Ways and sense of intramedullary fixation of fractures in children

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Abstract

Until recently long bone fractures in children have been treated only conservatively. Development of new surgical procedures has brought changes in this field, too. The French authors Prevot, Lascombes, Metaizeau and others have introduced treatment of femoral fractures using elastic stable intramedullary fixation. Following very good results after treatment of femoral fractures using special precurved titanium nails, the procedure is now used for treatment of other long bone fractures, too. This method is cheap, safe and easy to perform and nowadays represents the standard for the fixation of the femoral fractures in children. We shouldn't forget that the majority of fractures in children are treated conservatively.

Introduction

Development of new surgical procedures in the field of long bone fracture fixation in children has brought important progress, even though most fractures are still treated conservatively. But in some fractures, such as femoral, surgical treatment represents the standard method of fixation.

This method was initially founded by French authors Prevot, Lascombes, and Metaizeau, with the introduction of Elastic Stable Intramedullary fixation *(ESIF)* (1, 2). They proved in the 1980's that operative treatment of femoral shaft fractures gives results that are just as satisfying as conservative treatment, but requires a significantly shorter hospitalization period. Children rehabilitate sooner and feel less discomfort. Similar studies by other authors also confirmed these results. This success of ESIF led to the application of this method to other long bone fractures, too (3).

Biomechanical features of elastic stable intramedullary fixation

It is agreed that the type of bone reparation is determined by the extent to which particles can move after fixation. Fixation with plates and screws prevents movement therefore callus cannot form properly. The bone heals with direct bridging with ingrowth of the Havers canals. This form of bone reparation is known as primary healing. Second form of healing involves micro movement between particles and consequently the formation of periostal and endostal callus. This so-called secondary healing is the result of conservative treatment of long bone fractures or of elastic stable intramedullary fixation.

The principle of ESIF is to combine elastic and non-elastic fixation, which were long considered contradictory methods. In ESIF, certain movement is allowed in the area of the fracture. Pre-curved intramedullary wires change the rotational forces into longitudinal dynamic compression and stretching, and this movement accelerates the formation of callus and the healing

process (1). Stability is provided through the proper position of the pre-curved wires that fixate the bone in three places (picture 1). The contact between the fragments and the surrounding soft tissues (musculature) adds to this stability. Because of some biological and mechanical features titanium wires of different dimensions are more and more replacing steel wires.

Fixation of femoral fractures

The main advantage of ESIF in cases of femoral fractures is the fact that it is cheap, safe and easy to perform. The surgical wound and the blood loss during the operation are minimal. The rehabilitation process starts early, and the hospitalization period is short. Numerous studies indicate no special complications therefore ESIF can undoubtedly be considered as one of the possible methods of femoral fractures fixation (1).

Indications

Indications that speak in favour of surgical fixation are:

- femoral shaft fractures in children over 6 years old (some authors also suggest this method for younger children). Proper use of pre-curved wires allows fixation of femoral shaft fractures, sub-trochanteric and even some supracondylar fractures,
- instable fractures (secondary movement),
- cases of poly-traumatized patients and patients with many fractures,
- multi-layer fractures,
- open fractures,
- fractures that are associated with vascular or nerve damage,
- fractures in children with neurological diseases (spastic paralysis, paraplegics),
- other conditions and injuries that do not allow conservative treatment to be applied.

Picture 1. *Correct position of pre-curved wires.*

Picture 2. *Wires of various diameters.*

Surgical technique

Titanium nails of various diameters are used for fixation (picture 2). The thickest possible nail must always be chosen. Recommended approximate diameters of wires, depending on the age of the child, are:

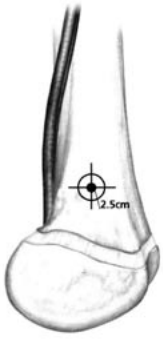
- 3.0 mm at the age of 6 to 8,
- 3.5 mm at the age of 9 to 11,
- 4.0 mm at the age of 12 to 14.

The child is laid on his back on a flat, X-ray transparent table. For bigger children, an extension table can be used. Sterile covered operative field includes the hip, goes over the knee to the tibia. The image intensifier must enable us to see the whole femur in antero-posterior and side projection. We enter the intramedullary canal up to 2 cm above the distal epiphyseal lines of the femur (picture 3).

The skin incision should be made somewhat under the estimated location of the entry to allow easier access to the instrument and easier placement of the pre-curved wires without damage to the skin. The instrumentary includes the T-handle for the insertion of the wires, a reamer with the 4.5 mm drill, pincers for the adjustment of the length of the wire, and a hammer (picture 4).

We can insert the first wire from any direction. After accessing the bone, we must check the location of the entry again, and then we ream the medullary canal with the 4.5 mm drill in oblique-upward direction. The entry at the opposite side must be at the same height. Choosing the most suitable length and diameter of the titanium wire is followed by preparation of the wires before insertion. The top 2 cm of the wire must be bent at an angle of 45° to facilitate insertion into the proximal fragment. Both wires must be curved symetrically before they are inserted, in the way that they meet above and bellow the fracture in the intramedullary canal. Then we place the wire, using the T-handle, with circular moves. At this point, the use of hammer should be avoided, because we can cause additional fractures. We then adjust the fracture with the assistant's help. We direct the top of the wire into the proximal particle and hammer it into the spongious bone. We repeat the described procedure at the other side.

The position of the wires and the fracture are then checked with an image intensifier. If necessary, we move the leg for additional reposition. If we notice any longitudinal gap between



Picture 3. *Entry on the femur.*

Picture 4. *Instruments for ESIF.*

the fragments, we press on the knee in the direction of the axis to force the particles to charge. Wires, if they turn out to be too long, must be shortened to avoid damage to the surrounding soft tissues.

Technical errors: wires of improper length, asymetrical curving, wires that cross at the point of the fracture instead of above and bellow it, interweaving of wires.

Complications

Two types of intra-operative complications have been described so far that occur because of technical errors:

- iatrogenic fracture (at the entry or in the area of the fracture)
- penetration through the cortical part of the proximal particle
- Most common post-operative complications are:
- skin irritation caused by a wire that is too long (sometimes it must be shortened later),
- axis deviation at an angle over 5°,
- problems of rotation,
- overgrowth of the injured leg (1 cm in average),
- reduced flexibility of the knee which improves completely after the removal of the wires.

Post-operative treatment

No additional immobilization is required after the operation. We should encourage the child to stand on his legs using crutches immediately after the acute pain period (2-3 days after the operation). Immediate partial weight bearing on the leg is possible, where the child determines the weight in accordance with his tolerance to pain. Physical treatment is designated to strengthen the quadriceps and to improve the flexibility of the knee. Special attention must be given to stretching. If the knee is bent too intensively, the wires can penetrate into the skin and cause pain. The child is normally hospitalized for 7 to 10 days. We usually remove the wires within 5 to 6 months after the operation.

Fixation of fractures of radius and ulna

Fractures of radius and ulna in children are usually treated conservatively, except when clear indications are present for operative treatment. This is usually the case in inefficient reposition and stability, which lead to secondary movement. Following very good results of ESIF in cases of femoral fractures, this method is now used in fractures of the forearm, too. The advantage of ESIF is the fact that it is a minimally invasive and simple method that gives good results at the same time (4, 5).

Indications and contraindications

ESIF is used in the following cases:

- in instable fractures,
- after unsuccessful conservative treatment,
- in open fractures,
- in multi-layer fractures,
- in special types of fractures (e.g. Monteggia fracture)

Repeated fractures in which the medullary canal is closed are considered as a relative contra-indication.

Surgical technique

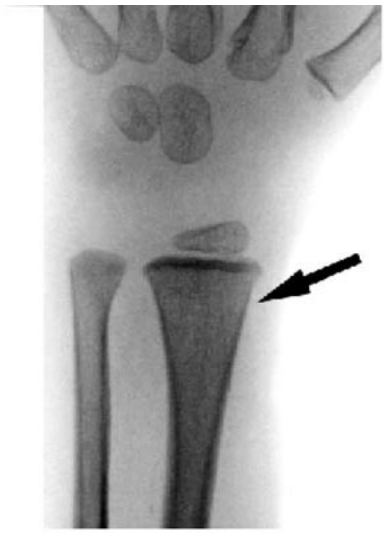
The required instrumentary is the same as in cases of femoral fractures, only the wires are thinner (2.0 – 2.5 mm). The child is laid on the back. The injured arm is preferably placed on an X-ray transparent table, uncovered. To fixate the fracture, we must place pre-curved wires into both bones of the forearm. The top 1 cm of the wire is curved at an angle of 20-30 ° to facilitate insertion. We place the first wire into the bone that we find easier to adjust, and then we place the wire and fixate the other bone. In 10% of cases, closed reposition is inefficient and we must perform open reposition. We insert the wire from the lateral side of the distal part of the radius (picture 5).

After we cut through the skin, we access the bone by shifting the surrounding tissues. We must be careful not to injure the n. radialis or extensor tendons. The easiest way to ream the medullary canal is with the 3.5 mm drill. We monitor the placement of the wire with an image intensifier. After inserting the wire, we must spin it at an angle of 180° to assure normal curving of the radius**.** We enter the medullary canal of the ulna at the medial side of the upper part, accessing it through the muscular tissue (picture 6).

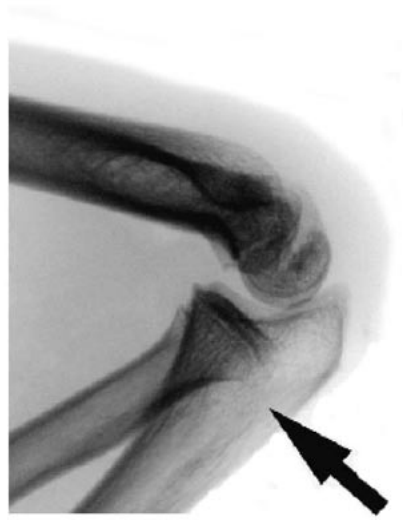
The procedure of placing the wire is the same as in the radius**.** If necessary, we shorten the wires to avoid skin irritation.

Post-operative treatment

Placing a cast is not obligatory, but we usually do apply it for 2-3 weeks to prevent pain. The child can start active movement when the pain is gone.



Picture 5. *Entry point in the radius from the lateral side of the distal part.*



Picture 6. *Entry point in the ulna at the medial side of the upper part.*

Picture 7. *Entries for nails for fixation of tibial fractures.*

Picture 8. *Entries for nails in humeral fractures.*

Complications

Literature does not state any severe complications. The most common intra-operative complication occurs in the form of unsuccessful closed reposition. Then open reposition is required. Infection occurs rarely; most common are local skin irritations because of the wires. Experts observe delayed union in cases of some fractures. In those cases, we remove the wires after a longer period of time. Additional fractures because of early removal of wires can also occur therefore it is recommended to wait 8 months before we remove the wires.

Fixation of tibial fractures

Diaphyseal fractures of tibia in children are normally treated conservatively. ESIF is used to treat fractures that cannot be repositioned properly and where dislocation occurred after reposition (3).

Surgical technique

Two wires, 2.5 to 3.5 mm in diameter, are inserted into the medullary canal through the openings at the medial and lateral side of the proximal metaphysis of the tibia (picture 7). We monitor the insertion of the wires with an image intensifier. Because of the triangular shape of the tibia in the cross section, the provided stability of the osteosynthesis is not always sufficient. Because of that, we usually put a cast on the tibia after ESIF in children for approximately 3 weeks. During that time, the bone should not be burdened. Then we remove the cast and weight-bearing can begin.

Complications

Additional movement of the tibia after ESIF occurs more often than in other long bone fractures. We can correct the position. We normally remove the wires after 5 to 6 months.

Fixation of humeral fractures

These fractures in children are also usually treated conservatively, although some injuries must be treated surgically (2, 4, 6).

Indications for surgical treatment:

- primarily instable fractures,
- secondary movement,
- open fractures,
- cominuted fractures,
- fractures that are associated with vascular and nerve injuries,
- fractures in polytraumatized patients,
- pathological fractures,
- fractures that could not be repositioned (the patient is still under local anesthesia, so we can just proceed with the operation),
- instable fractures in children older than 10 years (ESIF is a method of choice),
- supracondylar fractures.

Surgical technique

We make the incision at the lateral side of distal humerus in the area of lateral epicondyle (picture 8). We open the medullary canal with a 3.5 mm drill. 2.5 to 3.0 mm wires are used for fixation. We curve the top 1 cm of the wire at an angle of 20-30° for easier insertion of the wire into the proximal particle. We insert the wire with a T-shaped handle up to the fractured area with circular moves. Then we reposition the fracture, insert the wire into the proximal particle and push it into the spongious bone. We insert the second wire through a new hole at the lateral side. This wire must be shaped in the form of the letter S so that we can insert its end into the medial part of humeral head. When placing the wires into the proximal humerus, we must avoid breaking through the growth cartilage. The same method can be used for the fixation of the humeral surgical neck only here the wires do perforate the growth cartilage. In distal diaphyseal fractures, we place the wires from proximal to distal part of humerus. ESIF can also be used in cases of supracondylar fractures of the humerus, but this operation would require a highly experienced surgeon.

Post-operative treatment

Fractures are normally stable enough for the patient only to use a sling, but most authors still recommend temporary immobilization (2 to 3 weeks) in a Dessault band. The child begins physical treatment after 3 weeks. We remove the wires after 5 to 6 months.

Conclusion

Elastic stable intramedullary fixation (ESIF) is a cheap, safe and easy method of operative treatment of long bone fractures in children. Even though most long bone fractures in children

are still treated conservatively, ESIF already represents the standard method of fixation in some cases, particularly in femoral fractures. Clear indications and the proper surgical technique make ESIF a very successful way of treating our young patients.

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