plate or by locked plate (**12).**

Comminuted fibular fractures fixed with MIPO technique using a long bridging plate, or intramedullary fixation of the fibula with a small diameter flexible nail **(12)**.

Figure (6): Fixation of fibula**(12).**

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Figure (7): 1/3rd tubular plate **(12).**

Figure (8): locked plate of fibula **(12).**

Complication of Fracture Distal Tibia

I- Complication of Fracture Distal Tibia:

1-Compartment syndrome:

Incidence: Ranges from 2% to 9% of all tibial fractures, occurs where there is excessive swelling within a closed fascia-bone space leading to increased pressure within one of the leg's compartments results in insufficient blood supply to tissue within that space **(13).**

Predisposing factor: Young men with relative muscle hypertrophy (compared with older patients with muscle atrophy) have less residual space for muscle expansion, which could potentially increase ACS risk **(13)**..

Diagnosis: There are five characteristic signs and symptoms related to acute compartment syndrome: pain, paralysis, paresthesia (reduced sensation), pallor, and pulselessness. Pain and paresthesia are the early symptoms of compartment syndrome **(14).**

Prevention: Prophylactic anti-inflammatory anti edematous of risky patients can be helpful. Early diagnosis and early fasciotomy, good results can occur if compartment syndrome is recognized early. A missed compartment syndrome can lead to muscle fibrosis, nerve damage, and loss of function **(13)**..

Treatment: Surgical fasciotomy is indicated to decompress the compartments **(13).**

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2-Vascular injury:

Incidence: Very rare, but may occur with blunt trauma associated with stretching of vessels or crushed injuries.

Diagnosis: Doppler signals.

Clinical finding: (pulsatile bleeding, expanding haematoma, thrill at injury site, and pulseless dorsalispedis and posterior tibial arteries) may be subtle **(15).**

Complication:

1- Blood loss.
2- Compartmental syndrome.
3- Tissue necrosis.
4- Infection.
5- Amputation.
6- Death.

Treatment:

1- Emergency management:

- Control bleeding by compressive dressing.
- Fluid resuscitation.
- Reduce and splint of fracture.

2-Prompt arterial repair is essential for limb salvage, requires an initial recognition of arterial injury **(15).**

3-Thromboembolism (TA):

Incidence: Vary significantly based on the level of injury, fracture pattern, and inherent patient factors **(16).**

Predisposing factor: Hypertension, smoking history, diabetes, respiratory disease, alcoholism, obesity, bleeding disorder, dependent status, steroid use and angina.

Prevention: The use of thromboembolic prophylaxis (LMWH) after incidence of trauma and after the fixation surgery.

Diagnosis: Two third of cases of thromboembolism were a symptomatic, one third of these patients had clinical sign of DVT (swelling of foot and ankle, cramping pain, skin of affected area turning pale, a reddish or bluish color and warmer than surrounding area) **(16).**

Complication: Pulmonary embolism.

Treatment: Medications (anticoagulant), In severe cases may be used thrombolytic drugs **(16).**

4-Fat embolism:

Incidence:

Fat embolism is not common phenomenon following limb fracture. It develops in 0.5% to 2% of all patients with fractures of the long **(17).**

Diagnosis: The onset is then sudden, with breathlessness & chest pain, high pulse rate, petechial rash present in conjunctivae. Central nervous system symptoms, disorientation, confusion, renal oliguria and drowsiness are common **(18).**

Predisposing factor: Obese patient, longer injury surgery interval, long time of reamed nailing.

Prevention: Early fracture fixation and patient mobilization.

Treatment: Admission of intensive care unit, O2 supply if needed (some patients may need mechanical ventilation), IV fluids **(18).**

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II-Complication of fixation of fracture distal tibia:

1) Infection:

Incidence: 1.6% in closed fractures distal tibia and 8.0% in open fractures of distal tibia. Infection is a serious complication that may occur after open method of treatment. It may result in osteomyelitis of the tibia, septic arthritis of the ankle joint or loosening of the screws and plate.

Source of infection: Organisms may be introduced directly into the wound from the atmosphere, the instruments, the patient, or surgeon, or indirectly by hematogenous spread from distant focus **(18).**

Diagnosis:

-**Clinical:** Pain, fever, sign of inflammation (hotness, erythema, tenderness, swelling, and limitation of ankle joint), limping with weight bearing, and draining sinus tract in osteomyelitis and may be present with full-thickness skin slough and plate exposed**(18).**

Figure (9): Full-thickness skin slough and plate exposed **(19).**

-Laboratory:

- Leukocyte count (WBC): Increased

- ESR and CRP: Increased.

- Culture and sensivity from draining sinus.

- Blood culture.

- Bone biopsy: Gold-standard for guiding antibiotic therapy **(18).**

-Radiological:

- Osteolytic region surrounded by an area of sclerosis.

- Sequestrum: Devitalized bone that serves as a nidus for infection.

- Involucrum: Formation of new bone around an area of bony necrosis **(18).**

The basis of classification of infection is as follows:

A. Early infection:

1-Superficial.

2-Deep.

3-Both superficial and deep **(15)**..

B. Late infection:

1-Following early infection.

2-Hidden infection appearing later.

3-Following a long period **(15).**

Factors that favor bacterial invasion are:

1. Soft-tissue damage and bone death.
2. Poor contact between the implant and bone.

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3. Loosening of the implant.
4. Corrosion of the implant **(15).**

Factors that predispose to infection are:

1. High-energy injuries.
2. Open fractures.
3. Extensive surgical dissection that compromises osseous vascularity.
4. Prolonged time of open surgical wound.
5. Inadequate fixation **(18).**

Treatment:

-Superficial infection: IV antibiotic followed by oral antibiotic.

- Deep infection: Irrigation and debridement should be performed to remove all necrotic tissue and sequestrum. Deep cultures should be obtained. Strong IV antibiotic should administrate until culture result will appear **(19).**

Prevention:

- Careful preoperative screening of any focus of infection.
- Careful handling of the soft tissue. Intermittent irrigation of the operative wound with saline through the procedure help to remove contamination and debris. Prophylactic antibiotic should be administrated and then continued 48 hours after surgery at least **(20).**

2) Non-union:

Definition: permanent failure of healing following a broken bone.

Incidence: constitute 2-10% of all tibial fractures **(21).**

Predisposing factors:

-Related to patient:

1- Old age.
2- Poor nutrition.
3- Smoker, alcohol intake
4- Patients have metabolic disease **(21).**

-Related to fracture:

1- The fracture moves too much after trauma.
2- Poor blood supply.
3- Infection.
4- Soft tissue damage surrounding it.
5- Bone loss at the fracture **(21).**

-Related to fixation:

1- Inadequate reduction.
2- Inadequate stability.
3- Improper fixation device **(21).**

Diagnosis:

-**Clinical:** Persistent pain at the fracture site and may also notice abnormal movement or clicking at the level of the fracture.

-Radiological: Plate of the fractured bone shows a persistent radiolucent line at the fracture) **(21)**

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Classification:

1-Hyper vascular (hypertrophic): Callus is formed, but the bone fractures have not joined.

2-A vascular (atrophic): No callus is formed **(21).**

Treatment (surgical):

1- Removal of all scar tissue from between the fracture fragments.

2- Immobilization of the fracture with internal fixation.

3- Bone grafting.

Figure (10): Non-union of distal tibia fracture **(21).**

4) Delayed union:

Definition: Delayed union is absence of complete radiological union at 6 months or if do not show enough bridging callus to achieve clinical stability by 16 weeks

Incidence: 5-10 % of cases of fixation of fracture distal tibia.

Diagnosis and treatment:

Diagnosis:

-**Clinical:** Persistent pain at the fracture site and may also notice abnormal movement or clicking at the level of the fracture.

-Radiological: Plate of the fractured bone shows a persistent radiolucent line at the fracture **(21).**

Treatment (surgical):

1- Removal of all scar tissue from between the fracture fragments.

2- Immobilization of the fracture with internal fixation.

3- Bone grafting **(21**).

Figure (11): Delayed union for distal tibia fractures after 6 months **(21).**

3) Malunion:

Types of malunion:

-Varus of more than 10°.

-Valgus of more than 15°.

- shortening of more than 1 cm.

- Anterior or posterior angulation of more than 15°.

- External rotation more than 10°.

- Internal rotation more than 5° **(18).**

Incidence: Constitute 8 % of cases of fixation of fracture distal tibia.

Diagnosis and degree of tibial mal alignment and varus /valgus:

Grade 1: 2.5º malalignment&1cm shortening.

Grade 2: 5º malalignment&2cm shortening.

Grade 3: 10º malalignment&3cm shortening.

Grade 4: > 10ºmalalignment&> 3cm shortening **(18)**.

Treatment: Surgical intervention.

4) Neurovascular injury:

Because of the saphenous vein (SV) and saphenous nerve (SN) lie in the medial facet of the distal tibia, and cross the tibia from anterior to posterior **(22).**

5) Implant irritation:

Implant discomfort, skin impingement and irritation of distal tibia– fibula joint due to too long distal screws.

6) Joint stiffness:

Either knee or ankle range of motion is affected.

7) Secondary osteoarthritis:

Mal-reduction is main cause of secondary osteoarthritis. Many patients can be successfully treated with anti-inflammatory medication **(15).**

8) Implant failure (plate or distal screws of ILN):

Factors predispose to loss of fixation include **(figure 25)** :**(14)**

1-Fracture comminution.

2-Increased patient age and osteopenia.

3-Poor patient compliance with premature loading and weight bearing.

4-Infection.

5-Inadequate poor fixation technique.

6-Improper manufacturing material **(14).**

Figure (12): Implant failure **(14).**

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