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Open Tibial Shaft Fractures: A Review of the Literature

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Abstract

Fractures of the tibia more commonly result in an open fracture than any other long bone. Open fractures are classified by the Gustilo and Anderson classification. Such fractures are more commonly associated with neurovascular compromise and infection. All patients should be treated with appropriate antibiotics, irrigation of the wound and debridement. The techniques for the stabilisation of these fractures include immobilisation in a cast, external fixators and internal fixation with plates and screws or intramedullary (IM) nailing. The risks and benefits of each method of fixation are discussed. Wound management should involve orthopaedic and plastic surgeons.

INTRODUCTION

Due to the subcutaneous position of the tibia, fractures of the tibia more commonly result in an open fracture than any other long bone. A twisting force will result in a spiral fracture of the tibia and fibula at different levels. An angulatory force will lead to a transverse fracture of both bones at the same level. Indirect injuries are usually low energy and the open fracture occurs from within. Direct injury is usually high energy and result in open fracture from without.

EPIDEMIOLOGY

The frequency of open long bone fractures is approximately 11.5 per 100 000 persons per year (Court-Brown 1998). The majority of these fractures are open tibial diaphyseal fractures, of which about 60% are Gustilo type III. If one accepts the British Orthopaedic Association figure of about 241 000 patients for each District General Hospital in the UK and that surgeons have a 1:5 on-call rota the average orthopaedic surgeon will see five open long bone fractures annually, of which two will be of the tibial diaphysis and one will be Gustilo type IIIb in severity (Court-Brown 1998). The leading causes of open fractures of the tibial diaphysis is motor vehicle accidents followed by falls and accidents on the stairs.

CLASSIFICATION

Open fractures are classified by the Gustilo and Anderson classification. This classification system can be used to guide treatment. Wound infection in patients who have open fractures correlates directly with the extent of soft tissue damage. For type I fractures the rate of infection is 0-2%, for type II 2-7%, for type IIIA 7%, for type IIIB 10-50% and for type IIIC 25-50% (with a rate of amputation of 50% or more). The overall infection rate for type III fractures is from 10-25% (Gustilo 1990).

Type I: The wound is less than 1cm long. It is usually a moderately clean puncture wound, through which a spike of bone has pierced the skin. There is little soft tissue damage and no sign of crushing injury. The fracture is usually simple, transverse, or short oblique, with little comminution.

Type II: the laceration is more than one centimetre long, and there is no extensive soft tissue damage, flap or avulsion. There is slight or moderate crushing injury, moderate comminution of the fracture and moderate contamination.

Type III is characterised by extensive damage to soft tissue, including muscles, skin and neurovascular structures and a high degree of contamination. The fracture is often caused by high velocity trauma resulting in a great deal of comminution and instability. Type III fractures are divided into three subtypes. In type IIIA soft tissue coverage of the fractured bone is adequate despite extensive laceration, flaps or high energy trauma, regardless of the size of the wound. Type IIIB open fractures are associated with extensive injury to or loss of soft tissue, with periosteal stripping and exposure of the bone, massive contamination and severe comminution of the fracture from high velocity trauma. After debridement and irrigation is completed a segment of bone is exposed and a local flap is needed for coverage. Type IIIC includes an open fracture that is associated with an arterial injury that must be repaired, regardless of the degree of soft tissue injury.

The AO classification can also be used for tibial fractures and applied to soft tissue injuries. This is essentially descriptive, based on the pattern of the primary fracture and counting the number of fragments. Whilst useful in audit and research there is no evidence that this classification is helpful in decision making. The Oestern and Tscherne classification can also be applied to grade the soft tissue injury associated with both open and closed tibial fractures. It serves as a reminder that all tibial fractures are associated with some degree of soft tissue injury (McGrath 2003).

CLINICAL FEATURES AND INITIAL MANAGEMENT

Open fracture of the tibia and fibula present as any other fracture, with pain, swelling and deformity following trauma. Soft tissue injury of varying degree will be present over the fracture site. The patient should be approached as any other patient following trauma by the Advanced Trauma Life Support (ATLS) guidelines. Other concomitant life threatening injuries should be sought. Any further assessment of the site of the open fracture apart from the control of active bleeding should be deferred to the secondary survey (Giannoudis 2006). Once the patient is stable an assessment of the limb can be made. The wound should be carefully inspected and a photograph of the wound taken. Gross contamination should be noted and blistering, contusion, crushed areas of the skin and burns reflect the transfer of large amounts of energy to the limb (Olson 1996). The vascular and neurological status of the limb should be assessed as open fractures are more commonly associated with neuro-vascular damage. This should include examination of limb colour and warmth, an examination of the pulses distal to the injury, a measurement of the capillary refill time (normally <3 seconds) and a record of any active bleeding from the wound site (Giannoudis 2006). A detailed neurological examination should determine the sensory and motor function.

A detailed history should be taken if possible. A history of the cause of the trauma and the velocity will aid appreciation of the soft tissue damage. The environmental exposure should be recorded. For example farm yard injuries give a greater risk of contamination with soil and therefore Clostridium perfringens. AP and lateral X rays of the entire tibia and fibula as well as the knee and ankle joint should be taken.

Once the wound has been photographed a sterile dressing can be applied and need not be removed until the patient is in theatre. Some authors advocate irrigation of the heavily contaminated wound within the Accident & Emergency department (Olson 1996) but as Giannoudis (2006) points out this is normally avoided as there is a risk of inoculation of the deeper tissues. It is important to document the history and physical findings properly, and to prevent further contamination the wound should remain covered with sterile dressing until the patient is taken to the operating theatre (Gustilo 1990).

Infection is the most severe compilation of open fractures, and higher Gustilo types have been shown to have a higher incidence of this complication (Ostermann 1995). The rate of infection may be as high as 50% in grade IIIB open fractures (Gustilo 1990, Bhandari 2001). Antibiotics should therefore be started as soon as possible. Many studies have looked at the treatment of open fractures with antibiotics and the benefit of antibiotic therapy (Giannoudis 2006). The current recommendations are a second generation cephalosporin for 48 to 72 hours for type I fractures. For type II and III fractures a combination of second-generation cephalosporin with an aminoglycoside offers the best protection against most Gram positive and Gram negative bacteria. The addition of penicillin is recommended for fractures exposed to farm yard or soiled environments. Antibiotic therapy for three days is appropriate.

The patient should then be transferred to the operating theatre as soon as possible and certainly within 6 hours (Court Brown 1997). Under anaesthetic the limb is fully exposed. The skin edges are shaved and the wound and limb undergo a scrub and lavage prior to prep and draping. A tourniquet should not be used as it impedes blood flow to the already damaged tissues and makes differentiating damaged and undamaged tissue more difficult. Adequate debridement is only possible with extension of the original wound. However, as little skin as possible should be excised and the plastics team should be involved from the outset. Any dead and foreign material should be removed. Muscle viability should be assessed by observing the colour, consistency, contractility and capillary refill. Bone ends should be delivered into the wound so that non viable bone can be resected. Aggressive bone debridement has been demonstrated to lower infection rates in high-grade open fractures (Gustilo, 1990).

Tissue of questionable viability can be left for a second look in 48 hours. The wound and fracture site should be washed out with large quantities of normal saline. Swabs should be taken from the wound site to guide antibiotic therapy in the post operative period. Debridement within 6 hours is necessary to keep the rate of infection low. Repeated debridment at 48 to 72 hours is essential to establish a viable environment for soft tissue coverage. Early soft tissue reconstruction (in five to seven days) is recommended if a clean, stable wound has been achieved, and is the key to reducing the incidence of infection in type III fractures (Gustilo 1990).

STABILISATION OF OPEN FRACTURES

The treatment of open fractures requires the simultaneous management of both skeletal and soft tissue injury. Controlling the instability of the bone provides a number of benefits. . The continued damage to the surrounding tissue by displaced bone fragments is decreased, care of the soft tissue injuries is facilitated, and the patients comfort is increased (Olson 1996). Options include immobilisation in a cast, external fixators and internal fixation with plates and screws or intramedullary (IM) nailing. Immobilisation of open fractures in a cast is associated with increased prevalence of non union and delayed union (Hooper 1991). Such treatment prevents access to the wound and therefore prevents wound care in fractures with more extensive sort tissue injury (Olson 1996). Hooper (1991) compared the results of immobilisation of type I open fractures with cast and IM nailing. It was demonstrated that there was a higher prevalence of valgus and varus deformity and shortening with the former. Seventeen of the thirty three fractures managed in a cast had malunion.

External fixators offer several advantages in the management of open tibial fractures. They offer acceptable stability for the fracture (Behrens 1986), minimal operative trauma and good access to the soft tissues (Gustilo 1990). External fixators can be used for any configuration of tibial fracture and associated injury (McGrath 2003) but due to the minimal soft tissue dissection during application and good access to the soft tissues they are particularly useful in the management type III open fractures.

The use of external fixators is not without some problems. Inflammation about the pin site is not uncommon. Pin tracking infection is another complication and can be associated with thermal necrosis of the bone at the time of insertion (Mathews 1984). Pin track infection can rarely lead to osteomyelitis and the incidence of residual chronic osteomyelitis in a pin track after application of a fixator has ranged from 0-4% (Green 1984). Delayed conversion from an external fixator to an intramedullary nail has been associated with an increased prevalence of infection. Maurer (1989) looked at infection rates after IM nailing of severe open tibial fractures initially treated with external fixation. 24 patients were involved in the trial and 7 of the 24 had proved infection at one or more of the pin sites prior to conversion. 5 of these 7 patients went onto develop deep infection around the IM nail. This compared with only 1 of the 16 patients who had no clinical evidence of previous pin-tract infection. When a predictor of infection around the wound site was sought, a previous pin site infection was the factor that correlated most strongly (Maurer 1989). This study relates to treatment with IM nail following a significant period of treatment with external fixator. Good results, however, have been reported with IM nailing following a short term use of external fixator to facilitate soft tissue treatment. Blachut (1990) looked at IM nailing following a the short term use of external fixator to allow soft tissue healing gave good results without a high rate of infection and that many of the problems associated with external fixation such as pin site infection, malunion, delayed union and non union were avoided. The problems associated with such a treatment method are several operative procedures and a longer period of hospitalisation (Blachut 1990).

IM nailing without reaming has been advocated in the treatment of open tibial fractures. The prevalence of both deep infection and non-union in association with type I, II and IIIA open fractures treated with IM nailing without reaming has been lower than that associated with similar fractures treated with other fixation devices (Olson 1996). Bhandari (2001) compared treatment of open tibial fractures with unreamed nail and external fixator. It was found that there was an increased risk of re-operation, superficial infection and malunion in those treated with external fixator. The risk of deep infection was not increased in those treated with IM nail. In addition the use of IM nail rather than external fixation removes the risk of pin track infection facilitates soft tissue coverage. The management of grade IIIB open fractures with IM nailing however remains controversial. Tornetta (1994) compared type III fracture treated with un-reamed nailing and external fixation and found similar rates of deep infection in each group. However, the benefit of access to the soft tissues offered by external fixators means that these fractures are often treated with external fixators rather than IM nails.

The use of reamed nails in the management of open tibial fractures is controversial. Whilst reamed nails offer an improved stability of the fracture, their use carries an increased risk of infection and non union as a result of disruption of the endosteal blood supply (Keating 1997). A number of studies have demonstrated that there is an increased infection rate following reaming of the tibia although Keating (1997) compared infection rates and rate of non union between reamed and non reamed IM nails and found no significant difference.

Fixation with a plate has typically been reserved for the treatment of open periarticular fractures of the tibial plateau. The application of plates requires extensive dissection which devitalises soft tissue and bone and may lead to complications. The use of plates to treat open fractures of the tibial shaft is associated with a high infection risk and therefore is rarely used in the management of open tibial fractures.

The management of the wound should be carried out by a Consultant Plastic Surgeon and the management of open tibial fractures requires cooperation between consultant orthopaedic surgeon and plastic surgeon (Court Brown 1997). Operative extensions can be sutured primarily. The initial traumatic wound should be left open. Patients who have extensive soft tissue damage should return to the operating theatre 48 hours after admission for repeated debridement. When the soft tissue bed is stable and no necrotic tissue is present then coverage of the fracture can be performed. There are 3 ways to close wound in order of increasing complexity: i) skin graft, ii) local flaps, iii) microvascular free flaps. The site of the fracture, type of wound and the need for possible further orthopaedic procedure determine the closure technique (Court-Brown 1997).

In summery open fractures of the tibial shaft are limb threatening and potentially life threatening emergencies. Optimal treatment involves appropriate initial evaluation and administration of antibiotics, urgent operative debridement and skeletal stabilisation (usually by IM nailing or external fixator). Repeated soft tissue debridement may be required and soft tissue closure or flap coverage.

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