ANALYSIS OF THE EFFECTIVENESS OF OSTEOSYNTHESIS OF THE TIBIA WITH AN ELASTIC NAIL IN DIAPHYSEAL FRACTURES IN CHILDREN

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Abstract. *The article presents the evolution of views on the problem of treating children and adolescents with diaphyseal tibial fractures and the range of modern medical techniques applicable to this group of patients. The positions of authoritative supporters of conservative therapy and medical schools professing the idea of a stable, functional connection of bones are taken into account. The main trends in injury surgery in pediatric practice were identified and an effective and safe approach to the surgical treatment of patients with unstable tibial shaft fractures based on closed intramedullary osteosynthesis with an original locking nail was substantiated.*

Keywords: *diaphyseal fracture of the leg bones, children, closed intramedullary osteosynthesis, locking nail, tibial growth zones.*

Fractures of the tibial shaft account for 15–25% in the structure of injuries of long bones in children and adolescents [1, 9, 20]. Gender dependence is known - boys are more susceptible to injuries of this localization [5]. as a manifestation of the distribution of the traumatic force along the interosseous membrane [35, 45]. Plastic deformity of the fibula is characterized by the risk of valgus or rotational displacement of fragments in some children [8, 9, 27]. Fractures of the tibia with an intact fibula are observed in 70% of cases, as a rule, as a result of the action of a traumatic force on “twisting” [19,21]. Most fractures of the bones of the lower leg in children are classified as unstable, with the presence of oblique and oblique fracture lines, while 37% of them are multi-comminuted [29, 44]. According to the pediatric version of the AO (Arbeitsgemeinschaft für Osteosynthesefragen) classification, these lesions are classified as B1-3, C1-3 [37-38].

The range of medical technologies implemented in children with diaphyseal fractures of the tibia and remaining relevant at the present stage of development of injury surgery covers the range from purely conservative to open interventions in accordance with the ideology of stable functional osteosynthesis [12, 15, 21]. It should be noted that the therapeutic paradigm has been steadily shifting towards surgical treatment over the past 25 years [18, 19, 30]. This trend is confirmed by the results of the analysis of publications in domestic and foreign information sources of the 21st century [18, 19, 30]. The advantages of surgical treatment are considered to be a reduction in the duration of hospitalization, optimal conditions for rehabilitation, and the speedy integration of children into the family and society [18, 19, 20, 21]. Opponents are traditionally based on the known anatomical and physiological features of the child, which contribute to the consolidation of bone fragments in a short time, and the high potential for remodeling of residual deformities. The opinion of authoritative authors that the leading method of treatment is conservative retains predominantly historical significance [3, 5, 7, 8, 22, 39].

In accordance with modern views, closed reposition followed by external immobilization with a plaster or plastic bandage is considered as a limited method of choice for so-called “stable” diaphyseal fractures of the tibia bones or in infants and young patients in the absence of significant displacement of bone fragments [3, 5, 7, 8, 22, 27, 30]. Relative or temporary contraindications to the implementation of other treatment technologies arise due to the presence of initially unfavorable health conditions, intercurrent diseases.

Effective and safe practice of treating patients with diaphyseal fractures of the tibia by closed reposition and external immobilization is ensured by stable skills in manual reduction of displaced bone fragments, the availability of appropriate equipment, primarily X-ray surgical equipment, good plaster technique, scrupulous observance of the dressing change program, position control and consolidation of fragments [3, 4, 7, 15].

It should be pointed out that the presented system of views on the limited value of conservative therapy is dominant, but not the only one. The well-reasoned position of Sarmiento A. (2014) is known, according to which the expansion of indications for surgical interventions in children with fractures of long bones is primarily motivated economically and is accompanied by unjustified risks of various complications.

At the present stage of development of pediatric injury surgery, purposeful studies conducted at the RSSPCTO (Republican Specialized Scientific and Practical Center of Traumatology and Orthopedics) in the Department of Pediatric Trauma on the analysis of errors and complications during osteosynthesis in children are extremely relevant [9]. Skeletal traction in diaphyseal fractures of the shin bones remains important primarily in patients with oblique and helical fracture lines, displacement of fragments along the length [28, 35, 37]. Certain advantages of this technology are realized in conditions of open fractures, when current visual control of the course of the wound process is required [3, 4, 5, 10, 11, 22, 23]. At the same time, a number of authors recommend the use of this method only from adolescence, given the possibility of negative effects of transarticular traction with large loads in the presence of uncovered growth zones [4, 5, 6]. It should be taken into account that skeletal traction is not considered by the vast majority of researchers as a treatment technology in an exhaustive manner [4, 9, 15, 16, 23, 24, 30, 31, 35, 47]. As a rule, after 2-4 weeks after the formation of the primary callus, the patient is put in a plaster cast and, after making sure that the bone fragments are in an acceptable position, is discharged from the hospital for further outpatient treatment.

Diaphyseal fractures of the tibia in the middle third, they are the third most common pathology after fractures of the forearm and hip, with a clear predominance of occurrence in boys (75%) and an average age of 8 years. An increase in the number of such fractures is observed in road injuries, as well as in sports (alpine skiing, rollerblading, skating, snowboarding). In 70% of cases, isolated tibial fractures occur. Isolated fractures of the fibula will not be discussed in this publication. It is worth adding to the statistics that oblique fractures (35%) and helical fractures (15%) in young children are the result of an indirect injury when a torque is applied. fractures of the "green twig" type are more common. In helical fractures, both bones are usually damaged. Transverse fractures (15%) are rare. they are associated with a direct mechanism of injury and, as a rule, occur with the so-called "bumper" fractures. comminuted fractures occur in 30% of cases and are usually accompanied by a significant displacement of fragments, combined with a fracture of the fibula. Unstable fractures include a fracture of both bones of the lower leg, oblique fractures, helical or comminuted fractures, fractures with a third fragment. This type of fracture with conservative treatment often ends in shortening or consolidation with rotational deformity. Most tibial fractures are treated with a bipolar ante or retrograde technique (Fig. 1). At the same time, bipolar retrograde rod insertion is used to treat fractures of the proximal third of the tibial shaft. Humerus fractures are most often treated with monopolar retrograde intramedullary elastic osteosynthesis using a lateral supracondylar approach. In case of fractures of both bones of the forearm, a combined antegrade for the ulna, retrograde for the radius intramedullary elastic osteosynthesis is performed using one rod for each bone (Fig. 2). The method that we recommend is simple enough to be used in the usual practice of a traumatologist. Of course, each surgeon is free to apply the method of treatment that is more familiar to him and allows him to achieve good results.

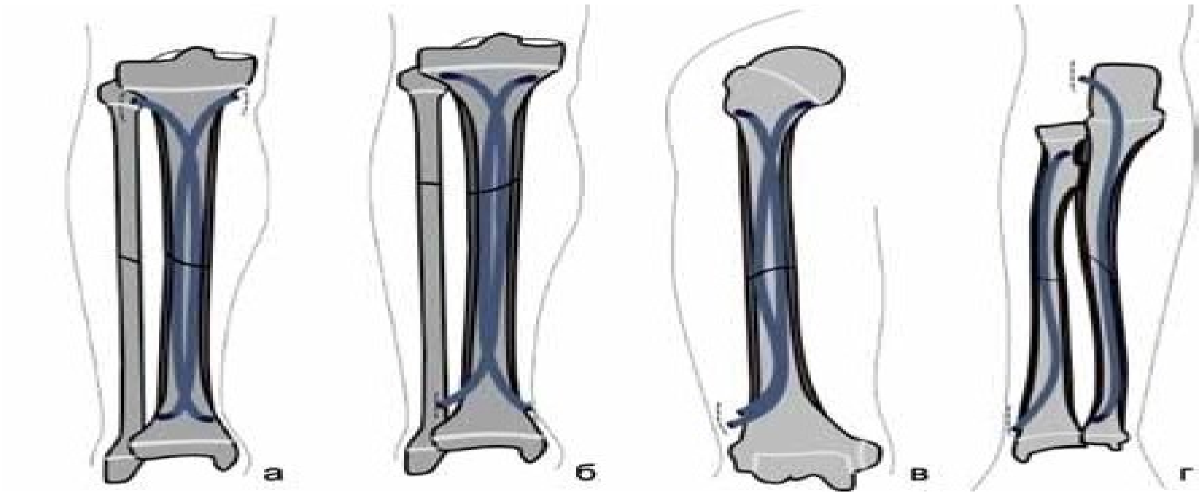


Fig. 1. Antegrade intramedullary elastic osteosynthesis of the tibia

It is preferable to use general anesthesia, since conduction anesthesia may mask the compartment syndrome in the postoperative period. The child is placed on the x-ray transparent operating table on the back, the electronic optical transducer is located at the foot end of the table. The choice of the nail diameter is determined by the basic rules of intramedullary stable elastic osteosynthesis - 40% of the diameter of the medullary canal in its narrowest part, however, we can say that the nail diameter of 2.5 mm is suitable for children from 6-8 years old; diameter 3 mm - for children from 8-11 years old; 3.5 mm - for children over 11 years old; 4.0 mm - rods of this diameter are used in adolescents during the completion of physiological growth. Two longitudinal incisions about 20 mm wide are made. on the lateral side of the proximal metaphysis, about 20-30 mm distal to the proximal growth zone, which is easily palpable at the level of the proximal tibia. These incisions should not be too far anterior to avoid damage to the growth plate at the tibial tuberosity. For the orientation of the incision, it should be said that the incision along the inner surface should be located strictly along the medial surface of the leg, the lateral incision should be located in the middle between the tibial tuberosity and the head of the fibula. on the side of the medial approach, dissection with blount scissors is performed directly to the bone. through the lateral approach, the dissection is performed in such a way that the superficial fascia is deflected posteriorly along with the anterior muscle group. Next is the sequential introduction of curved rods. Ideally, the bending vertices of the rods are at the level of the fracture. however, it is not uncommon for a small amount of displacement to remain after both rods are placed and locked in the distal fragment. In this situation, reposition is achieved by additional rotation of the rods in this position. thus, with a slight valgus, the final reposition is achieved by turning the lateral rod by 180°, so that its concave side is oriented toward the inside. An example of osteosynthesis of the tibia is shown in Figure 4. A slight antecurvation deformity can be corrected by slightly orienting both rods with the concave surface anteriorly, while maintaining the aspect of the orientation of the bends of the medial rod to the inside, the lateral - outward, which is possible when both rods are rotated by about 90 °.

Implant selection

Various types of elastic intramedullary nails are currently available. The main material for the manufacture of rods is titanium or stainless steel. The curved and flattened end of the nail is an effective way to achieve immersion and lock the intramedullary nail in the opposite diaphysis from the insertion point. Also, the curved edge facilitates the passage of the rod inside the medullary canal due to "sliding". The length of the curved edge should not exceed the width of the narrowest part of the medullary canal.

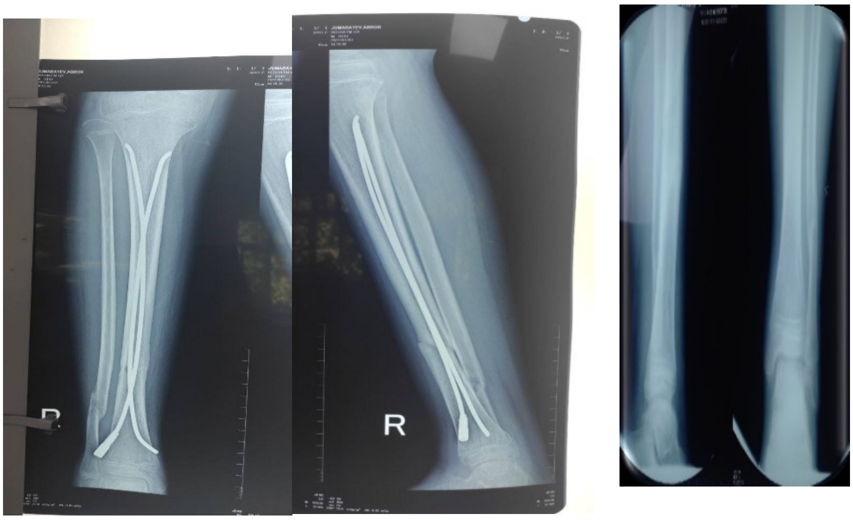
It is in the process of bending and preparing the shape of the intramedullary nail that the abilities and skills of a pediatric orthopedist are manifested. The implementation of intramedullary reinforcement implies not only achieving reposition of the fragments, but also the ability of elastic rods after installation to create elastic forces in the medullary canal that prevent secondary displacement. The true purpose of intramedullary elastic reinforcement is to create corrective forces. To achieve these goals, the apex of the bend of the intramedullary nails should be localized at the level of the fracture line. Both curved rods must intersect proximally and distally, therefore the surgeon must type the rod appropriately on his own. The bending radius should be 50–60 times greater than the diameter of the nail, and the location of the apex of the bend depends on the anatomical location of the fracture. The diameter of the nail for the lower limb should be at least 40% [19] of the diameter of the medullary canal; less than 33% of the intramedullary canal, in particular for the humerus. There are rare cases where a nail larger than 3 mm in diameter is used to fracture the humerus. For the radius and ulna, the diameter of the elastic rod can reach 50% or more of the diameter of the medullary canal. However, the diameter of the rod rarely exceeded 2.5 mm during osteosynthesis of the bones of the forearm. Intramedullary elastic reinforcement should be performed using instruments specially designed for this purpose, especially if a 3.5-4 mm rod is used. As a rule, the intervention begins with access to the area of intramedullary rods insertion. Special instruments that can be used during the operation: bending special handles that allow uniform bending throughout, the surgical awl or trocar must be slightly larger in diameter than the inserted intramedullary rods, or the surgeon can use a drill, but in this case a special soft tissue protector. The T-handle is the most convenient tool for insertion of intramedullary rods and their correct orientation in the medullary canal. The T-handle should have a section that would allow the use of a hammer to pass the rods in difficult situations. A T-handle tapping hammer is used when a correctly oriented rod passes through the level of the fracture. In addition, the hammer is used at the moment of impaction of the fracture. Guillotine-type rod cutters provide cutting of the end of the rod without burrs and without sharpening. In addition, a variety of cannulated impactors can be used that allow the nail to be immersed, leaving a free end long enough to allow the nail to be freely removed after fracture consolidation. Clamps are available in different kits to facilitate the removal of intramedullary nails. A prerequisite for clamps is a secure grip on the rod, as well as an area that can be tapped when removing the rod.

MATERIALS AND METHODS - In the period from January 2019 to November 2022, about 12 patients were taken in the departments of pediatric trauma at the Tashkent Republican Specialized Scientific and Practical Center for Trauma and Orthopedic Hospital who were treated and examined with a fracture of the tibia (9 boys and 3 girls in ages 6 to 14). In all patients, the examination included such as taking an anamnesis, studying complaints, physical examination, general laboratory examination, radiography

Examples: 1. ***Djumaboev A. 16 years old.***

Diagnosis: Fused fracture n/3 of the diaphysis of both bones of the right leg. S.P.O. with elastic nails.

Fig.2



(August 2022) ***Fig. 3***

2. Patient: ***Bazarov I. 8 years old***

Diagnosis: Fractures of the distal quarter of the tibia

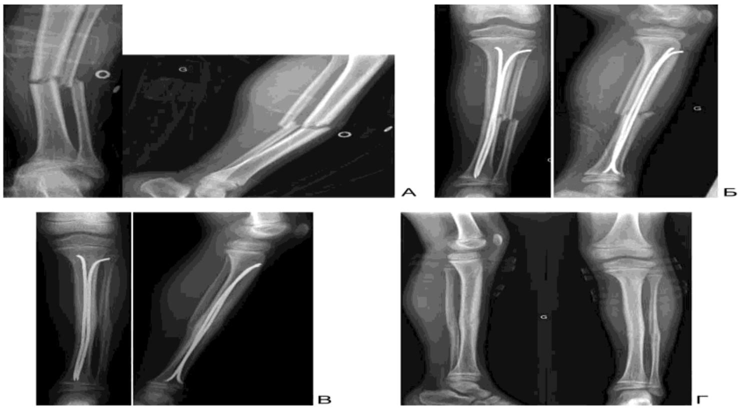


Fig. 4. Intramedullary elastic osteosynthesis for fractures of the bones of the lower leg in an 8-year-old child:
A - radiographs of the lower leg - transverse fracture of the tibia and fibula bones in the middle third, B – the next day after osteosynthesis, C – 3 months after surgery (consolidation), D – after removal of intramedullary nails.

Postoperative period*:* From the first day after the operation, the child is allowed to perform movements in the ankle joint, raise the straight leg, and perform isometric muscle contractions. on the second or third day, the child is verticalized with crutches and gait is taught without load on the operated limb. walking with a gradually increasing load is allowed 3-4 weeks after surgery and depends on the nature of the fracture: two weeks for a transverse fracture, four weeks for an oblique, helical or comminuted fracture.

Indications for intramedullary elastic reinforcement in tibial fractures: Indications are polytrauma or combined injuries [17–19], open fractures (Gustilo type 1 and 2) [20], initial unstable fractures, or secondary displacements during treatment with a plaster cast.

SUMMARY

At first glance, intramedullary elastic stable osteosynthesis seems to be a fairly easy technique for the surgical treatment of diaphyseal fractures in children, however, a certain number of surgeons are forced to perform repeated interventions to eliminate residual or secondary fragment displacement due to inadequate initial surgical technique, incorrect calculation of the parameters of the rods used. Intramedullary osteosynthesis is not only a static placement of intramedullary elastic rods in the medullary canal, this surgical method requires perfect knowledge of the biomechanics of fractures, the biomechanical aspects of the orientation of the rods relative to each other and the fracture line. The skill of the surgeon consists in assessing the required bending of the rods, the correct assessment of the diameter of the rods, the low-traumatic technique for inserting the rods and their location and orientation in the medullary canal. All this creates the conditions for creating the necessary stable fixation of fragments for the entire period of consolidation with minimal trauma to osteogenic tissues and the possibility of early function of the damaged segment, which leads to a guaranteed good result of treatment. This requires a certain creative attitude from the pediatric traumatologist, due to the anatomical and age characteristics of the patient, as well as the characteristics of the fracture.

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