Focus On  
Tibial fractures

Epidemiology
A review of the literature suggests that tibial diaphyseal fractures are declining in incidence in the developed world. Weiss et al. have shown that the incidence of tibial diaphyseal fractures in Sweden declined from 18.7/10^5/year in 1998 to 16.1/10^5/year in 2004. They also found that 48% of fractures were caused by a fall from a standing height, compared with 21% of fractures which occurred as a result of a road traffic accident. This decline is supported by an analysis of the fracture database in Edinburgh over the last 20 years. Between 1988 and 1990, the incidence of tibial diaphyseal fractures was 26/10^5/year. This fell to 21.5/10^5/year in 2000 and in 2007/8 it was 14.3/10^5/year. In addition, an analysis of the cases of tibial diaphyseal fractures that occurred between 1988 and 1990 showed that 37.5% were the result of a road traffic accident, 30.9% followed a sports injury and 17.8% occurred as a result of a fall from a standing height. Twenty years later, in 2007/8, 27.4% of the fractures followed sports injuries, 20.5% occurred as a result of a road traffic accident and 32.8% followed a fall from a standing height. It is interesting to note that the average age of patients with tibial diaphyseal fracture rose from 37 years in 1988-1990 to 40 years in 2000 and remained at 40 years in 2007/8.

An analysis of the age and gender specific curves relating to tibial diaphyseal fractures shows that these fractures have a bimodal distribution but there is a unimodal peak in young males and a unimodal peak in older females. The epidemiological changes that have been highlighted suggest that orthopaedic surgeons are facing a somewhat different spectrum of tibial diaphyseal fracture compared with twenty years ago. It seems likely that the bimodal distribution will persist, but in developed countries there will be a more elderly population presenting with fractures although the increase in sports related fractures suggests that we will continue to see a number of low energy fractures in the younger population. Obviously, despite the decline in the incidence of tibial diaphyseal fractures caused by road traffic accidents, the complex open fractures caused by high-energy injury will continue to present a challenge to orthopaedic surgeons.

A review of the epidemiology of proximal and distal tibial fractures in Edinburgh has shown a slight increase in proximal tibial fractures from 13.3/10^5/year in 2000 to 15.6/10^5/year in 2007/8 with an increase from 7.9/10^5/year to 10.2/10^5/year in distal tibial fractures. The average age of patients presenting with proximal tibial fractures rose from 48.9 years in 2000 to 56.0 years in 2007/8 and the average age of patients with distal tibial fractures rose from 37.1 years to 44.6 years in the same period. It therefore seems that surgeons in the future are going to have to treat an increasing number of osteopenic or osteoporotic proximal and distal tibial fractures. This needs to be taken into account when considering the optimal treatment methods for the various tibial fractures that occur.

Treatment options
Until 25 years ago in many countries, tibial diaphyseal fractures were traditionally treated non-operatively. Since then surgeons have used both plates and intramedullary nails to treat these fractures, although the results of unlocked tibial nailing were not particularly good and the results of plating were very variable. External fixation methods have also been used, especially in open fractures.

In 2008 Busse et al. examined the popularity of the different methods of treatment of tibial diaphyseal fractures. They surveyed 450 Canadian Orthopaedic Trauma Surgeons and found that 87% used intramedullary nailing for closed tibial diaphyseal fractures compared with 8% who used plates and a further 2% who preferred non-operative management. In open tibial fractures 83% of surgeons used nails compared with 7% who used plates and 7% who favoured external fixation. In closed tibial fractures there was a slight preference (54%) for unreamed nailing, compared with reamed nailing, whereas in open fractures, 71% of the surgeons who used intramedullary nailing, favoured unreamed nailing. Since many of the surgeons who took part in this survey would have trained in a time when non-operative management of closed tibial fractures was the accepted method of treatment for most fractures, the results of this survey indicate that intramedullary nailing has taken over quickly from non-operative management as the preferred treatment method.

Intramedullary Nailing. The introduction of locked intramedullary nailing of the tibial diaphysis revolutionised the treatment of both closed and open tibial diaphyseal fractures. Court-Brown and Caesar summarised the available literature in 2006. They showed that in closed and Gustilo I and II open tibial fractures the union time averaged 16.6 weeks. The infection rate averaged 1.9% and the non-union rate averaged 2.9% with the malunion rate averaging 7.6%. Joint stiffness, usually of the hind foot, averaged 8.9%. In papers discussing the use of unreamed intramedullary nailing in open tibial fractures ranging from Gustilo Type I – III in severity, the average union time was 29.3 weeks with an average infection rate of 6.1%. The non-union rate averaged at 21.5% and the mal-union rate averaged 9.5%. There was an average of 38% joint stiffness although this was poorly recorded in many papers.

In the relatively few papers detailing the results of reamed intramedullary nailing in Gustilo I – III open tibial fractures, the average union time was 32.3 weeks and the average infection rate was 6.5%. The non-union rate averaged 12% and the mal-union rate averaged 5.4%. The rate of joint stiffness averaged 21.9%. It can be seen that the results of reamed and un-reamed nailing of open tibial fractures are very similar. Analysis of the use of intramedullary nailing in the treatment of
Gustilo IIIB fractures, showed little difference between reamed and unreamed nailing. However it is worth noting that the average infection rate of the six papers discussing the use of nailing in Gustilo IIIB fractures was 18.2% indicating the severity of these fractures.

There are however still a number of discussion points concerning the use of nails in tibial diaphyseal fractures. The main ones are the use of reaming to facilitate the introduction of the intramedullary nails, the use of exchange nailing in the treatment of non-union and the frequency and consequences of knee pain, which is the most common complication of nailing. Other complications are relatively few unless treating a Gustilo IIIB fracture, in which case, the prevalence of non-union and infection is much higher.

Reamed vs unreamed. Initially intramedullary tibial nails were reamed nails. They were unlocked nails and maximum stability was gained from broad contact between the nail and the endosteal surface of the tibia. This was facilitated by reaming the endosteal surface so that a large diameter nail, often measuring 14 mm or 15 mm, could be inserted. With the introduction of locked nailing, stability was radically improved but concern was expressed about the effects of reaming on the endosteal blood supply. However there was a considerable debate about the advantages and disadvantages of reaming particularly as research indicated that reaming increased the periosteal blood flow.

Rieker et al examined 26 closed tibial fractures treated with an unreamed nail. They commented on the high re-operation rate (42%). If dynamisation procedures were ignored the non-union rate was 26.9% which is extremely high for a group of closed tibial fractures. Court-Brown et al undertook the first comparative study of reamed and unreamed nailing. They purposely chose to treat Tscherne type C2 and C3 fractures as these are common fractures which are predominantly low energy injuries and not associated with significant soft-tissue damage.

They theorised that if reaming had a beneficial effect it was likely to be nullified by the effects of soft-tissue damage in severe open fractures where the prognosis was going to be determined by factors other than reaming-induced enhanced periosteal circulation or a possible minor bone grafting effect. Their studies showed a significantly prolonged union time in fractures treated by reamed intramedullary nailing. This occurred because 20% of the unreamed group failed to unite and required exchange nailing. Other studies found similar results in closed fractures but studies of open fractures showed no difference between reamed and unreamed nailing.

The biggest study of the effects of reaming was undertaken by the SPRINT group in the USA, Canada and the Netherlands. They analysed 1226 patients who were randomised to reamed or unreamed nailing of their tibial diaphyseal fractures. In the closed tibial fractures, 11% of the reamed group and 17% of the unreamed group experienced a ‘primary event’, which was a significant complication. The main difference between the two procedures related to a statistically significant increase in the number of bent or broken cross screws in the unreamed group.

There was no difference in the use of exchange nailing to treat non-union. In the open fracture group there was no difference between reamed and unreamed nails. The authors stated that their results supported the use of reamed nailing for closed fractures and they felt that their results suggested that surgeons should wait longer than six months before undertaking exchange nailing for nonunion of a tibial diaphyseal fracture.

Knee pain remains the most common complication of intramedullary tibial nailing. It has been reported in up to 69% of patients although in a study of the severity of knee pain Court-Brown et al found that 82.3% of patients either had no or mild pain. There is little evidence that the type of incision causes a rise in the prevalence of knee pain and, in particular, it would seem that a transpatellar approach gives the same incidence of pain as a paratendinous approach. Väistö et al followed a cohort of patients for eight years after tibial nailing. They found that anterior knee pain resolved with time in many patients.

Other complications of intramedullary nailing include neurological damage, damage to the common peroneal nerve at the fibular neck from oblique cross screw insertion and sural nerve damage related to the insertion of distal cross screws. Surgeons should be aware of the potential complication of thermal necrosis caused by applying excessive force during reaming. This is a rare complication and the only estimate of its prevalence in the literature is 0.2%. It is minimised by the use of sharp reamers and careful reaming technique.

Plating

In 1976 Ruedi, Webb and Allgower published excellent results of conventional dynamic compression plating of both closed and open tibial fractures with minimal complications in closed fractures and only 5.3% non-union and 11.6% infection in open fractures. Other surgeons have not achieved these results with non-union rates of 38.5% and 54% being reported. Court-Brown et al and Hansen reported 19% infection in Gustilo I-IIIB open tibial fractures.

In recent years there has been a renaissance in interest in the use of plating for the treatment of tibial diaphyseal fractures. The interest in this technique has followed the introduction of locking plates and new minimally invasive operative techniques. Williams and Schenk treated 20 tibial fractures with a bridging locking compression plate applied using a minimally invasive technique. A total of 16 of the fractures were diaphyseal. They reported that 20% of the fractures had an uncomplicated union but they had two superficial infections, one delayed union and one re-operation, and that 40% of their patients had ‘plate sensitivity’ and 25% of patients had the plate removed with resolution of the symptoms. These figures are not dissimilar to those associated with nailing-induced knee pain.

It is more likely that plating will become an important technique in the management of proximal and distal tibial fractures. Few surgeons use nailing for intra-articular, proximal and distal tibial fractures but there is debate as to the best method of management of the extra-articular AO Groups A2 and A3 proximal tibial fractures and the AO Type A distal tibial fracture. AO Groups A2 and A3 proximal tibial fractures are essentially fragility fractures. The Edinburgh 2007/8 database showed that patients who present with these fractures had an average age of 64.7 years. Distal tibial fractures have a reputation for being high energy fractures occurring in young people but a review of the AO Type A distal tibial fractures in the Edinburgh database showed that the average age of the patients who present with...
these fractures is 57 years and, like proximal tibial fractures, many of the patients will be osteopenic or osteoporotic.

**External fixation.** External fixation can be used as a form of primary fixation in diaphyseal tibial fractures but its main use is in complex limb fractures such as open fractures, diaphyseal fractures extending into the metaphysis or joint, delayed or non-unions, and infected cases. Many groups have shown good results with this technique.29,31

There are numerous frame constructs described in the literature.34 The main goal, like any fracture fixation is to achieve stability that allows the fracture to heal in the correct alignment. Application of the frame should take into account the zone of injury and the requirement for soft-tissue management. The frames are relatively easy to apply, allow early mobilisation, good stability and access to the soft tissues. Despite these various options, external fixation is associated with high rates of metal-ware complications and pin site problems. There is an increased rate of nonunion and malunion compared with intramedullary nailing. These complications can be minimised with accurate reduction in the operating room, meticulous pin site care and fracture fixation of at least six weeks. The frames can be dynamised by releasing struts whilst still retaining stability in other plains of motion.

Tornetta et al36 showed that in Gustilo and Anderson grade IIIb open tibial fractures there was no difference in healing or complications but that patients preferred nailing. In a prospective randomised study Santoro et al37 directly compared stabilisation with an external fixator with non reamed locked intramedullary nailing. They found a higher union rate, shorter time to union and fewer malunions in the nailing group.

Many authors have cited the interruption of blood supply,37-39 on introduction of an intramedullary nail, compared with the technique of external fixation but Rhinelander40 found that intramedullary nails interrupted the blood supply only temporarily and only when there was direct contact with the cortex.

**Nonunion.** One of the main advantages of intramedullary nailing over plating of tibial diaphyseal fractures is the usefulness of exchange nailing in the treatment of aseptic non-union.12 This is a relatively unusual complication of closed fractures but, as has already been discussed, it is more common in open fractures.2,21 The operation consists of removing the intramedullary nail and then reaming the endosteal surface of the tibia by a further 1 mm to 2 mm following which a broader intramedullary nail is inserted. Initial evaluation of this technique showed excellent results in the treatment of aseptic tibial nonunion16 but it is not an appropriate technique if there is bone loss of more than 2 cm and 50% of the bone diameter or if there is active infection. In an analysis of 843 closed tibial fractures, Petrisor et al19 drew attention to the fact that with a regime of primary intramedullary tibial nailing followed by exchange nailing of septic nonunions only six patients required bone grafting to achieve union. If an aseptic non-union develops after plating, bone grafting is invariably required although conversion to a reamed nail may well be successful.

**Distal and proximal tibial fractures.** Distal tibial fractures may be difficult to nail. Not only may there be an undisplaced or minimally displaced intra-articular fracture which may displace during the nailing procedure but, like proximal fractures, reduction may be difficult to achieve and maintain.

However surgeons have developed a number of techniques to try and improve the results of intramedullary nailing of proximal and distal tibial fractures. In proximal tibial fractures the main problems encountered by surgeons are malalignment of the fracture fragments with the fracture being nailed in valgus or with excessive anterior angulation.41,42 A number of methods have been suggested to minimise these complications including the use of external fixation43 or distracters to reduce the fracture prior to nailing. The use of Poller or blocking screws has also been suggested.42 Tornetta et al45 advocated the use of the semi-extended position to facilitate fracture reduction but the use of locking plates and minimally invasive techniques is another option.

Cole et al44 published the results of the use of the LISS system in the management of proximal tibial fractures. They analysed both proximal tibial fractures and proximal diaphyseal fractures and followed 77 patients until clinical union. They found that 70 (91%) of their fractures healed without major complications but they did have two early losses of fixation, two nonunions, two delayed deep infections and one deep peroneal nerve palsy. They found some mal-alignment in eight patients but it was not severe and they thought that the technique was associated with a high union rate and a low rate of infection and mal-alignment.

A tibial plate may be used but if nailing is to be undertaken, it is probably easiest to pass a fine Steinman pin into the distal tibial fragment and then manipulate the fracture into a reduced position. The pin should be placed parallel with and close to the subchondral bone. However plating may well be preferable and it is interesting to note that it is distal tibial fractures that have attracted more interest amongst surgeons than the more common proximal tibial fractures.44-46 This is probably because much of the literature is based on the management of intra-articular distal tibial fractures presenting to high volume trauma centres.50,52

In distal tibial fractures, Bedi et al47 summarised the literature regarding both intramedullary nailing and plating. They quoted five papers dealing with intramedullary nailing of distal fractures. Altogether the papers dealt with 266 fractures treated by intramedullary nailing. Ten patients were lost to follow up but of the remaining fractures 84.4% united without secondary surgery with the remaining 15.6% requiring a reconstructive procedure. In the six papers dealing with percutaneous plate fixation of distal tibial fracture there were 116 fractures of which six (5.2%) required secondary surgery to facilitate union. However 16 (13.8%) of the patients had a malunion although few were significant. The authors also pointed to the symptomatic hardware prominence and irritation that is associated with subcutaneous plating.

Vallier et al48 also compared distal tibial diaphyseal nailing with plating. They defined a distal fracture as a fracture that occurred 4 cm to 11 cm proximal to the tibial plafond. They retrospectively reviewed 113 extra-articular distal tibial fractures of which 76 were treated with an intramedullary nail and 37 were treated with a plate. They found that 4.4% of patients developed osteomyelitis after nailing compared with 2.7% after plating and that 12% of the nailed group had delayed or non-union compared with 2.7% of the plated group. There was a significant
increase in angular malalignment after nailing. They showed that 29% of patients had at least 5° of malalignment after nailing compared with 5.4% after plating. They observed that non-union was more common if fibular fixation had been undertaken. Their conclusions were that delayed union, mal-union and secondary procedures were more frequent after intramedullary nailing.

Good results have also been reported by Collinge et al. They showed that in 26 patients treated with minimally invasive plating of high energy distal tibial fracture the mean union time was 35 weeks with good alignment being restored in all but one case. However 35% of the patients required secondary surgery to achieve union. They stated that risk factors for healing problems included high grades of fracture, commination and bone loss. They reported good results two years after surgery. Good results in high energy fractures have also been reported by Krackhardt et al.

An analysis of the results of treatment of proximal and distal tibial fractures suggest that plating using modern plates and insertion techniques will give better results than intramedullary nailing. However neither technique is easy and surgeons need to be aware of the problems associated with both plating and nailing.

Conclusions
Much of the literature has dealt with the use of both nails and plates in younger patients with high energy injuries but, as has already been stated, many of the fractures involving the tibia in the future will occur in older people with osteopenic or osteoporotic bone. Therefore, it would seem that intramedullary nailing will remain a treatment of choice for diaphyseal fractures but it does seem likely that plating techniques will prove more common for proximal and tibial fractures. With modern plates, using plates has become less invasive. However it is still more invasive than intramedullary nailing and is associated with more soft-tissue stripping and potential devascularisation. The results for intramedullary nailing of tibial diaphyseal fractures are very good and it is likely that the technique will continue to be used.

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