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Skeletal Stabilization In Open Injuries

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Abstract

Skeletal Stabilization in open injuries is as important as soft tissue cover in providing a good outcome following open injuries. Unilateral external fixator forms the workhorse of open injuries of the lower limb. In fractured ends with good bone circumference, good reduction and fixation leads to primary union. Primary internal fixation was considered unacceptable even about two decades ago in open injuries. However, nowadays following refinement in techniques of debridement, the pendulum has now swung towards early internal fixation whenever indicated. Definitive internal fixation before soft tissue cover has also shown to give good results.Modern multiplanar and circular fixators are used if there is significant contamination, bone loss and multilevel fractures of the tibia.

Keywords: Skeletal stabilization, external fixator, debridement, primary internal fixation

Principal Recommendations:

· Spanning external fixation is advocated when definitive stabilization and immediate wound cover is not performed at the time of primary debridement

· Fracture patterns and amount of bone loss determine the most appropriate form of definitive skeletal stabilization

· Exchange from spanning external fixation to internal fixation is done as early as possible

· Internal fixation is safe if there is minimal contamination and soft tissue coverage is achieved at the same time as insertion of the implant

· Modern multiplanar and circular fixators are used in selective cases of bone loss and multilevel fractures of the tibia

· Reamed nailing is preferred over unreamed nails

General Principles:

It is good practice to discard the instruments and table that are utilized during debridement and use a separate set of fresh instruments for skeletal stabilization so that contamination is avoided. In cases of severe organic contamination, it is also advisable to redrape the limb and for the surgical team to rescrub before reconstruction is undertaken. Stable skeletal stabilization must be achieved as it helps to alleviate pain and prevent further soft tissue injury. During skeletal stabilization, the length of the limb must be restored as this restores the correct tension to the soft tissues and this improves circulation, decreases swelling and aids venous and lymphatic return. It also increases the comfort of the patient during wound inspection and facilitates movement of joints and early rehabilitation. Skeletal stabilization should be undertaken quickly especially in the setting of vascular deficit and it must be designed to allow future soft tissue reconstruction. A variety of stabilization methods are available and the choice depends on the morphology of the fracture and the planned reconstructive procedures. In high-energy injuries associated with contamination, our preference is to use a temporary external fixator device followed by secondary internal fixation at a later operation. In situations where there is a good soft tissue envelope as in upper limb and femoral fractures or in situations where soft tissue cover could be achieved within 48 to 72 hours primary internal fixation can be considered. The choice of plate or nailing depends on the location of injury. As a general rule, we have found that plate fixation is preferable for all open upper limb injuries and periarticular injuries with or without articular surface involvement. Lower limb diaphyseal fractures are usually treated by intramedullary nailing either as a primary or secondary procedure. However there are many exceptions to these rules and individual decisions need to be done on a patient to patient basis.

Role of External Fixation:

External fixation, especially half pin unilateral frames, is the workhorse for skeletal stabilization in open fractures as it provides a swift versatile method of providing stability without

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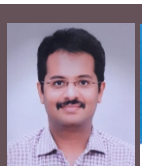
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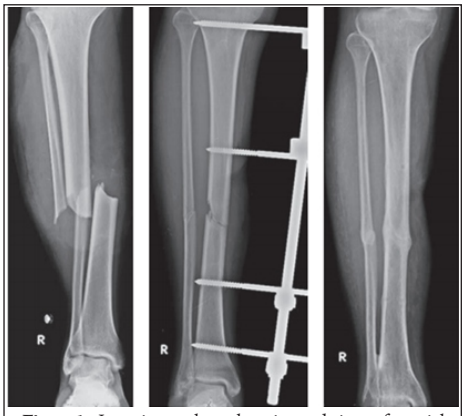

Figure 1: In patients where there is good circumferential bone contact, with a stable reduction, external fixation can be maintained until bone union is achieved.

the need for additional exposure or periosteal striping even in demanding situations [1-3].Ilizarov ring fixators and other ring fixators are used mainly in juxta-articular fractures with soft tissue injury and in fractures with bone loss. External fixators are mainly used as temporary stabilizers with conversion to internal fixation being undertaken at an appropriate time. They can be used as a definitive treatment when a stable fracture configuration with good reduction and circumferential contact is achieved [Fig 1].A meta-analysis of the treatment of open tibialdiaphyseal fractures by Giannoudis et al [1] reported a union rate of 94% at a mean of 37 weeks and an overall infection rate of 16.2%. Chronic osteomyelitis developed only in 4.2% of fractures. External fixators also have a high rate of complications, the most common being pin loosening, infection, and malunion. Pin tract infection occurs in up to 32% of patients. This can lead to chronic osteomyelitis and make future conversion to IM nailing difficult and hence utmost care should be exercised in the placement of the pins and during follow-up [2,3].

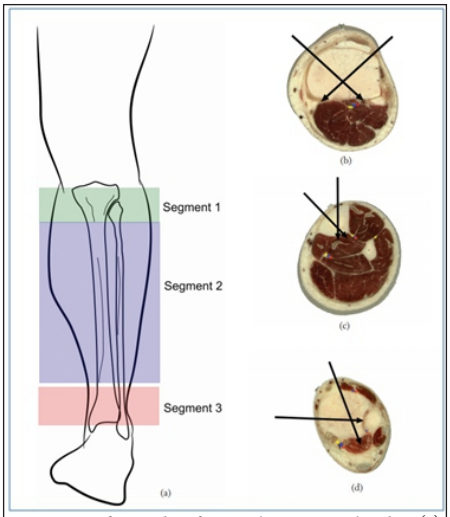

Figure 2: Safe corridors for pin placement in the tibia. (a) The tibia can be conveniently divided into three segments in which the safe corridors are relatively constant. (b) In segment one, the posterior tibial neurovascular bundle lies close to the midline and directly behind the posterior cortex. Obliquely-directed screws avoid accidental injury. (c) In segment two, a 'buffer' of the deep posterior compartment muscles lies between the posterior cortex of the tibia and the posterior tibial neurovascular bundle. Although anteromedial placement is popular, anteroposterior screws are safe as long as care is taken to avoid over-penetration. These sagittal plane screws are useful as they give good access for plastic surgical procedures on either side of the sagittal plane of the limb. (d) In segment three, the anteroposterior screw is inserted through a small incision and the plane between the lateral edge of the tibialis anterior and extensor hallucislongus is found. An anteromedial screw is also useful but attention needs to be paid to avoid tethering the medial skin in the event a distally-based fasciocutaneous flap is needed for fracture cover. (BAPRAS Guidelines 2009)

The following points need emphasis with regards to external fixator application in open injuries [2-6]. Following an 'Orthoplastic' approach has shown to give good results.

- Whenever external fixation has to be maintained for a long period, pre-drilling should be done to minimize thermal necrosis as this may lead to pin loosening and infection.
- The pins must be judiciously placed to allow further soft tissue reconstruction. The availability of a plastic surgeon at the time of debridement is valuable to plan the soft tissue reconstruction and place the pins suitably.
- Pins should be placed through intact soft tissues rather than through the open wound.
- In the presence of degloving, further debridement may lead to further secondary loss of skin and the need to change pin sites.
- External fixators must be applied with good reduction of the fracture. When the fracture is distant from the open wound small pin incisions may be made in consultation with the plastic surgeons.

Figure 3: Pre-operative and Post-operative clinical images and radiographs of a comminuted type IIIb fracture that has been treated with a locking nail and a rotational flap.

- Whenever conversion to internal fixation is planned in advance, care must be taken to avoid placing the pins in the line of future surgical incisions.
- In fractures with articular surface involvement, especially in fractures around the knee and elbow, joint congruity must be achieved on day 1 with appropriate internal fixation as late reconstruction of the joint surface is often not possible [5]
- Pins must be placed with a thorough knowledge of the regional anatomy so that injuries to the neurovascular structures are avoided.
- Pins should avoid joints and the capsular reflections of joints as any infection will lead to septic arthritis.For example, proximal tibial pins should be placed 14 mm distal to the articular surface to avoid intra-articular placement [6]
- Muscle and tendon impalement must be avoided as entrapped musculotendinous units restrict movementand cause pain and discomfort.
- Drill sleeves should be used and appropriate dissection of the soft tissues must be done to avoid critical soft tissue impalement. Meticulous care of pin tracts is very important to avoid infection. The pin tracts must be cleaned with hydrogen peroxide and dressed every day with chlorhexidine solution or povidone iodine. Even a few days of neglect may result in a deep pin tract infection which will complicate the management of the fracture

Figure 4: Plate fixation is the preferred form of skeletal stabilization in metaphyseal and articular fractures of both the femur and tibia. Serial clinical images and radiographs of a type IIIb open fracture of the proximal tibia which was stabilized with a plate. A medial gastrocnemius flap was used for soft tissue cover.

and delay the process of reconstruction. Conversion to internal fixation, when needed, must be performed early provided there are no contraindications. In our experience definitive internal fixation either by an interlocking nail or a plate is ideally performed before the stage of definitive soft tissue cover. Once a flap is performed, conversion has to be postponed to accommodate the flap settling time which may be between 3 and 4 weeks.

The ideal points for pin placement have been well explained in the guidelines of the Recommendations from the BAPRAS (British Association of Plastic, Reconstructive & Aesthetic surgeons) [4] as shown in Fig 2. There is a high chance of colonization of bacteria through the pin tracts at this time. In a meta-analysis [7] it was demonstrated that conversion of external fixation to IM nailing in open tibial and femoral fractures within 28 days resulted in a reduced rate of infection of only 3.7% compared to 22% when performed later. In late conversions, an interval of 10 to 14 days between removal of the external fixator and internal fixation has also been advised.

Primary Internal Fixation:

Primary internal fixation was considered unacceptable even two decades ago due to the fear of increased infection and damage to the blood supply during the process of fixation [3,4,7,8]. However, with refinement of the techniques of debridement, primary bone stabilization by interlocking nails and plate fixations are being increasingly performed with good results.As a general rule, plate fixation is ideal for fractures of the upper limb. The choice between a locking nail and a plate for the lower limb bones is made depending on the fracture morphology, the instrumentation that is available and the surgeon's preference.

Plate Fixation:

Plate Fixation Internal fixation using plates has the disadvantages of needing increased soft tissue exposure and periosteal stripping but these can be largely minimized by experience and careful technique [8,9]. Plate fixation is the method of choice in most open upper limb fractures, femoral fractures involving the periarticular and articular regions[Fig 4], all intra-articular and juxta articular fractures, and in open injuries with vascular involvement. If plate fixation is performed, a critical factor to maximizing the chances of success is achieving wound cover within 3 days. Locking plates provide internal fixation with greater stability but it should be stressed there are no large series reporting the outcome or superiority of locking plates.

Intramedullary Nailing:

Intramedullary nails are often the first choice for fixation of lower limb diaphyseal fractures as they provide superior biomechanical conditions and also maintain the length and rotation of the limb [3,7]. They are ideally suited for Gustilo type I and II injuries and even in type III injuries where contamination is less [Fig 3].

To ream or not to ream?

To ream or not to ream in open injuries has been a controversial topic since many years. Giannoudis et al [10] found a union rate of 95% for unreamed nails and 97% for reamed nails in open tibial fractures proving the safety and superiority of this method of skeletal fixation even in open injuries. Analysis showed that 15.5% of patients required bone grafting and 32% required an additional procedure to achieve bone union. The overall infection rate was 6% to 7%. Kakar and Tornetta [11]reported a very low rate of infection of only 3% and there are now many studies proving the advantages of primary nail fixation in open injuries. Unreamed nails appear more biologic as they cause less devascularization, are quicker to perform and have lower incidence of fat embolism and thermal necrosis. But they have the disadvantage of an increased rate of implant failure with screw and nail breakages, fracture disruption during surgery and a higher rate of nonunion and malunion [1,3,10,11]. The general consensus nowadays is toward the use of reamed nailing, but over-reaming must be avoided to prevent thermal necrosis and infection.

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