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Closed intramedullary nailing of tibia without c-arm in a resource-deficient setup: nail-over-nail technique

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ABSTRACT

Intramedullary nailing is a standard technique for the treatment of long bone fractures. This technique requires the use of on-table image intensifier in almost every step, of which the most important are guide-wire insertion and distal locking. Therefore, a c-arm is an important tool for closed intramedullary nailing. However, if a technique can be done without the use of a c-arm, intramedullary nailing could be done in setups with deficient resources and in poor countries. Thus, we developed the “nail-over-nail” technique, which can be done without using a c-arm for distal locking of the nail.

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Introduction

The management of tibial diaphyseal fractures has always held particular interest for orthopedic surgeons. These fractures are relatively common and are often difficult to treat. Until somewhat recently, surgeons have had to rely on nonoperative management, and the incidences of nonunion, malunion, and joint stiffness were high. Thus, a paradigm shift towards intramedullary nailing has occurred. With recent advances in the design of nails, it is now possible to fix fractures of the tibia at almost every level.

The use of a c-arm starts from the very first step of making an entry point into the proximal tibia, which should be at the level of the head of the fibula and not medial to the medial tibial spine in the antero-posterior view. Afterwards, a c-arm is required to confirm the reduction of the fracture and correct guide-wire placement. After installing a nail of correct length, it is used to lock the distal holes.

However, if a technique can done without the use of a c-arm, intramedullary nailing could be done in setups with deficient resources and in poor countries. Thus, we developed such a method called the “nail-over-nail” technique. This technique is based on the clinical acumen of the surgeon. An entry-point is made after palpating

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the fibular head and feeling for the tibial spine accordingly. A guide wire is inserted by externally reducing the shaft of the tibia, and locking is done by keeping another nail of the same size externally over the skin between a jig and the bone, as shown in Figure 1.

Figure 1: Guide wire is passed by keeping the knee flexed by the edge of the table and another person keeping the fracture reduced by palpating the shin.

Technique

The use of the nail-over-nail technique requires a good clinical acumen. Before starting the surgery, an appropriate length of tibial nail is measured from the opposite leg by measuring the distance of the tibial tuberosity to the medial malleolar (TMD), which is a standard method in clinical practice. It can also be measured by a scannogram or orthogram. This gives a fair idea about the length of the nail.

All of the standard pre-operative steps are taken, and the patient is placed on an operating table. The patellar tendon is split in the midline, and the joint is breached. An awl is inserted through the tibial tuberosity after palpating the fibular head and tibial spines. After making an entry into the proximal tibia, the guide wire is inserted while keeping the limb either in a figure-of-four position or keeping the knee hyperflexed dangling over the edge of the table over a bolster (Figure 1).

The guide wire is inserted while an assistant reduces the fracture by palpating the shin. Once the fracture is reduced clinically, the guide wire is traversed through it. At this point, a question arises in regard to how to confirm whether the guide wire is inside the bone or present in the soft tissues. Because a c-arm is not used, clinical findings must be used for confirmation. The following are some methods to make sure that the guide wire has traversed into the distal fragment through the fracture.

The gritty feel of the guide passing through the intramedullary canal of the tibia is quite different from when it passes through the soft tissues. If the wire is outside the distal fragment, it could be palpated by the assistant who is holding the reduction. After passing into the distal fragment, the guide wire stops before the ankle, and a certain amount of resistance is felt, which provides a fair idea that the wire is in the distal fragment. The guide wire does not proceed further beyond the ankle. The length of the guide wire inside the canal is measured to be equal to the length of the nail measured earlier from the opposite leg (Figure 2).

Figure 2: Measuring the length of the guide wire outside gives a confirmation of the length of the nail and presence of intramedullary wire inside the distal fractured fragment.

The mobility at the fracture site in both the anteroposterior and lateral plane is reduced once the wire passes through it. We prefer to use fixed flexible reamers so that a beaded guide wire does not need to be used, which allows for the additional step of exchanging the guide wire to be omitted. This omission reduces the operating time.

After putting the guide wire through the fracture into the distal fragment, reaming is done as usual. Another innovation of this technique is the omission of a bulky and unstable tissue protector, which is normally used for protecting the patellar tendon. Instead, a 10-ml syringe is used after removing its plunger and cutting the distal end. Using the guide wire, the syringe is placed into the entry point in the proximal tibia. Thus, while reaming, the canal the syringe acts a sleeve for the reamer around the patellar tendon (Figure 3).

Figure 3: Intramedullary reaming is done over the guide wire and syringe is used as a substitute for the tissue protector

Therefore, chances of accidental injury to the tendon can be minimized.

After reaming the canal to the required length and thickness, the appropriate size of nail is introduced into the canal with the help of a jig. The standard jigs available have slots for proximal locking only. Thus, after inserting the nail up to the appropriate length, proximal holes are made using the jig. The jig remains attached, but the proximal holes are not yet locked. Using a wire holder, the length of the guide wire is marked, which is inside the canal and is then withdrawn. Now, another nail of the same size is kept abutting the skin over the medial surface of the tibia between the jig and the leg. This nail is fixed over the leg by passing two long drill bits, which are those used to drill the same holes through the proximal holes of the jig and proximal holes of the two nails. One is kept outside the canal, and the other is kept inside (Figure 4).

Figure 4: Nail is inserted and proximal holes and being drilled after keeping the leg in figure of four position

This step is the namesake for the "nail-over-nail" technique. Keeping both the proximal holes engaged with the drill bits of the same size prevents rotation of the outer nail and makes distal locking more accurate. Using the distal holes of the outer nail as markers, the distal holes in the leg are drilled, which pass through the distal holes of the inner nail (Figure 5).

Figure 5: Distal hole is being drilled using the outer nail as a guide and keeping the proximal holes occupied with the drill bits to prevent rotation of outer nail.

To confirm the distal locking, the already marked guide wire is inserted into the canal, and the difference in the length is noted. This method has been reported previously and was termed as the "tak-tak" method (7).

This method provides a foolproof way of ensuring the distal locking. Now that both the proximal and distal holes have been drilled through the bone into the nail, all of the wires and drill bits can be removed, locking can proceed, and the jig can be removed as usual. The nail is inserted without a single shot of the c-arm being required. In this way, we can reduce the exposure of the patient and doctors to harmful X-rays.

Discussion

The tibia is the most commonly fractured long bone. The goals of treatment are to obtain a healed, well-aligned fracture, pain-free weight bearing, and functional range of motion of the knee and ankle joints. The recommendations in the literature vary widely and include 4 to 10 degrees of varus-valgus malalignment, 5 to 20 degrees of anteroposterior malalignment, 5 to 20 degrees of rotatory malalignment, and 10 to 20 mm of shortening.

Trafton recommends achieving less than 5 degrees of varus-valgus angulation, less than 10 degrees of anteroposterior angulation, less than 10 degrees of rotation, and less than 15 mm of shortening. Maintaining fracture alignment is difficult in certain fracture types, and if repeated attempts at realignment have been unsuccessful, operative fixation is indicated.

Locked intramedullary nailing is currently considered the treatment of choice for most type I, type II, and type IIIA open and closed tibial shaft fractures and is especially useful for segmental and bilateral tibial fractures. Intramedullary nailing preserves the soft-tissue sleeve around the fracture site and allows early motion of the adjacent joints. The ability to lock the nails proximally and distally provides control of length, alignment, and rotation in unstable fractures and permits stabilization of fractures located below the tibial tubercle or 3 to 4 cm proximal to the ankle joint. Nailing is not recommended for patients with open physes, anatomical deformity, burns or wounds over the entry portal, and most type IIIC open fractures.

Küntscher developed V-shaped and cloverleaf nails in the 1930s. In the 1950s, Lottes developed a rigid nail that could be inserted without reaming using either an open or closed technique. Lottes reviewed tibial fractures treated with a triflanged intramedullary nail and developed a technique without image intensifiers or fracture tables, which could be used for closed nailing in %99 of fractures. Sedlin and Zitner reported healing of 63 consecutive closed and type I and type II open fractures treated with the Lottes nail. Flexible intramedullary nails also have been used successfully to treat tibial shaft fractures. In the 1970s, Grosse and Kempf and Klemm and Schellmann developed nails with interlocking screws, which expanded the indications for nailing to include more proximal, distal, and unstable fractures.

With time, the design of the tibial nail has improved. The advent of various options for locking provides a fair chance of fixing more distal and more proximal fractures. The dependence of an orthopedic surgeon on an image intensifier is well understood. As far as nailing is considered, the use of a c-arm has been well established. But in India, the ever-increasing use of vehicles has given rise to an epidemic of trauma. The availability of an orthopedic operating table is always a luxury in this context, so the practicing orthopedist has to work with the resources available. The c-arm is not always available, and if it is, it does not always function. Thus, a way to bypass this necessity is needed.

We have done 70 cases of tibia interlocking without a c-arm in the past 5 years, and we have improved with every case. The learning curve for this technique is somewhat staggering, but in trained hands, it is promising. It brings the clinician back into the scene, who relies on clinical signs and symptoms for diagnosis and treatment.

Compared with the nailing technique under radiographic guidance, less time is required for our technique, which is 20 percent shorter on average. The time required to position the limb and confirm the hardware placement under the c-arm is reduced. This decreases the tourniquet time and thus the chances of complications. The decrease in surgical time also leads to a decrease in the rate of infection.

Nevertheless, complications can also occur during this technique. For example, in one case, the nail length was not measured properly, so an oversized nail was installed, and the surgery had to be revised immediately. Thus, measuring the length of the nail accurately is very important before starting the surgery. The correct placement of the guide wire is second most important step, so utmost care is required to keep the fracture reduced during placement.

After the guide wire is passed into the distal fragment, there are several ways to confirm it: 1) The wire stops at the distal tibial platfond, so it does not go further beyond that point. 2) The mobility at the fracture site is dramatically reduced. 3) The wire is also not felt in the soft tissues around the distal fragment.. 4) While the wire is moving through the medullary canal of the distal fragment, the feeling of its passage through bone is quite different from when it is passing through soft tissues. Thus, one has to be very cautious and double check this step before starting the reaming steps.

Distal locking of the nail is again very important, and if care is not taken, the hole will be missed. Therefore, some precautions must be taken as follows: 1) The length of the guide wire inside the medullary canal must be marked first. This is the most important way to confirm the distal locking by doing the "tak-tak" method (7). In this method, the marked guide wire is introduced again after the drill bit breaches the first cortex. The change in length of the wire that can be inserted is a foolproof method to confirm the presence of the drill bit inside the distal hole.

2) The outer nail should be kept abutting the skin. 3) Long drill bits with drill sleeves should be kept occupying the proximal holes, and both the holes should be kept engaged. This reduces the sagittal motion of the outer nail and keeps it fixed to the inner nail. 4) While drilling the distal hole, the distal drill bit should be kept parallel to the proximal drill bits so that the direction remains as accurate as possible.

Proximal locking is done after distal locking, and the jig is removed. Closure is done as usual, and dressing is performed. Post-operative radiographs confirm the results. The nail-over-nail technique reduces the use of image intensifiers, so this surgery can be performed in centers where a c-arm is not available. It will also be greatly helpful when an image intensifier suddenly develops a technical issue while operating.

Many others in developing countries have tried to develop a technique that reduces the need for the c-arm. The SIGN technique is one example and uses a slot finder mounted proximally on the nail. This technique also involves a large corticotomy and may cause a problem later, such as when the implant is removed, as these large cortical gaps may cause the bone to fracture. Although this technique is said to be independent of the c-arm, it may not be %100 accurate. The nail-over-nail technique has been used to fix only the tibia thus far. We have not tried it on any other long bones such as the femur because the reduction is more difficult to maintain due to bulky soft tissue cover.

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