Introduction

Surgical reconstruction of tibial non-unions with or without associated infection can be a great challenge for the orthopaedic surgeon. These non unions are usually the result of high-energy trauma accompanied by extensive soft tissue damage at the time of initial injury. Bone defects can result from these injuries primarily or secondarily from the subsequent debridement for contamination or infection, or it may result after the debridement of devascularised or contaminated bone; prone to ischemic or septic necrosis. Bone resection may also be indicated in the treatment of atrophic or infected pseudoarthrosis and in the presence of bone tumors(1).

External fixation, which is a well-accepted treatment for open fractures and damage control orthopaedics has acquired increasing importance in the treatment of bone loss in recent years. The technique proposed by Ilizarov involves the use of a circular external fixation frame with bone-gripping elements which transfix the limb(2).

The debate of treating those cases is mainly between two methods, using Ilizarov as a method of fixation: acute shortening and lengthening versus bone transport mainly for looking into indications, complications, duration of treatment, another surgical intervention and requirement of bone grafting at the resected non union site.

Acute shortening and lengthening technique implies repair of the bony defect by initial compression and thus shortening of the segment involved this is coupled or followed-by an osteotomy in a region furthest from the defect, at which subsequent lengthening is carried out[3-4-5]

Bone transport technique implies an osteotomyis performed proximal to the bone defect (ante grade transport), or distal to it (retrograde transport). Subsequently, gradual movement of the detached fragment towards the bone gap is achieved via a process which is completed when the transported segment reaches the end of the bone gap[6-7].

The main indication for the two techniques is different: bone transport is indicated for the treatment of major bone loss, whereas compression-distraction is suitable only for treating less extensive bone gaps, since compression may compromise neural and vascular structures.

Aim of the Essay

The purpose of this study is to compare between acute shortening and lengthening versus bone transport using ilizarov as external fixator in the management of atrophic tibial non union.

Chapter (1):

The anatomic location for insertion of wires and half-pins

The use of trans osseous wires for Ilizarov's method necessitates intimate awareness of anatomic topography to avoid injury to nerves and vessels.

The method used in the topographical study of the extremity and its articulations with the external ring fixation required the following systems:

- A reference system for the section level in the longitudinal section of the extremity and in strict conventional anatomical position.
- A goniometric system for the incidence angle at which the wires must be inserted into the extremity, which must also be in conventional anatomical position[8].

Reference system of level:

The reference system of level in which it had been carried out, the anatomical cuts on a standard cadaver 170 CM tall are not the same on a child, a teenager and an adult. Therefore, proportional measurement of each individual patient needs to be derived. Both in clinic and at the beginning of surgery, a reference system based on the viewing and palpating of the anatomic structures, such as osseous eminences, spines, tuberosities, condyles and articular axes as well as muscular and tendinous landmarks or cutaneous folds should be resorted.

Goniometric System:

To identify the insertion position of the half-pins into the limbs, we shall use the goniometric system, which ranges between 0° and 360°. Increases in the thickness of the adipose layer have no influence on the incidence angle of the wires and half-pins as long as the extremities remain in the anatomical position shown in the drawings.

The starting reference point 0° is assumed to be directly anterior. All the cuts are from their lower (Caudal) face on the left extremity. In this way the angles increase clockwise. The cuts on the right extremities correspond to the mirror image and are therefore opposite to clockwise (Counter clockwise) [9].

Cut 1:

The first cut crosses the medial and lateral tibial plateau just below the level of the knee joint. The tibia is palpable throughout the anterior two thirds, but not posteriorly. Other superficial landmarks include the lateral collateral ligament attaching to the fibular head, the patellar tendon and the patellar tubercle inferiorly. The tibia is approximately 80% cancellous at this level.

The fibula is also becoming predominantly cancellous in composition on the postero lateral side. The medial tibial surface provides attachment for the sartorius, gracilis and semitendinosus, making up the pes anserinus. The saphenous N. and V. run between these muscles with the inferior geniculate A., and the infra-patellar N emerges superficially.

The major neurovascular structures are posterior and slightly lateral, except for the common peroneal N. situated laterally along the posterior border of biceps femoris, and the saphenous N. and V. medially, about a hand's breadth medial to the medial border of the patella[9].

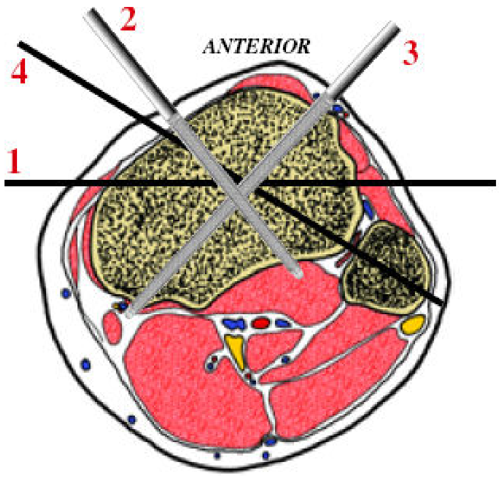

Figure (1): Cut 1 (Tibial) [9]

The diagram demonstrates the wide medial and lateral access to the tibia that is available for pin insertion. A reference wire is usually first inserted for fine wire fixation. This is inserted in the trans condylar transverse plane anterior to the fibula. Optimum fixation is then obtained using two half pins placed anteriorly. The medial one can be used to also fix the fibula head, if this is the case a drill guide and trochar should be used. Alternatively a 2-3mm smooth pin can be used to transfix the proximal tibio-fibular joint, for example in tibial lengthening. This is inserted by palpating and protecting the common peroneal N. with the thumb and holding the soft tissues posteriorly, while the knee is flexed and the pin is driven through the fibular head. The pin is directed anteriorly, medially and slightly distally toward the closest available ring.

Cut 2:

This section is taken about 7-8 cm distal to the knee joint. At this level the whole of the anteromedial border of the tibia is palpable, which provides a useful guide to the relative cross-sectional diameter of the bone. The cortical component at this level is approximately 40% of the tibial diameter. The neurovascular bundle takes a more central position in the leg here, with the anterior bundle lying in close proximity to the inter osseous membrane in the sagittal axis. Posteriorly the neurovascular bundle runs just posterior to the tibialis posterior muscle, again in the sagittal axis. The gastrocnemius has divided into its lateral and medial heads in the calf.

The half pin is inserted perpendicular to the subcutaneous border of the tibia on the medial aspect. The fine wire is inserted slightly obliquely to the transverse plane of the tibia to engage it in its widest portion(9).

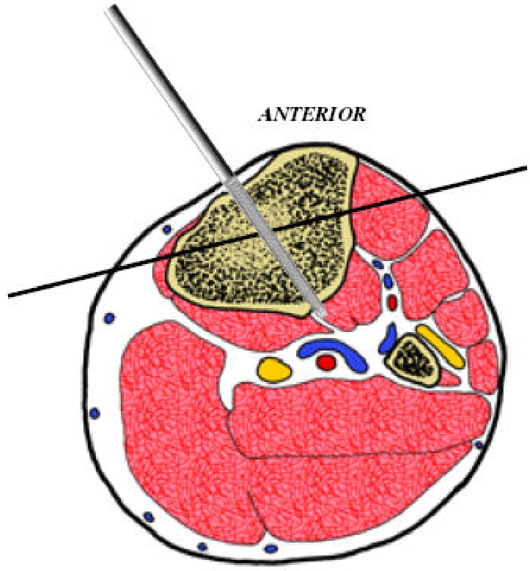

Figure (2): Cut 2 (Tibial)[9]

Cut 3:

This section is taken about 12 cm distal to the knee joint. The medial border of the tibia is still located in a subcutaneous position. The cortical component of the bone is gradually increasing. At this level the fibula is more triangular in cross section, and here has its smallest diameter. Again the neurovascular bundles are relatively central, between the tibia and fibula.

The anterior tibial A. and V. and the deep peroneal N. are centered on top of the inter osseus membrane, in the sagittal plane. Tibial fixation is with a medial-oblique wire and a half pin inserted into the medial aspect of the tibia perpendicular to the medial aspect[9].

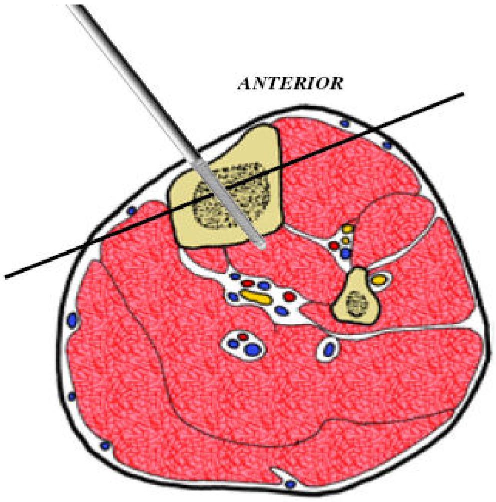

Figure (3): CUT 3 (Tibial)[8]

Cut 4:

This section is taken just inferior to the midpoint between the knee and ankle joints. The tibia maintains its dense cortex, now comprising up to 80% of the cross section, with a medial subcutaneous position. The fibular now takes on a more quadrangular cross section. The major neurovascular bundle is very close to the geometric centre of the leg. The anterior bundle is anterior to the inter osseous membrane.

The posterior tibial A. and V. with the tibial N. runs posterior and lateral to the tibia at the confluence of the soleus, tibialis posterior and flexor digitorum longus muscles. The peroneal vessels remain medial in relation to the fibula. The muscular contributions remain similar with the one significant difference being the increasing mass of gastro-soleus.

The insertion of the wire and half pin at this level is similar to that described for cut 3[9].

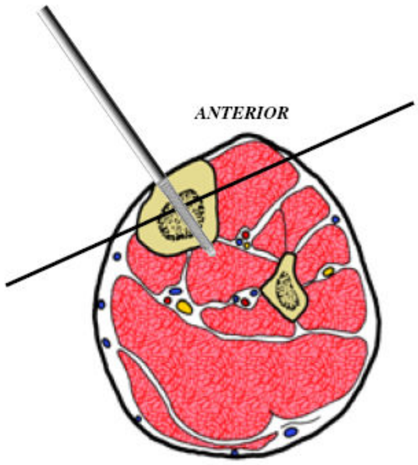

Figure (4): Cut 4 (Tibial)[9]

Cut 5:

This section is taken at about 12 cm from the ankle joint, where the tibia remains palpable along its medial surface, but is relatively anterior because of the increasing posterior musculature. The fibula is not usually palpable due to the peroneal muscle mass. Both bones at this level consist primarily of cortical bone.

The anterior tibial A. and V. with the deep peroneal N. run in a more posterior position, now lying adjacent to the interosseous membrane. The tibialis anterior and the extensor hallucis longus muscles cover these structures. The posterior tibial A. and V. with the tibial N. are located centrally between the soleus muscle and the deep posterior compartment, descending on the tibialis posterior muscle. The wire at this level is placed almost parallel to the frontal plane of the tibia. The half pin is inserted again on the medial aspect, slightly obliquely to the wire as shown in the diagram(9).

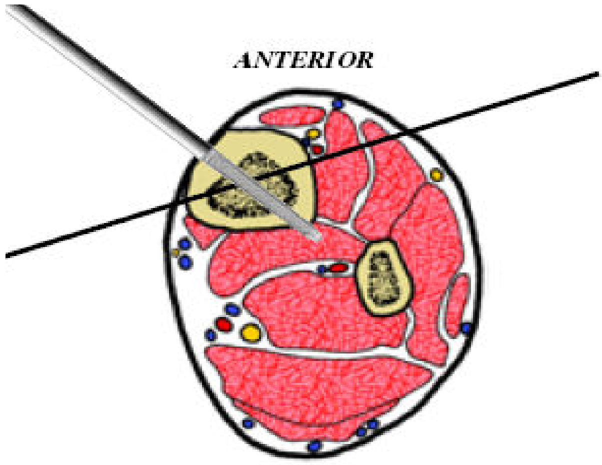

Figure (5): CUT 5 (Tibial)(9)

Cut 6:

The last section of the leg is taken just proximal to the ankle joint, 2 cm proximal to joint. At this level both malleoli are well-defined, palpable landmarks. The epiphyses of both the tibia and fibula are quadrangular in cross section at this level. The major tendons are also usually readily palpable in their subcutaneous positions.

A distal tibial reference wire is the initial fixation used, with a direct medial to lateral wire. The fibular stabilization takes place through a lateral oblique wire directed from posterolateral to anteromedial. Additional stabilization can be achieved with a wire directed form anterolateral to posteromedial, anterior to the neurovascular bundle.

Alternatively a stabilizing half pin can be inserted anteriorly, lateral to the tibialis anterior tendon. This should be done with care using a limited open technique through a small incision, which is dilated with an artery forceps. The forceps is used to displace the soft tissues and therefore protect the anterior neurovascular bundle, allowing safe pre-drilling and insertion of a 5 or 6mm half pin[9].

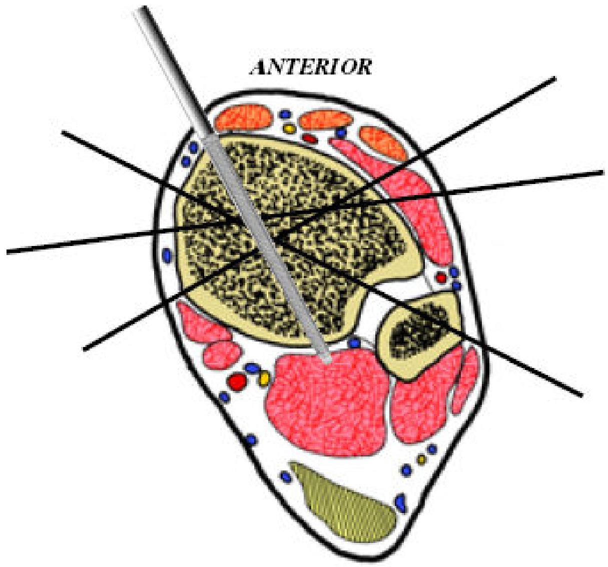

Figure (6): CUT 6 (Tibial)[9]

Chapter (2)

Causes and classification of atrophic non union of the tibia

The nonunion of the tibia is usually the result of high-energy trauma accompanied by extensive soft tissue damage at the time of initial injury. Bone defects can result from these injuries primarily or secondarily from the subsequent debridement for contamination or infection, or it may result after the debridement of devascularised or contaminated bone; prone to ischemic or septic necrosis. Bone resection may also be indicated in the treatment of atrophic or infected pseudoarthrosis and in the presence of bone tumors(10).

Nonunion is defined as the failure of a fracture to heal in twice the usual period of time (at least 6 months after trauma); the fracture gap is bridged by fibrous tissue or fibro cartilage instead of bone tissue. The main clinical signs are tenderness and presence of micromotion. Radiographic signs include: persistent fracture line, bone end sclerosis, or atrophic bone resorption(11).

Pseudoarthrosis is defined as a fracture that has failed to heal and in which a cleft is observed between the bone ends. This cavity is fluid-filled and lined by a membrane(11).

Epidemiology:

The incidence of non union is higher in open diaphyseal fractures. The reported rate of non union in lower grade open tibial shaft fractures (Gustilo types I and II) varies from 16% to 60% and in higher grade open tibial shaft fractures (Gustilo types IIIA, IIIB and IIIC) ranges from 43% to 100%(11)**.**

Non union classification:

Non unions can be classified on the basis of their biological potential.

Hypertrophic non unions are characterized by abundant bone formation and are often referred to as having the appearance of an elephant foot.

In general, they are stiff and relatively stable. The patients have excellent blood supply and biological potential, and often require only the addition of stability for the fracture to unite(12).

Atrophic non unions, on the other hand, have little biological potential. Atrophic non unions are often the result of open fractures or previous surgical procedures that have caused a disruption of the normal vascular supply to the bone. They have had a cessation of the regeneration process, resorption of the bone ends and sometimes capping off of the endosteal canal of the bone(12).

These non unions are mobile; patients usually are unable to bear weight and may require external immobilization for comfort. A special case of the atrophic nonunion is a true pseudarthrosis in which a false joint has been created between the two ends of the bone.

These fractures need biological stimulation in addition to skeletal stability. Bone grafting and other adjuvants often play a role in their treatment[(12)].

Oligotrophic nonunions are somewhere in between these two extremes. They have very little callous formation, but the bone ends are vital. They often require both biological and mechanical augmentation[(15)].

The preliminary and most important classification is obviously the classification into non infected and infected non unions, based on the presence or absence of infection[(13)].

Infected nonunion:

Infected non unions are generally classified according to the infection extent and the bone stability divided osteomyelitis into four anatomic types, based on the local extent of the infection:

- Type 1: medullary osteomyelitis
- Type 2: superficial osteomyelitis
- Type 3: localized osteomyelitis
- Type 4: diffuse infection