MANAGEMENT OF EXTRA-ARTICULAR DISTAL TIBIAL FRACTURES WITH COMBINED EXTERNAL FIXATION AND LIMITED INTERNAL FIXATION - A PROSPECTIVE STUDY

Dissertation submitted to

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CERTIFICATE

This is to certify that DR P SELVARAJ, post-graduate student (2007- 2010) in the Department of Orthpaedic Surgery, Government Royapettah Hospital, Kilpuak Medical College,Chennai has done dissertation on "**MANAGEMENT OF EXTRA-ARTICULAR DISTAL TIBIAL FRACTURES WITH COMBINED EXTERNAL FIXATION AND LIMITED INTERNAL FIXATION- A PROSPECTIVE STUDY"** under my guidance and supervision in partial fulfillment of the regulation laid down the **THE TAMILNADU DR M.G.R MEDICAL UNIVERSITY, CHENNAI-600 032** for M.S (Orthopaedic Surgery) degree examination to be held on March 2010.

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DECLARATION

I, DR P SELVARAJ, solemnly, declare that dissertation titled "**MANAGEMENT OF EXTRA-ARTICULAR DISTAL TIBIAL FRACTURES WITH COMBINED EXTERNAL FIXATION AND LIMITED INTERNAL FIXATION- A PROSPECTIVE STUDY"** is a bona fide work done by me, at Government Royapettah Hospital, Kilpauk Medical College between 20.07-2010, under the guidance and supervision of my respected unit chief **Prof Dr N O Samson M.S.Ortho, D.Ortho.,.**

This dissertation is submitted to THE TAMILNADU DR M.G.R MEDICAL UNIVERSITY, towards partial fulfillment of regulation for the award of M.S.DEGREE BRANCH-II in Orthopaedic Surgery.

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INTRODUCTION

Distal tibial fractures are among the most challenging of orthopaedic problems. Distal tibia have been treated by a variety of methods, including plaster immobilization, traction, lag screw fixation, open reduction and internal fixation with plates, and external fixation with or without limited internal fixation.

Open reduction and rigid internal fixation replaced the traditional non-operative treatment of these injuries in the late 1960's and 1970's.[1, 2]

The optimum treatment of this fracture remains controversial, as retrospective reviews of the results of open reduction and internal fixation have demonstrated high rates of complications. External fixation with limited internal fixation has gained some popularity since the late 1980's.[3]

More recently, staged protocols have been advocated consisting of temporary external fixation spanning the ankle joint, followed by open reduction and internal fixation with plates and screws after the condition of the soft tissues has improved, usually 2 to 3 weeks after injury.

Several factors must be considered when formulating a treatment plan. The mechanism of injury, whether high energy or low energy, usually correlates with the extent of skeletal and soft-tissue damage. The fracture type should be determined according to the amount and location of displacement and comminution and impaction.

Distal tibial metaphyseal fractures are often caused by high-energy axial compressive, direct bending or low-energy rotational forces.(4) These fractures represent less than 7% of all tibial fractures [5] and less than 10% of all lower extremity fractures.[6] Specifically, metaphyseal fractures of the distal tibia comprise 15% of all fractures of the distal third of the tibia. [7]

This injury commonly occurs in males 35–40 years of age and is the result of motor vehicle accidents, falls from heights or twisting injuries. But no age is exempted from sustaining this type of injury.

The fractures of the distal tibia have been treated by a variety of methods, including plaster immobilization, traction, lag screw fixation, open reduction and internal fixation with plates, and external fixation with or without limited internal fixation. A variety of external fixators have been used: traditional half-pin fixators spanning the ankle, articulated half-pin fixators that allow ankle motion, half-pin fixators that do not span the ankle, and hybrid fixators that combine tensioned wires with half-pins in the tibial diaphysis and do not span the ankle joint. Hybrid frames may be composed of rings proximally and distally (Ilizarov, Monticell-Spinelli) or may use a bar to connect the half-pins proximally to a ring or rings and wires distally.

If the latter design is used, additional support struts are needed to reduce cantilever bending forces.

More recently, staged protocols have been advocated consisting of temporary external fixation spanning the ankle joint, followed by open reduction and internal fixation with plates and screws after the condition of the soft tissues has improved, usually 2 to 3 weeks after injury. Primary arthrodesis has been performed in selected severe open fractures with extensive articular comminution and talar injury. The surgeon's preference and experience should play a role in preoperative decision making. [8]

AIM OF THE STUDY

Aim of this prospective study is to evaluate the clinical outcome of extra-articular distal tibial fractures treated with external fixation combined with or without limited internal fixation.

REVIEW OF LITERATURE

Distal tibial extra-articular fractures are often a result of complex high-energy trauma, which commonly involves associated fibular fractures and soft tissue injury. The goal of tibial fixation is to maximize fracture stability without increasing soft tissue morbidity from surgical intervention. (9)

Soft tissue injury:

Soft tissue injury with distal tibial fractures is common, as the soft tissue envelope of the tibia is limited. When the threshold of impact absorption in the distal tibia is exceeded, as in a fracture, there is rapid transmission of the residual destructive forces to the thin cover of adjacent soft tissues. Consequently, the incidence of open fractures is high at 16%–47% of all distal tibial fractures (10).

Closed tibial fractures are often accompanied by extensive contusions, fracture blisters or significant muscular damage. An increased rate of complications in open tibial fractures is also associated with the degree of soft tissue injury (11)

Concomitant fibular fractures:

High-energy distal tibial injuries involve concomitant fibular fractures in 80% of cases. The presence of ipsilateral fibular fractures in distal tibial fractures has been correlated with a higher severity of injury than those without fibular fractures.[12, 13]

Infection rates at fracture sites of 16% and delayed unions of 14% are common sequelae encountered in severe open tibial fractures.[14] Pin tract infections are the most common complication of external fixation, reported at between 0.9% and 60%. [15]

Evaluation:

It must be remembered that the soft-tissue envelope around the distal part of the tibia is the limiting factor in the treatment of these injuries. The soft-tissue injury must be evaluated carefully, as postoperative problems with soft-tissue healing or coverage are associated with a substantial increase in the morbidity associated with this injury.

Anteroposterior, lateral, and oblique radiographs should be made. A traction radiograph of the injured extremity is helpful as traction and ligamentotaxis often cause the displaced fragments to be pulled back into position, which allows for a better definition and understanding of the fracture pattern.

When the injury pattern is not seen clearly on plain radiographs, a computed tomographic scan can be made to allow for a better, three-dimensional evaluation of the injury. Precise preoperative planning and drawings made with use of the uninjured ankle as a template are helpful to ensure that the needed equipment and instruments are available.

Careful planning also reduces the need for extensive soft-tissue dissection to allow the surgeon to see the fracture, reduces the operative time, and facilitates each step of the operation[16]

Treatment Planning:

Factors to consider in the formulation of a treatment plan include the fracture pattern, soft-tissue injury, patient co-morbidities, fixation resources, and surgical experience. The degree of articular comminution, talar damage, and soft-tissue injury is dictated by the injury; however, the surgeon does have some influence over other prognostic factors. The goal should be to obtain the best possible articular reduction and axial alignment, while respecting the soft tissues. If the articular surface does not reduce by ligamentotaxis, some form of open reduction usually is indicated after the soft tissues have recovered.

Fracture union can be enhanced by bone grafting areas of impaction, bone loss, or extensive metaphyseal comminution. Whichever method of stabilization is chosen, the construct should be sufficiently stable to maintain the reduction. The frequency of wound healing problems and infection can be decreased by recognizing open and closed soft-tissue injury and not operating through compromised soft tissue. In some cases, the surgeon must achieve a balance between the goals of anatomical reduction and prevention of wound complications. Anatomical reduction often is more difficult to achieve after a delay of 2 to 3 weeks; however, surgical incisions through swollen, contused soft tissues can lead to wound breakdown and infection, which may require free tissue transfer or even result in amputation.

Non-displaced fractures, such as AO types A1, B1, and C1, have been treated successfully with operative and non-operative methods. These are the only fracture types in which cast immobilization alone may be suitable. If casting is chosen, the patient should be followed closely for displacement, and weight bearing should be restricted for at least 8 weeks if non-arthritic. Calcaneal traction alone often is helpful in temporarily stabilizing severe fractures associated with soft-tissue swelling, but it seldom is used for definitive treatment.

External fixation accomplishes the same goal of fracture reduction through ligamentotaxis and allows the patient to be mobilized. Limited fixation with 3.5-mm or 4-mm screws, inserted after either percutaneous or limited open reduction, combined with plaster immobilization may be adequate treatment for AO types B1, B2, and stable C1 fractures. If the stability of the fracture is uncertain, however, an external fixator should be used instead of a cast.

Plate fixation is effective in stabilizing distal tibia fractures. Conventional techniques involve extensive dissection and periosteal stripping, which increase the risk of soft-tissue complications. Percutaneous plating techniques use indirect reduction methods and allow stabilization of distal tibia fractures while preserving vascularity of the soft-tissue envelope. External fixation is effective in the setting of contaminated wounds or extensive soft-tissue injury. Careful preoperative planning with consideration for fracture pattern and soft-tissue condition helps guide implant selection and minimize postoperative complications.

Rationale for fibular fixation in distal tibial fractures:

In general, adjunctive fibular fixation seems to lessen the risk of distal tibial malalignment, but only a few clinical reports have specifically evaluated this clinical impression.

In a retrospective study, Egol et al. evaluated the role of fibular fixation in maintaining alignment of distal tibial fractures stabilized with a statically locked intramedullary nail. Of the 72 cases, there was loss of tibial alignment in 1 of 25 (4%) patients who had the fibula stabilized as compared to 6 of 47 (13%) who did not. Late loss of distal tibial alignment was statistically associated with the lack of adjunctive fibular fixation. [17]

The role of fibular fixation was also studied by Weber et al. The study demonstrated that additional stability of tibia conferred by fibular fixation depended on the method of both tibial and fibular fixation. The investigators concluded that the maximal reduction of tibial motion resulted from fibular plating coupled to tibial external fixation.[18]

TREATMENT

Non-operative treatment:

Nonsurgical treatment of tibial fractures can increase the incidence of mal - alignment with unacceptable shortening. Hooper et al concluded that non-operative treatment resulted in more malunion and shortening. [19]

Open Reduction and Plate Fixation:

For displaced fractures, operative treatment has been found to be superior to non-operative treatment. Rüedi and Allgöwer popularized the technique of open reduction and internal fixation with plates and screws for tibial pilon fractures in the 1960s. This technique follows the AO principles of anatomical reduction, rigid stabilization, and early motion.

In the 1980s to the mid-1990s, series involving larger percentages of open and high-energy injuries reported far fewer successful results and a high incidence of complications with this technique, especially in Rüedi and Allgöwer type III (AO type C3) fractures. When complications occur, they can be devastating. Free tissue transfer often is necessary to salvage the extremity, and the final result in some cases is amputation. Bourne et al. reported satisfactory results in 82% of 17 Rüedi and Allgöwer type I and type II fractures and 37% satisfactory results in 16 type III fractures treated with open reduction and internal fixation; infection occurred in 12.5% of type III fractures. Teeny and Wiss reported acceptable results in 60% of type I and type II fractures and in 40% of type III fractures; 37% of type III fractures became infected, and 26% required arthrodesis. McFerran et al. investigated the complications in 52 tibial plafond fractures, most of which were treated by open reduction and internal fixation. Overall, there was a 54% incidence of local complications, and eight of 11 open fractures were associated with complications. Similarly, Teeny and Wiss reported poor results in 67% of open fractures treated with open reduction and internal fixation according to AO principles.

Plate and screw fixation has been associated with more frequent wound breakdown and infection than in similar fractures treated with external fixation.

Wyrsch et al. prospectively compared 18 pilon fractures treated with open reduction and internal fixation with 20 fractures treated with external fixation with or without limited internal fixation. In the open reduction group, six patients (33%) required free flaps for the treatment of wound breakdown, six patients (33%) developed deep infection, and three patients (17%) eventually required an amputation.

In the external fixation group, two patients (10%) developed a deep infection, one patient (5%) had a loss of reduction, one patient (5%) had an injury to the posterior tibial nerve, and four patients (20%) healed in malalignment. Articular reduction was better in the open reduction and internal fixation group; however, there were no type III fractures in the external fixation group. The authors concluded that external fixation was a satisfactory method of treatment for tibial pilon fractures and had fewer complications than open reduction and internal fixation. Watson et al. also reported more excellent and good results at 5-year follow-up with external fixation (81%) than with open plating (75%) in 94 pilon fractures. They based their treatment choices on the severity of the soft-tissue injury: Tscherne grade 0 and grade I were treated with plating, and grade II and grade III and open fractures were treated with external fixation.

Intramedullary nailing:

The intramedullary nailing technique for diaphyseal fractures of the tibia gained popularity for its minimally invasive approach, preservation of the extra-osseous blood supply and ability to restore axial alignment. However, as indications expanded to the distal tibial metaphysis, an increase of malalignment was seen.[20]

Combined External and Limited Internal Fixation:

In response to reports of unacceptable results with plating of high-energy tibial pilon fractures with traditional techniques, external fixation combined with limited internal fixation of the fibula and articular surface of the tibia has been advocated as an alternative approach. Reports of external fixation combined with limited internal fixation for tibial pilon fractures have shown a decreased incidence of infection compared with similar fractures treated with plate and screw devices.

Bone et al reported no infections in 20 open or severely comminuted tibial pilon fractures treated with a delta half-pin fixator and limited internal fixation. Range of motion was good or excellent in 75% of patients. [21]

Similarly, Bonar and Marsh reported no infections in 21 Rüedi and Allgöwer type II and type III fractures treated with an articulated half-pin fixator. One third of the fractures were open. In a later study, Marsh et al. reported no deep infections in 49 tibial pilon fractures treated with articulated fixators, but found a 20% incidence of pin complications, and three patients (6%) had wound healing problems over the fibular incision.[22]

In a long-term follow-up study, Marsh, Weigel, and Dirschl examined 35 pilon fractures followed for 5 to 12 years after treatment with monolateral spanning external fixation. Arthrodesis had been performed in 13% of ankles with known outcome. Reduction was rated as good in 14, fair in 15, and poor in six. Osteoarthrosis was grade 0 in three, grade 1 in six, grade 2 in 20, and grade 3 in six. Arthrosis was correlated with severity of injury and quality of reduction, but did not correlate with clinical result. Fifteen patients rated their outcome as excellent, 10 as good, seven as fair, and one as poor. Most patients (27 of 31) were unable to run. [(23)]

Dickson, Montgomery, and Field reported a single surgeon's series of 37 high-energy tibial pilon fractures (AO B3 and C3) treated by spanning external fixation and a second-stage open reduction of the articular surface at 10 to 21 days. Iliac crest bone graft was used at the second stage in all closed fractures and was delayed 4 to 6 weeks in open injuries. The investigators reported 81% good and excellent results.Complications included infection in 8%, loss of reduction in 11%, secondary arthrosis in 8%, and one (3%) amputation in a diabetic patient with a failed arthrodesis[(24)]

Tornetta et al. reported only one deep infection (4%) in 26 intraarticular and extraarticular distal tibial fractures treated with hybrid external fixators. This series included six open fractures and 13 Rüedi and Allgöwer type III fractures. Good or excellent functional results were obtained in 69% of type III fractures.

Barbieri et al. used hybrid external fixators to treat 37 tibial pilon fractures, 75% of which were caused by high-energy trauma. There were five pin track infections (15%) and three deep infections (8%), two of which were thought to be caused by the wire. Anatomical or good alignment was obtained in 97% of fractures; however, three (8%) required frame revision because of loss of fixation. [25]

Court-Brown et al. treated 24 type A and type C tibial pilon fractures with Hoffmann II external fixators. These fixators consist of three 3.5-mm half-pins inserted into the reconstructed distal tibial fragment and attached to a half-ring and then connected to two tibial diaphyseal half-pins by two side bars. There was one deep infection (4.2%), six malunions (25%), and nine pin track infections (37.%). Overall, 75% of patients had good or excellent results, and 67% of the intraarticular fractures had good or excellent results. The authors concluded that the technique achieved results similar to the results obtained with small wire fixators, but the technique was easier and safer. [26]

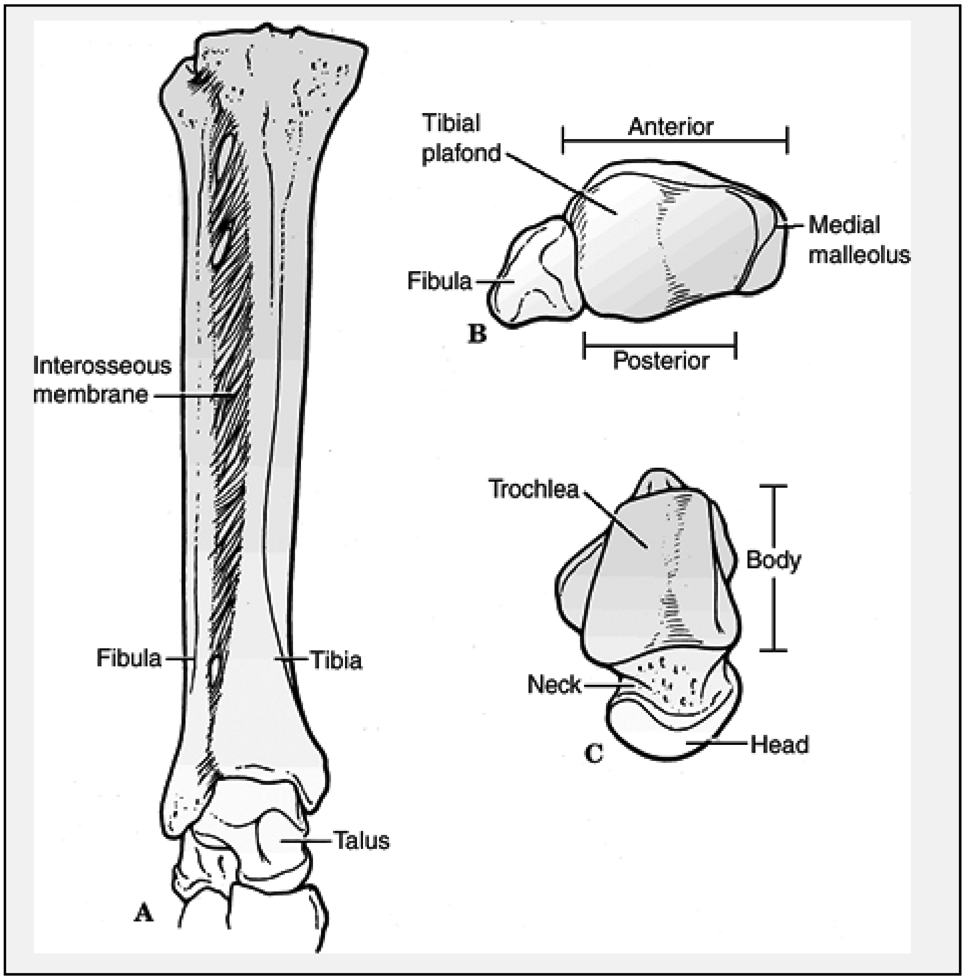
Okcu and Aktuglu compared 24 tibial plafond fractures treated with Ilizarov fixation with 20 fractures treated with a monolateral external fixator. Both groups had limited open reduction and fixation as necessary. There were no significant differences between the groups except for better ankle and subtalar movement in the Ilizarov group. All fractures united, and there was no osteomyelitis in either group. Malunion was defined as more than 5 degrees angular or rotational deformity or more than 2 mm articular step-off. Using these criteria, five fractures (20%) treated with the Ilizarov fixator and five (25%) treated with the monolateral fixator had malunions. No patient required arthrodesis (3 to 9 years of follow-up). The authors concluded that both methods were satisfactory.[27]

SURGICAL AND APPLIED ANATOMY

The bony anatomy of the ankle and distal tibio-fibular joints provide stability in dorsiflexion and relative mobility in plantarflexion. In the standing, dorsiflexed, close-packed position, the ankle joint behaves like a true mortise, with stability conferred principally by articular contact. In the non-weight-bearing, plantarflexed position, ankle joint stability is mostly conferred from ligamentous structures.

Tibia:

The lower end of the tibia is formed by five surfaces: inferior, anterior, posterior, lateral, and medial. The inferior surface is articular, concave anteroposteriorly, and slightly convex transversely, dividing the surface into a wider lateral and narrower medial segment. The posterior border of the ankle joint is lower than the anterior border. The posterior border is in continuity with the posterior surface of the medial malleolus. This segment has an oblique groove medially, which is directed downward and inward, that corresponds to the tendon of the tibialis posterior muscle. The distal lateral border of the tibia is concave, with anterior and posterior tubercles. The anterior tubercle overlaps the fibula. This relationship is the basis for the radiologic interpretation of tibiofibular syndesmosis alignment. The more superficial aspect of the posterior tubercle extends around to the posterior surface of the distal tibia. The medial surface of the distal tibial articulation is directed obliquely downward and inward. The medial surface is prolonged distally by the medial malleolus. The articular surface of the medial malleolus is comma shape, with a larger surface anteriorly.



Bony anatomy of the leg and ankle[28].

Mortise view (A), inferior superior view of the tibiofibular side of the joint (B), and superior inferior view of the talus (C).

Fibula:

The lower end of the fibula is a complex bony structure, giving rise to multiple ligaments and housing the lateral articular surface of the ankle. The distal fibula has two major surfaces, lateral and medial, which widen into the three-surfaced lateral malleolus at the level of the tibial plafond. The interosseous ligament attaches where the lateral surface twists and becomes the posterior border of the lateral malleolus. The lateral malleolus is encased in strong ligamentous attachments anteriorly, posteriorly, inferiorly, and superiorly. These ligamentous attachments include the anterior tibiofibular ligament, the calcaneofibular ligament, the posterior talofibular ligament, the superficial and deep components of the posterior tibiofibular ligament. Superiorly, the fibula is held in continuity to the tibia by the tibiofibular interosseous ligament.

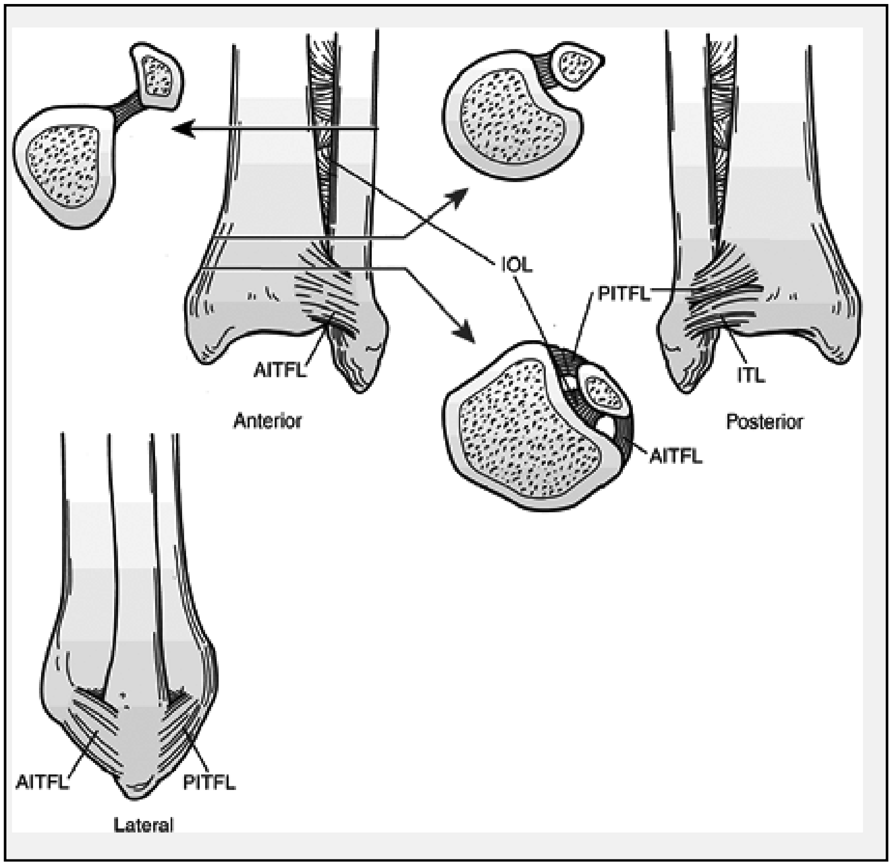
Ligaments:

Ankle stability is conferred by bony architecture, and ligamentocapsular structures. There are three distinct groups of ligaments supporting the ankle joint: (a) the syndesmotic ligaments, (b) the lateral collateral ligaments, and (c) the medial collateral ligament. The syndesmotic ligaments are composed of three distinct portions. They are: the anterior inferior tibiofibular ligament, the posterior tibiofibular ligament and the stout interosseous ligament. The interosseous ligament which extends upward and blends in continuity with the interosseous membrane. These structures are largely responsible for the integrity of the ankle mortise.

Tendons and neurovascular structures :

Five nerves, two major arteries and veins, and 13 tendons cross the ankle joint. These tendons are divided into four groups: the posterior group, the medial group, the lateral group, and the anterior group. The posterior group includes the Achilles and plantaris tendons. The Achilles is the most power plantarflexor of the ankle, and the plantaris is a small, perhaps vestigial and inconstant tendon that can be used to supplement tendon or ligament repairs in the ankle or elsewhere. Immediately lateral to the Achilles tendon lies the sural nerve, which innervates the skin on the lateral heel and lateral border of the foot.

Anterior to the medial malleolus courses the saphenous vein and accompanying nerves. Typically, these lie immediately medial to the tibialis anterior tendon. The saphenous vein is an excellent portal for re-establishment of intravenous access in cases of trauma with shock. However, the accompanying nerves can be inadvertently injured with incisions placed around the anterior aspect of the medial malleolus.



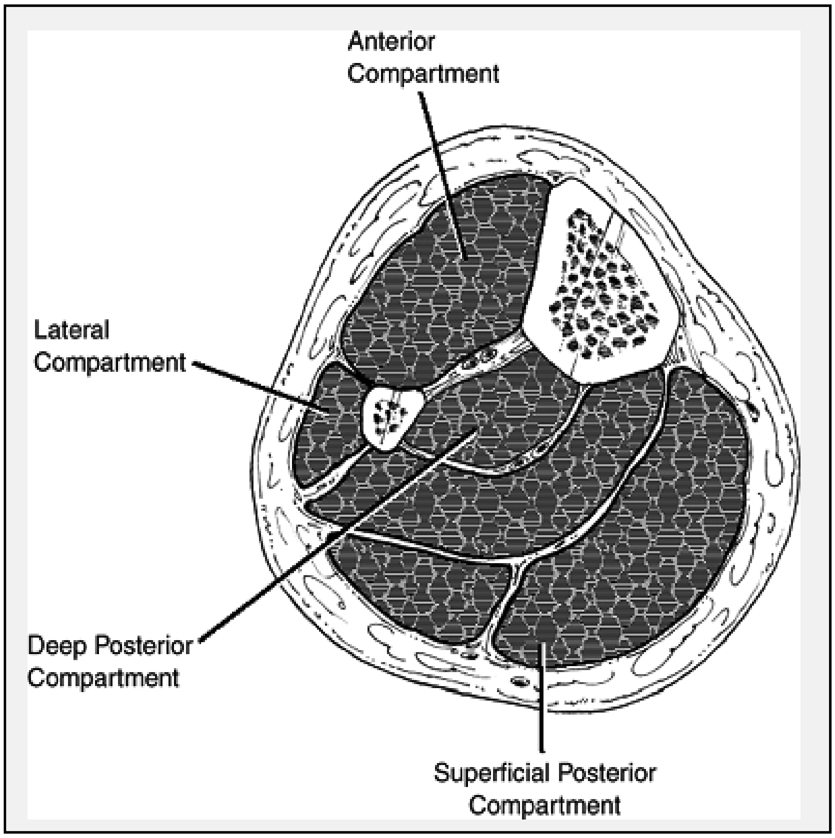
Three views of the tibiofibular syndesmotic ligaments.[29]

Anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), inferior transverse ligament (ITL), interosseous ligament (IOL).

Lateral approaches to the fibula can injure the superficial peroneal nerve proximally and the sural nerve distally. These nerves and their terminal branches sometimes are best exposed and protected during fixation of fibular fractures.

The superficial peroneal nerve fans into two or three major terminal branches that cross the ankle joint to innervate the dorsum of the foot.

Because injuries to these branches can cause considerable pain and dysfunction and are not easily amenable to salvage surgical procedures, extreme care should be exercised when one approaches the anterior aspect of the ankle or the distal fibula.



The four compartments of the leg.[28]

The surgical approaches to the tibia are straightforward. The basic rule is that all approaches should be longitudinal and never transverse. The skin overlying the anteromedial border should not be breached, as wound healing problems will often necessitate plastic surgery. The most useful surgical approach to the tibia is the anterolateral approach, with a straight incision being placed 1 cm lateral to the anterior border of the tibia. The anterior compartment muscles can be mobilized and retracted laterally to facilitate plating or bone grafting. The only other commonly used approach to the tibial diaphysis is the posterolateral approach often used to bone graft the tibia when the anterior soft tissues are in poor condition. A straight incision is made along the posterior border of the fibula. The plane between the peroneal muscles and gastrocnemius and soleus is located. The flexor hallucis longus is then dissected off the posterior border of the fibula and interosseous membrane to expose the tibia.

CLASSIFICATIONS

AO/OTA Classification:

The classification system of the AO/Orthopaedic Trauma Association is even more comprehensive and includes subdivisions that are based on the amount of comminution[30]. AO/OTA classification system provides a comprehensive description of distal tibial fractures.

Type A fractures are extraarticular distal tibial fractures, which are subdivided into groups A1, A2, and A3, based on the amount of metaphyseal comminution.

Type B fractures are partial articular fractures in which a portion of the articular surface remains in continuity with the shaft; these are subdivided into groups B1, B2, and B3, based on the amount of articular impaction and comminution.

Type C fractures are complete metaphyseal fractures with articular involvement; these are subdivided into groups C1, C2, and C3, based on the extent of metaphyseal and articular comminution [31]

Tibia = 4 Distal end = 3

Extra articular= A

Partial articular= B

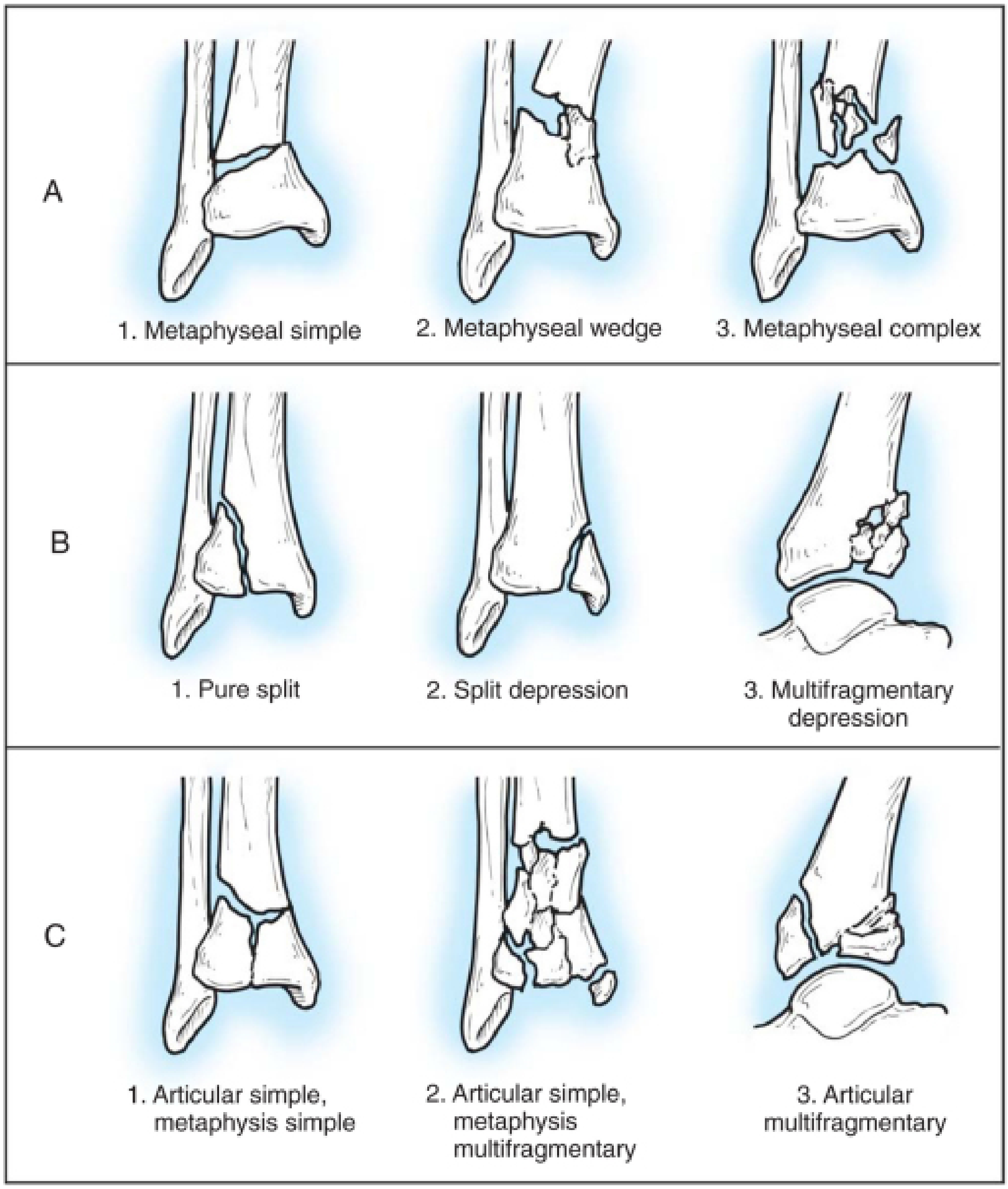
Complete articularfractures with metaphyseal-diaphysealdissocation= C

1. No comminutionor impaction in articular and metaphyseal areas

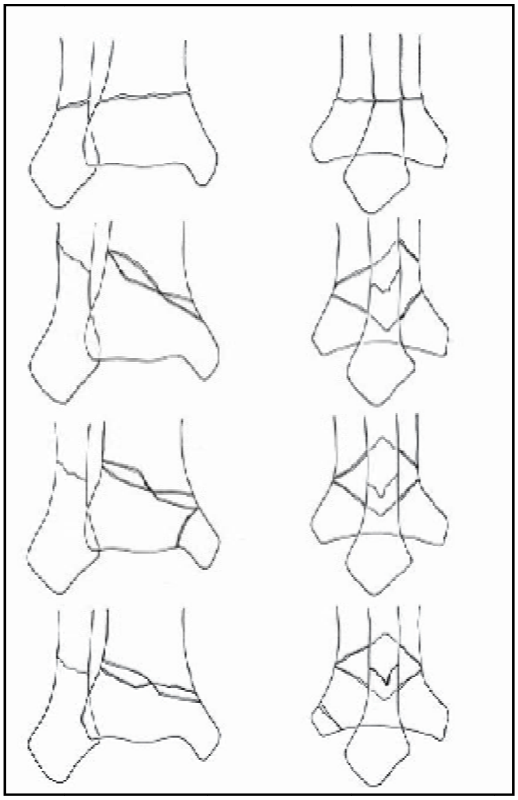
2. Impaction involving only the supraarticular metaphysis

3. Comminution and impaction of both metaphysic and articular surface

This system is very useful for research studies as it permits a more exact description of the injury and therefore allows better comparisons between studies.



Robinson classification of distal tibia metaphyseal fractures:



Type I:

Type I fractures have a simple transverse or oblique distal fracture line with out intra-articular extension. Typically, there is an associated fibular fracture at the same level.

Type II:

Type II fractures demonstrate a spiral fracture line with an oblique fibular fracture at the same or different level.

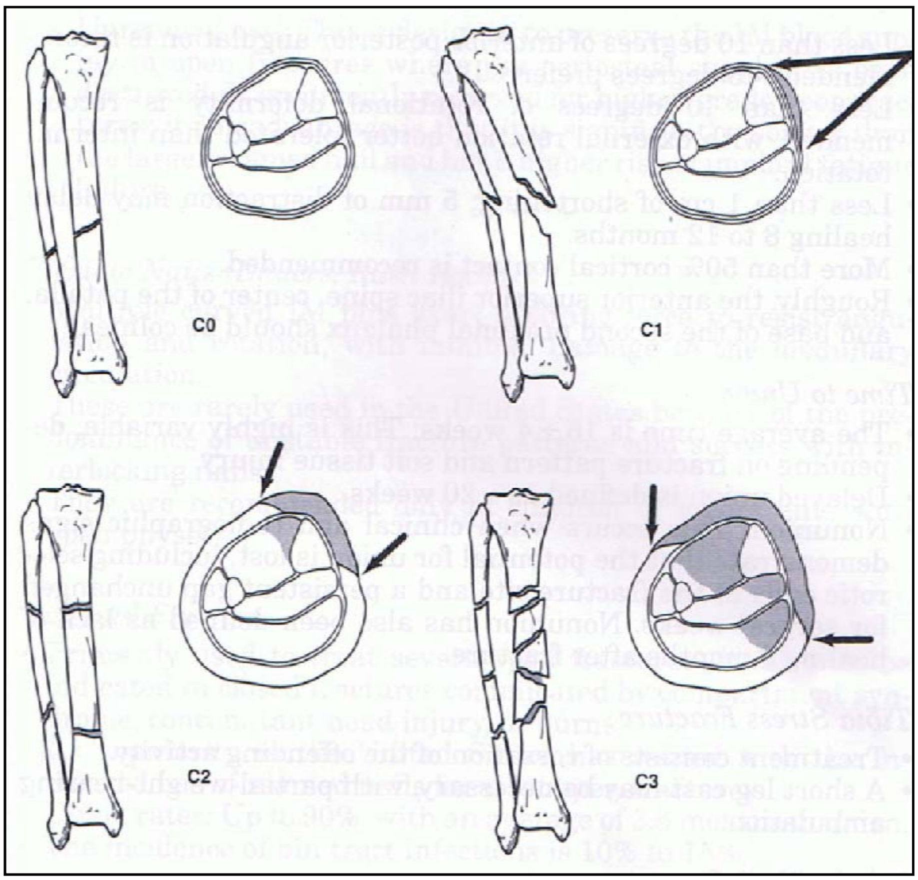
Type II- B and II-Cfractures present with intra-articular extension into the medial or posterior malleolus, respectively.

Tscherne Classification of Closed Fractures[32]

Grade 0: Injury from indirect forces with negligible soft tissue damage.

Grade I: Low moderate energy mechanisms, with superficial abrasions or contusions of soft tissues overlying the fracture.

Grade II: Significant muscle contusion, with possible deep, contaminated skin abrasions associated with moderate to severe energy mechanisms. High risk for compartment syndrome.



Tscherne Classification of Closed Fractures

Grade III: Extensive crushing of soft tissues, with subcutaneous degloving or avulsion, with arterial disruption or established compartment syndrome.

Gustilo-Anderson Classification [33]

Grade I:

Clean skin opening of <1 cm, usually from inside to outside; minimal muscle contusion; simple transverse or short oblique fractures.

Grade II:

Laceration >1 cm long, with extensive soft tissue damage; minimal to moderate crushing component; simple transverse or short oblique fractures with minimal comminution.

Grade III:

Extensive soft tissue damage, including muscles, skin, and neurovascular structures; often a high-energy injury with a severe crushing component.

III A:

Extensive soft tissue laceration, adequate bone coverage; segmental fractures, gunshot injuries, minimal periosteal stripping.

III B:

Extensive soft tissue injury with periosteal stripping and bone exposure requiring soft tissue flap closure; usually associated with massive contamination

III C:

Vascular injury requiring repair.

TREATMENT PROTOCOL

Initial Management:

A closed reduction was attempted for every fracture.

The closed fractures were treated with reduction and application of a splint, followed by operative treatment within seventy-two hours unless severe swelling or fracture blisters were present or there were medical contraindications.

If the operation was delayed for more than forty-eight hours, the patient was elevated on a Bohler-Braun frame. The average time from the injury to the operative fixation of the closed fractures over-all was five days.

The indications for an operation included an open fracture and unacceptable alignment of the fracture (greater than 10 degrees in any plane) of the tibia or the fibula.

An open fracture was treated by irrigation, thorough debridement, and appropriate intravenous antibiotics. After repairing the fractures, the wounds were left open or were approximated loosely to cover most of the exposed bone, according to the condition of soft tissue.

Preoperatively and postoperatively, antibiotics were administered parenterally to all patients. The patients who had a closed fracture received cefotaxime, one gram every 12 hours for forty-eight to seventy-two hours before and after the operation; an aminoglycoside (gentamicin) was added to this regimen for the patients who had an open fracture.

Surgical Procedures:

All patients had limited internal fixation combined with external fixation. AO fixator was used for external fixation of tibia in 16 patients. For external fixation, three proximal and two distal 4.5-millimeter half-pins were used. Distal fixation was accomplished with use of two half-pins in the distal fragment using a T-clamp in 8 patients, one calcaneal pin& one in the distal fragment in 6 patients and with two calcaneal pins in 2 patients.

No tibia was fixed with a plate. Bone-grafting was not done at the time of the initial fixation in any patient.

Fracture of the fibula was fixed in all patients, with a plate (Asian Dynamic Compression Plate, Reconstruction Plate, one-third tubular plate).

Reduction of the fracture was performed by closed manipulation with traction or through a small (less than two-centimeter-long) anteromedial incision in each patient. Reduced fractures were fixed with use of a 3.5-millimeter interfragmentary screw or 4.0mm partially threaded cancellous screws or a percutaneous Kirchner’s wires in 4 patients.

Methods of fixation:

Method of fixation	No of patients
External fixator for tibia	20
Additional Limited internal fixation of tibia	4
Plate osteosynthesis of fibula	20

Post operative protocol:

Care of the pin site was begun immediately postoperatively. The patients were also advised to maintain toe-touch weight-bearing for ten to twelve weeks. The external fixator was kept in place for an average of twelve weeks (range, ten to fourteen weeks) and was removed after there was radiographic evidence of healing callus.

Bone grafting was done in 4 patients at an average of six weeks (range, four to eight weeks) after the initial treatment. Bone from the iliac crest was grafted to fill a metaphyseal defect and promote fracture-healing in ten patients. Postero-lateral approach was used for bone grafting.

On second post-operative day, gentle exercises for the ankle were begun. Partial weight-bearing started depending upon their clinical and radiographic evaluation. The time taken for partial weight bearing, time taken for full weight bearing, time for starting full weight bearing & time interval for complete union were noted. The mean interval for radiological union was 12 weeks.

Patients returned for follow-up visits at least every month for first 6 months and every 2 months thereafter. Serial radiographs were made during follow-up visits at the OP and were evaluated for the development and progression of callous formation and bone union.

Removal of external fixator was carried out at an average 15 weeks, as an out-patient procedure. Severe pin site infection was treated with appropriate antibiotics and pin site care. Pin loosening was managed with either pin revision or external fixator removal and plaster cast application.

Signs of non-progression of fracture union was anticipated as Delayed Union and managed with iliac crest bone grafting packed at fracture site through postero-lateral approach.

Wound dehiscence was managed with split skin grafting.

Secondary Procedures:

Bone grafting	4 cases
Split skin grafting	2 cases
Pin revision	3 cases

INSTRUMENTS & IMPLANTS

The following implants were used:

- Asian DCP
- Reconstruction plates
- One-third tubular plate
- 3.5 mm cortical screws
- 4.0 mm cancellous screws
- 2 mm Kirschner’s wires
- AO rod
- Universal AO Clamps
- Tube to tube clamps
- T – clamps
- 4mm / 4.5 mm Schanz pins

The following instruments were used during the surgical procedures:

- Homann’s retractor
- Reduction clamps
- Bone holding forceps
- Periosteal elevator
- 2.7 / 3.2 drill bits
- Drill machine
- 3.5 / 4.5 Screw drivers
- 10 / 11 size spanner
- T –handle.

MATERIALS AND METHODS

This is a prospective study of 20 extra-articular distal tibial fractures that were operatively treated at the Department of Orthopaedic Surgery, Government Royapettah Hospital, Kilpauk Medical College between August 2007 to December 2009.

Inclusion criteria:

- Extra-articular distal tibial fractures (Type A fractures of AO/OTA classification system) with fibular fractures, closed injuries and all grades of open injuries.
- Age above 20 years.

Exclusion criteria:

- All intra-articular fractures (Type B & C of AO/OTA classification system)
- Severe osteoporosis,
- Inadequate follow-up.
- Open physis

All of the patients were in age group of 24-64 years with mean age of 38 years. Road traffic accidents were found to be the commonest mode of trauma. Right limb was involved more often (60%) than the left.

All of the patients included in the study had sustained an extra-articular fracture of the distal tibia, which was classified with use of the system of AO/OTA classification system. Type A fractures are extraarticular distal tibial fractures, which are subdivided into groups A1, A2, and A3, based on the amount of metaphyseal comminution.

The open injuries were classified according to Gustilo-Anderson classification system. The soft tissue conditions were classified by using Tserne classification.

All the twenty patients were managed with external fixation, with or without limited internal fixation.

Of the twenty fractures, fourteen (70 per cent) were closed and six (thirty per cent) were open.

Age distribution:

Age	No. of patients
21-30	4
31-40	8
41-50	5
51-60	3
>60	Nil

Sex Distribution:

Male	12
Female	8
Total	20

Side of Injury:

Right	12
Left	8
Total	20

Type of Injury:

Closed	14
Open	6

Most are closed fractures. About six cases were found to be open injuries, which were classified according to Gustilo-Anderson Classification. The fracture pattern was assessed and classified according to AO / OTA Classification System. Extra-articular fractures, i.e Type A with all three subtypes were taken up for this study.

AO/OTA Classification System:

Type	No. of patients
A1	10
A2	6
A3	4

Gustilo-Anderson Classification:

Grade	No. of patients
I	2
II	1
III	3

Mode of Injury:

RTA	10
Fall	6
Others	4

Mode of injury was recorded; most cases found to get injured by Road Traffic Accidents (RTA). And most of the victims were in fourth decade age group.

OBSERVATION

- All cases were acute fractures due to injury by significant trauma.
- Male preponderance is noted. Ratio M:F = 6:4
- Road traffic accident is accounted for 10 of 20 cases.
- Right side is more involved than the left.
- AO/OTA classification Type A-1 is most common fracture pattern in our study.
- Closed fractures are seen in 70% cases.
- Most are closed injuries (14 cases).

American Orthopaedic Foot And Ankle Society (AOFAS) Score [34]

This scoring system classified the evaluated items into three major categories: pain, function, and alignment. In this scale, 50 points have been assigned to function, 40 points to pain, 10 points to alignment. Each category is scored independently and overall score can be calculated with high score indicating better function. These scores were obtained from direct questioning and examination.

AOFAS Score:

Item	**Maximum points**	**Measured in the case No.**
Pain	40	
Function	50	
Alignment	10	
Total	100	

Rating:

Excellent	>75
Good	50-75
Fair	< 50

CASE-I

Name	: Shantha
Age /Sex	: 45/ F
Mode of Injury	: RTA
Open / Closed injury	: Closed
AO Classification	: A-1
Associated Injuries	: Nil
Surgical details	:
• Interval between injury & surgery	: 7 days
• Distal Shanz pin locations	: 2 pins in distal tibia
• Internal fixation: K-wires / Screws	: Nil
• Fibular fixation	: Recon plate
Post-op period	: Uneventful
Complications	: Nil
Union / malunion / non union	: Union in alignment
Secondary Procedures	: Nil
• Bone grafting	
• Pin revision	
AOFAS Score	: 80
Functional outcome	: Excellent

CASE-II

Name	: Manohar
Age /Sex	: 52 / M
Mode of Injury	: RTA
Open / Closed injury	: Closed
AO Classification	: A-2
Associated Injuries	: Nil
Surgical details	:
• Interval between injury & surgery	: 10 days
• Distal Shanz pin locations	: 2 pins in distal tibia
• Internal fixation: K-wires / Screws	: Nil
• Fibular fixation	: Asian DCP
Post-op period	: Uneventful
Complications	: Nil
Union / malunion / non union	: Union in alignment
Secondary Procedures	:
• Bone grafting	: Yes
• Pin revision	
AOFAS Score	: 75
Functional outcome	: Excellent

CASE – III

Name	: Valliammal
Age /Sex	: 42 / F
Mode of Injury	: RTA
Open / Closed injury	: Grade II
AO Classification	: A-3
Associated Injuri	: Nil
Surgical details	:

- Interval between injury & surgery : 14 days
- Distal Shanz pin locations : 1 in calcaneum, 1 in distal tibia
- Internal fixation: K-wires / Screws : Nil
- Fibular fixation : 1/3 rd tubular plate

Post-op period	: Uneventful
Complications	: Nil
Union / malunion / non union	: Union in alignment
Secondary Procedures	: Nil

- Bone grafting
- Pin revision

AOFAS Score	: 70
Functional outcome	: Good

CASE – IV

Name	: Karthikeyan
Age /Sex	: 36 / M
Mode of Injury	: RTA
Open / Closed injury	: Grade I
AO Classification	: A-1
Associated Injuries	: Nil
Surgical details	
• Interval between injury & surgery	: 14 days
• Distal Shanz pin locations	: 1pins in calcaneum
• Internal fixation: K-wires / Screws	: Nil
• Fibular fixation	: 1/3 rd tubular plate
Post-op period	: Uneventful
Complications	: Nil
Union / malunion / non union	: Union in alignment
Secondary Procedures	: Nil
• Bone grafting	:
• Pin revision	
AOFAS Score	: 80
Functional outcome	: Excellent

CASE – V

Name	: Arokiyadass
Age /Sex	: 46 / M
Mode of Injury	: RTA
Open / Closed injur	: Closed
AO Classification	: A-2
Associated Injuries	: Nil
Surgical details	
Interval between injury & surgery	: 8 days
• Distal Shanz pin locations	: 1pins in calcaneum
• Internal fixation: K-wires / Screws	: K - wires
• Fibular fixation	: 1/3 rd tubular plate
Post-op period	: Uneventful
Complications	: Nil
Union / malunion / non union	: Union in alignment
Secondary Procedures	: K wires removal
• Bone grafting	
• Pin revision	
AOFAS Score	: 80
Functional outcome	: Excellent

OUTCOME

Patients returned for follow-up visits at least every three months for the first year and every six months thereafter. The duration of follow-up was ranging from 5 to 24 months. A clinical score was derived with use of a questionnaire with which the patient evaluated pain and the functional outcome. Postoperative radiographs were evaluated for the adequacy of the reduction amount of callous formation.

Follow-up

Maximum	24 months
Minimum	5 months
Average	12 months

Reduction & Union:

Total Cases	Union in anatomical alignment	Union in malalignment
20	16	4

Sixteen fractures had an anatomical reduction. The joint in-congruency was not a problem since all the fractures included were extra-articular group. Four fractures healed in varus malalignment of the tibia at ankle level. Substantial metaphyseal communition or bone loss, or both, was associated with all of these fractures. The remaining fractures healed in anatomical alignment.

Rate Of Union:

Minimum	Maximum
14 weeks	20 weeks

The fractures healed at an average of 15.5 weeks after the operation. None had bone-grafting at the time of the initial treatment of the fracture; four patients had bone-grafting, at an average of six weeks after the initial treatment.

American Orthopaedic Foot And Ankle Society (AOFAS) Score:

Rating	**Score range**	**No. of patients**
Excellent	>75	16 (80%)
Good	50-75	3 (15%)
Fair	< 50	1 (5%)

About 16 (80%) cases scored excellent results, 3 (15%) cases obtained good result. And one case scored fair result.

COMPLICATIONS

A major complication was defined as an infection that necessitated operative treatment, breakdown of the wound that necessitated a soft-tissue coverage procedure, failure of fixation, malunion (more than 10 degrees in any plane), non-union. Non-union was defined as failure of clinical and radiographic union more than six months after the injury. Serial radiographs were made during follow-up visits were evaluated for the development and progression of callous formation. Deformity appearance also monitored.

All cases shown union within 20th weeks; though 4 united in varus malalignment. None of the patients developed osteomyelitis. Three cases developed pin loosening which were managed with pin revision. Two cases, there was wound healing problems necessitating skin grafts.

Complications	**No. of patients**	**Management**
Delayed union	4 (20%)	Bone grafting
Nonunion	Nil	-
Malunion	4 (20%)	-
Wound infection	2 (10%)	Antibiotics & Skin grafting
Pin site infection	4 (20%)	Antibiotics & Pin site care
Pin loosening	3 (15%)	Pin Revision
Osteomyelitis	Nil	-

DISCUSSION

The results of open reduction and internal fixation of fractures of the distal tibial have not been excellent or good at many trauma centers. The thin, traumatized soft-tissue envelope about the ankle and the complex pathoanatomy of this fracture can lead to numerous complications. In various clinical series, the rates of wound breakdown and deep infection have been reported to be as high as 100 per cent after open reduction and internal fixation of severely comminuted fractures of the tibial plafond. In a recent retrospective study of the operative treatment of these fractures, major complications developed in twenty-one of fifty-two patients who had had open reduction[35]. Excellent results with few complications after treatment with external fixation have recently been reported [36].

Delicate handling of soft-tissues and meticulous debridement of wounds in open fractures have been advocated to minimize soft-tissue complications([37]). The timing of the operation also is an important factor; an operation that is performed in the presence of severe intradermal edema or fracture blisters may increase the risk of wound tension, leading to sloughing of the skin and tissue necrosis, with subsequent infection. Even with at least a seven-centimeter skin bridge between the medial and lateral incisions, skin slough and wound breakdown may be inevitable because of the initial soft-tissue injury. Excessive skin tension at the time of closure of the wound may also be problematic when tissue edema is present. Even after swelling of the soft tissues has subsided, there may be increased wound tension as a result of the medial skin flap being stretched over a buttress plate on the tibia.

Several investigators have returned to the principles of Scheck, who advocated reconstruction of the joint surface with limited open reduction and emphasized that little soft-tissue stripping is needed for this technique. In two reports by Bone et al.([38]), the result was good or excellent for eleven of sixteen patients who had been managed with external fixation combined with limited internal fixation; there were no infections or clinically important complications related to the wound. Recently, Bonar and Marsh[(39)] reported on twenty-one patients in whom a severe fracture of the tibial plafond had been treated with unilateral external fixation. There were no soft-tissue complications and osteomyelitis did not develop in any patient. The early functional results were promising. Those authors also demonstrated good functional results with few complications after use of an articulated fixator[(40)].

The results of our study are similar to these findings; we demonstrated a substantially lower rate of soft-tissue complications after the use of external fixation, even for severely comminuted and open fractures.

In our series, Union in anatomical alignment was noted in 16 of the 20 cases, the union rate being 80%. Malunion in varus alignment was noted in 4 cases (20%).

Four cases reduction was not satisfactory, hence they were minimally opened and fixed with screws / K-wires. In 3 cases, pin loosening were encountered; which was managed with pin revision.

Wound infection was seen in 2 cases (10%) which were managed with split skin grafting later. Pin site infection was noted in 4 cases (20%) which healed after wound care and antibiotics. No case developed osteomyelitic changes.

This is in comparison to certain international studies in which union rate and complications are from 78-100%.

In our series, the average time of union was 15.5 weeks. Three cases required bone grafting after 6-8weeks, as there were no progressive signs of callous formation. Final functional scoring measured with AOFAS score showed about 80% cases obtained Excellent results, 15% scored good result.

Because of the substantially lower rate of soft-tissue complications after the use of external fixation, we conclude that external fixation with or without limited internal fixation is an equally effective and safer method of treatment for most fractures of the metaphyseal region of the distal tibia.

CONCLUSION

- External fixation with or without limited internal fixation is an alternative option for the management of extra-articular distal tibial fractures.
- Union rate is comparable with open reduction and plate osteosynthesis.
- Wound complications are much less compared with open reduction and plate osteosynthesis.
- Instruments and implants are cheap.
- Operative procedure is simple.
- Ankle stiffness is prevented by ankle sparing external fixator, early mobilization and proper rehabilitation protocol.

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PROFORMA

Name: Age: Sex: IP No:

Address:

DOA: DOS: DOD:

Mode of Injury:

Side of Injury

Open / Closed injury:

AO Classification:

Associated Injuries:

Neurovascular complications:

Investigations:

- Plain X-ray AP & Lateral views of leg with ankle,
- CXR,ECG,
- Blood grouping, Hb, PCV,
- Blood urea, Blood sugar, S.Creatinine.

Initial Management:

- Improvement of general condition,
- wound debridement,
- plaster slab

Surgical details:

- Interval between injury & surgery
- Anaesthesia
- Duration of surgery
- Fracture reduction
- Shanz pin locations
- Internal fixation: K-wires / Screws
- Blood loss

Complications:

- Per operative
- Early post-operative
- Late-post operative

Clinical assessment during follow up period

- Wound healing
- Pin site infection
- Ankle movements

Radiographic assessment:

- Callous formation
- Union time
- Delayed union
- Non-union

Secondary Procedures:

- Bone grafting
- Pin revision
- External fixator removal
- Cast application

AOFAS Score:

Functional outcome:

- Excellent
- Good
- Fair

MASTER CHART

Sl. No.	Name	Age / Sex	Fracture Class. (AO)	Wound Class.	Bone Graft	Fibula Fx/ ORIF	Limited internal fixation	Fx union In aligmnt	Pin site infection	Delayed union	Malunion	Wound infection
1	Manohar	52/ M	A2	Closed	YES	Yes	No	Yes	Nil	Yes	No	No
2	Perumal	37/M	A3	Closed	No	Yes	No	Yes	Yes	No	No	No
3	Shantha	45/F	A1	Closed	No	Yes	No	Yes	Nil	No	No	No
4	Kannan	30/M	A1	Closed	No	Yes	No	Yes	Nil	No	No	No
5	Devagi	32/F	A2	Closed	YES	Yes	Yes	Yes	Nil	Yes	No	No
6	Abdul khader	24/M	A3	Gr III	No	Yes	No	No	Nil	No	Yes	No
7	Rajammal	57/F	A1	Closed	No	Yes	No	Yes	Yes	No	No	No
8	Valliammal	42/F	A3	Gr II	No	Yes	No	Yes	Nil	No	No	No
9	Kanniyappan	60/M	A2	Closed	No	Yes	Yes	Yes	Yes	No	No	No
10	Arumugam	47/M	A1	Closed	No	Yes	No	Yes	Nil	No	No	No
11	Rosemary	45/F	A3	Gr III	No	Yes	No	No	Nil	No	Yes	Yes
12	Chandra	40/F	A1	Closed	YES	Yes	No	Yes	Nil	Yes	No	No
13	Karthikeyan	36/M	A1	Gr I	No	Yes	No	Yes	Nil	No	No	No
14	Joseph	39/M	A2	Closed	No	Yes	Yes	No	Nil	No	Yes	No
15	Ganesh	32/M	A1	Gr III	Yes	Yes	No	Yes	Yes	Yes	No	Yes
16	Rajathi	40/F	A1	Gr I	No	Yes	No	Yes	Nil	No	No	No
17	Arokiya dass	46/M	A2	Closed	No	Yes	Yes	Yes	Nil	no	No	No
18	Chitra	28/F	A2	Closed	No	Yes	No	Yes	Nil	No	No	No
19	Elumalai	30/M	A3	Closed	No	Yes	No	No	Nil	No	Yes	No
20	Natesan	35/M	A2	Closed	No	Yes	No	Yes	Nil	No	No	No