Intramedullary nailing of tibial fractures

Andrej Kelc, Alojz Kranjc

Abstract

Intramedullary nails are beeing increasingly used for the stabilization of the tibial fractures. With the developement of the locking mechanism their application possibilities have expanded from the diaphyseal fractures to stabilization of methaphyseal fractures and even simple joint fractures. For good stability proximal and distal locking screws have to be fastened firmly into end bone fragments. As a rule reamed intramedullary nails are used except when soft tissue injuries are associated and stabilization with nonreamed nail is performed.

Introduction

In the 1930's and the 1940's, Böhler's conservative technique was the prevailing method of tibial fracture treatment. In the USA conservative treatment by Dahne and Sarmient domained in the 1960's. Most fractures in that time occured under the influence of weak forces. After the failures at the beginning of operative treatment, the AO group (Arbeitsgemeinschaft für Osteosyntesefragen) made a revolutionary break-through with the introduction of stable osteosynthesis, constant experimental scientific work and constant improvements of the surgical strategies and techniques.

Today intramedullary nailing of tibial fractures is a widely used method. Classical Küntscher nail was only suitable in simple fractures in the middle third of tibia. Stability was only ensured with the contact between the transversally elastic nail and the non-elastic bone. The contact surface was enlarged with reaming of the medullary canal. Thicker nails were firmer and provided more stability, but required more extensive reaming, which led to higher intramedullary pressure and distractions in bone blood circulation. Therefore the method was not suitable for fractures that were associated with severe soft tissue damage.

Some groups treated tibial fractures with associated severe soft tissue injuries with intramedullary implants of small diameter (Ender nail, Lottes nail, Rush pins). The post-operative infection rate was low, but the ostesynthesis was not stable enough. Therefore tibia was additionally fixated with a cast. Further treatment was functionally impossible; treatment of soft tissue injuries was obstructed.

The introduction of locking intramedullary nails was a giant step forward. Close contact between the nail and the bone is no longer necessary for rotational stability. The contact between the intramedullary nail and the locking screws defies the axes and rotational forces. Bone fragments are influenced only by the force of elastic bending and the torsion of the intramedullary nail. Proximal and distal locking screws have to be fastened firmly into the end bone fragments to provide good stability. The possibilities of placing the locking intramedullary nail have now expanded from the diaphyseal fractures to the fixation of metaphyseal fractures, and even to some cases of simple articular fractures. The anatomic reposition of the joint and its fixation, usually with individual screws, is followed by intramedullary stabilization, performed as usually. Intramedullary nails differ from reamed to non-reamed, steel or titanium, etc.

When choosing the best available treating technique, we must examine each individual patient thoroughly, and choose a certain method with regard to the type of fracture, the surgeon's experiences and available technical accessories. The crucial factor that influences the variability of fractures and their treatment is the amount of energy that caused the injury.

When deciding on the method of treatment, we must consider:
- the condition of the surrounding soft tissues,
- the number of fragments,
- movement of fragments,
- possibility of compartment syndrome,
- associated injuries,
- duration of the reparation process,
- complications.

Fractures associated with severe soft tissue damage and open fractures are usually stabilized with an external fixator. Infections occur in 8-24%, depending on the size of the injury. Complications that can occur in final treatment are slow healing process, infections around Schantz nails, relative discomfort and potential additional infection when converting from external to internal fixation.

The new method of fixation of tibial fractures, combining the advantages of external and internal fixation, is the use of non-reamed intramedullary nail. Because the intramedullary nail is not reamed, extensive damage on the circulation followed by bone necrosis is avoided. Closed and open fractures with associated severe soft tissue damage (type A1, A2 and A3 open fractures in Gustilo-Andersson typology) can be treated in this manner without increased risk of infection.

When deciding on the fixation method, we must take into consideration the advantages and the disadvantages of a certain method, and also bear in mind the patient's condition. Non-reamed intramedullary nails are thinner than the reamed nails; therefore the fixation is less stable. When more stability is required, we have to ream. Usually the reamed nail is placed in level 1 closed and open fracture. Reaming causes damage on the bone and circulation. Surprisingly, it later accelerates the reparation process to a greater extent than the non-reamed nails.

There is no unit opinion on the treatment of level 2 open fractures. American literature recommends the use of reamed nails and does not speak of increased infection rate in this type of fixation. In Europe, most level 2 open fractures are fixated with a non-reamed nail. Experienced operative teams managed to stabilize fractures type 3B this way at the same infection rate as when an external fixator was used.

Surgical technique in IM fixation of tibia fractures

The operative technique in IM fixation with reaming slightly differs from the one that does not involve reaming. Non-reamed nails are thinner, the operation lasts less. Problems can occur in young patients with firm intramedullary cancellous bone. There, minimal reaming of the medullary canal is required, and a thin nail is placed and fastened firmly at the distal and the proximal side.

The patient's position

Position on an extension table

This position was common in the beginning of the use of this method. The patient lies on the back. The leg and the knee are bent at an angle of 90°. The support of the extension table under the knee must lean against the femur. The side support prevents the knee to slip or rotate. The foot is stabilized with a shoe or with a Steinman nail through the heel bone. Before the operation, we adjust the rotation of the leg. Pre-operative preparation takes more time; placement on the extension table is obstructed in cases of multiple fractures or in poly-traumatized patients. Long lasting extension increases the pressure in the muscles. The peroneal nerve is subject to injuries. The image intensifier cannot display the proximal metaphysic of the tibia. The advantages of such placement are the possibility of rough reposition of the bone fragments all through surgery, pre-operative adjustment of rotation. The position of the patient on an extension table is shown in Picture 1.

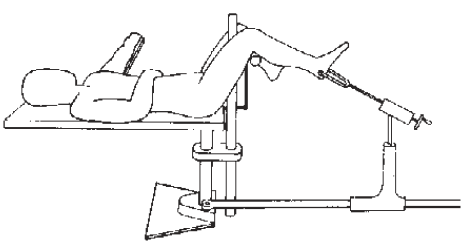
Position on a flat X-ray transparent table

The patient lies on the back. The assistant holds the knee bent at an angle of at least 90°, if necessary the tibia can be supported with a triangular pillow under the knee. Distractor or a contact (pinless) fixator can be used to help. The advantages of such placement are shorter pre-operative preparation, more flexibility in fragment reposition, possibility of simultaneous covering in associated femur fractures, good display of the whole tibia with an image intensifier, less possibility of nerve damage, clinical control of rotation of the tibia during surgery, etc. The position of the patient on a flat table is featured in Picture 2.

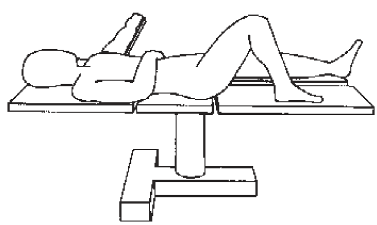
Appointing the length of the intramedullary nail

We appoint the proper length of the intramedullary nail with:

- measurement in X-ray films at a given magnifying quotient,
- X-ray films of the healthy extremity with the help of a measure,
- Measurement of the healthy extremity during the operation. We must be careful to place the measuring device rectangulary above the proximal and the distal part of the tibia.



Picture 1. *Position on an extension table.*



Picture 2. *Position on a flat table.*

Approach
In most cases, we make the incision through the middle of the patella ligament, but we can also make it at the medial side of the patella. In this case, the knee can remain in an almost stretched-out position during surgery. In non-reamed nails, the incision must be 2-3 cm long. Placement of reamed nails requires an incision in the length of 4-5 cm, so that we can move aside the surrounding soft tissues and ream the medullary canal. The entry is presented in Picture 3.

Opening the medullary canal
We make our way into the medullary canal with an awl through the tuberosity of the tibia. The entry must lie precisely in the extension of the medullary canal. If we enter it more laterally, valgus deformity can occur in proximal fractures. If we enter it more medially, varus deformity is possible. If we enter the medullary canal too dorsally in the longitudinal plane and we do not follow the course of the medullary canal, the tibia can indent forward in proximal fractures. The nail is directed backwards and can rebound a part of the bone to the dorsal side.

Reposition
When using an extension table, the position of the particles remains the same through surgery, which is good when we have to ream. On a flat table, there is more free space, which is positive when we are dealing with open fractures. But the particles in this case cannot be held in the same position throughout the whole operation. Therefore additional help of an assistant is required to bend the knee and hold it in that position while we are placing the nail and repositioning the bone. When placing full nails without a guiding wire, we use the tip of the nail to feel the distal particle. When reaming or placing hollow nails, we locate the distal particle with the guiding wire. Then we place the nail over the guiding wire. The antero-medial surface of the tibia is covered with a thin layer of delicate soft tissues. We can reposition the particles manually, with the help of a sling, with a Schantz screw in the distal particle (the so-called *joystick* method), with a special handle or a contact fixator.

Picture 3. *Entry point for the tibial intramedullary nail.*

Reaming
We ream the medullary canal to the desired extent over a guiding wire with a thickened end. Nails of wider diameter assure more stability, but excessive reaming causes the bone to die off. Therefore a compromise is necessary. Excessive reaming is no longer in use. We fixate most tibial fractures with a 9 to 10 mm intramedullary nail. We must ream the medullary canal 1 to 2 mm wider than the chosen nail. When placing non-reamed nails, we do not ream the medullary canal.

Locking the nail
To avoid excessive reaming, we place locking screws to sustain the proper length and rotation until the end of the reparation process. We lock transversal fractures dynamically (through the oval openings which allow movement or by not locking the long particle). This way particles charge when burdened. We might push aside the distal particle while placing the nails and the gap between particles increases. This can be avoided if we insert distal locking screws and then knock the nail we initially sunk a bit deeper back out so that the distal particle charges on the proximal particle. It is important that we do not allow the proximal part of the nail to stand out over the front edge of the tibia and irritate the patella ligament. We must stabilize the distal and the proximal part of the tibia with at least two locking screws, except in transversal, well charged fractures in the middle third of the tibia.

Precise evaluation of rotation
Evaluation of rotation is based on the position of the foot and the knee, the track of the fracture and the width of the cortical bone of the distal and the proximal fragment. Before surgery, we evaluate the rotation and the flexibility of the foot on the healthy extremity when the knee and the hip are bent at an angle of 90°. After fixation of the fractured extremity the flexibility of the foot and the position of the tibia must be the same on both extremities. We display the side projection of the stretched knee on the image intensifier and mark 0° on the accelerator. We display the ankle in the vertical projection and measure the angular difference. This way we can establish the correct rotation of the foot on the injured extremity.

Post-operative treatment
After the operation, we lift the tibia slightly and support it with a pillow or a Braun's brace. We must monitor the patient for possible compartment syndrome, neurological seizure or disrupted circulation. We drain the entry wound for 2 days. Physical treatment begins immediately after the operation with bed exercises. We encourage the patient to walk on crutches. We usually allow full burdening in transversal and well charged fractures. In most cases, partial burdening of 15 to 20 kg is recommended. We normally increase the burdening after 6 weeks when callus appears. The recommended amount of burdening depends on the type of fracture, the amount of callus on the X-ray films, the experienced pain during weight-bearing, the type and diameter of the nail, and on the amount of time since the operation.

Dynamization of the nail means the removal of proximal or distal locking screws (which ever are further from the point of fracture). We usually perform it on the tibia as it allows charging of fragments and accelerates the reparation process. The decision on when to perform the dynamization depends on the type of fracture and on how fast the callus is being formed.

Transversal and inclined fractures can be dynamized after only 6 weeks. Comminute fractures are usually dynamized after 4 months. In some cases not even dynamization can speed up the reparation process. Additional surgical procedures are inevitable in such cases, such as implantation of the cancellous bone or replacement of the nail. We usually remove the nail within 2 to 3 years.

Complications

Most common *intra-operative* complications are:

- problems during reposition of particles (usually because of impinged soft tissues or particles),
- improper choice of entry in proximal tibial fractures (valgus deformity or inclination forward can occur),
- additional fractures caused during the placement of the nail (improperly chosen entry, overlooked fractures; in some cases, when additional fractures occur between the locking screws and stability is questionable, we must choose a different method),
- incorrect locking when the screw does not go through the opening in the intramedullary nail,
- improper rotation of the tibia.

To avoid those complications, we must check the position of the foot immediately after surgery and correct any irregularities if necessary.

Most common *post-operative* complications are:

- deep vein thrombosis and pulmonary embolism,
- compartment syndrome,
- extensive hemathoma that needs to be to be drained,
- infection of soft tissues and bones, bacteraemia and sepsis,
- fracture of the locking screws,
- fracture of the intramedullary nail.

Controversies

Fixation of proximal and distal fractures

These cases require precision and experiences. Even small errors can result in improper length and rotation or insufficient stability of particles. It is important to:

- fasten the locking screws firmly into the distal particle,
- precisely choose the entry into the medullary canal in proximal fractures,
- direct the nail exactly into the middle of the distal particle in distal fractures.

We rarely stabilize proximal metaphyseal fractures with a nail nowadays, except in cases when soft tissues would obstruct an open surgical procedure or when transversal diaphyseal fracture is associated, which is the most appropriate to perform the nailing technique on.

Fixation of metaphyseal fractures

We insert thicker nails for fixation of metaphyseal fractures and additionally stabilize he fibula in distal fractures if necessary. We can additionally stabilize the fracture or repair varus or valgus deformities with Poller screws, fastened into the bone by the nail.

Supplying the fibula with a plate and screws

There is no unit opinion in literature on whether or not we should additionally support the fibula. Some especially recommend this method in fractures in the distal third of the fibula or when we used thinner non-reamed nails. In our hospital, this method is chosen when additional stabilization is required in distal metaphyseal fractures or when the tibio-talar (upper ankle) joint is damaged.

Reaming – yes or no?

We must take into consideration the pros and cons of reaming in each patient individually. Reaming accelerates the reparation process because of mechanical internal re-arrangement of the cancellous bone, acceleration of periost and intracortical circulation, and because of more sufficient stabilization that the thicker nail provides. The disadvantage of reaming is its impact on the bone (necrosis) and therefore higher risk of infection. That is why we usually place non-reamed nails in cases of extensive associated injuries that also call for proper surgical treatment of soft tissues at a higher risk of infection.

Fixation in polytraumatized patients

Unlike in femur fractures, there was no higher risk of fat embolism, ARDS or multi-organ failure discovered in reamed or non-reamed nailing of tibial fractures. The choice of fixation technique depends on the patient's general condition, type of fracture, surgeon's experiences and the available technical equipment.

Fixation of coinciding femur and tibia fractures on the same side

In cases of coinciding fractures of femur and tibia on the same extremity, we must first stabilize the femur with a distractor or an external fixator on a flat operative table. Then we fixate the tibia, if possible with an intramedullary nail. If the patient's general condition allows it, we then nail the femur, too, and if not, we convert to internal fixation later.

Converting from an external fixator to intramedullary nail

We can replace the external fixator within 2 to 3 weeks, usually without increased risk of infection. If more time has passed in between, we recommend waiting until the entries of Schantz screws have healed before placing the nail.

Unrepaired tibial fracture

The best way to stabilize an unrepaired tibial fracture (pseudoarthrosis) is with reamed intramedullary nail. In case of bone defect, we add cancellous bone. We cannot use this method for fixation of inflamed or infected pseudoarthrosis.

Infections

We know that a bone can heal even when infection is present, if it is sufficiently mechanically stabilized and the circulation is normal. If the patient's condition indicates no systemic signs of infection, draining and proper antibiotic treatment should suffice in case of infection. When the bone has repaired, we remove the nail and ream the medullary canal. If sepsis occurs with incontrollable bacterial infection, we must remove the nail and replace it with an external fixator.

Conclusion

Intramedullary nailing of tibial fractures is currently the most common method of treatment. Locking screws must hold the proper length of the bone, whereas their position must allow rotation. Intramedullary nails are bio-mechanically considered to be the most appropriate method of fixation. Their placement causes minimal additional damage to the surrounding soft tissues, they allow closed fracture fixation. Even fractures with severe soft tissue disruptions can be stabilized with non-reamed nails. The method causes less discomfort to the patient in comparison to external fixator.

References

1. *Krettek C, Schandelmaier P, Rudolf J, et al. Aktueller stand der operativen Technik fur die unaufgebohrte Nagelung von Tibiaschaftfrakturen mit dem UTN. Unfallchirurg 1994; 74: 575-99.*
2. *Sanders R. The Management of Fractures with Soft-Tissue Disruptions. J Bone Joint Surg 1993: 778-89.*
3. *Schatzker J, Tile M. The Rationale of Operative Fracture Care. Berlin: Springer, 1996.*
4. *Brug E, Pullen M. Kritische Gedanken zur ungebohrten Nagelung offener Tibiafrakturen. Unfallchirurg 1999: 245-7.*