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Osteosynthesis with Elastic Titanium Nail for Fractures of Long Bones of the Lower Extremities in Children

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Annotation: A diaphyseal fracture in children is a fracture that occurs in the middle (shaft) of a long tubular bone, such as the humerus, femur, forearm, or tibia. Such fractures are most often caused by falls and blows, especially from car accidents or other traumatic events, and may be accompanied by vascular and nerve damage. Treatment involves immobilization (plaster cast) for uncomplicated cases and surgery for more complex fractures, and the prognosis for bone recovery in children is usually good due to the high regenerative capacity of the child's body. Lately, in order to treat children and teenagers diaphyseal thigh fractures, the approaches that allow to shorten immobilization and the time of hospitalization and to return to customary life as soon as possible are predominantly used. In retrospective investigation, the comparison between the conservative method of diaphyseal thigh fractures therapy and closed elastic method of nails fixation was made. Between 2020 and 2025 In our clinic, 11 diaphyseal hip fractures and 16 lower legs were treated. In all cases, osteosynthesis with elastic nails was used.The conservative therapy resulted in the grater number of complications, because of the limb-length discrepancy and inaccurate reposition. In case of the closed fracture fixation with the help of flexible nails the consolidation and fast mobilization whis small number of complications was achieved.

Keywords: osteosynthesis, elastic method of nails fixation, diaphyseal thigh fractures, children.

Introduction. Fractures of the long bones of the lower extremities are a common type of injury in childhood and occupy a leading position among all musculoskeletal injuries. The incidence of these fractures has increased to 28% due to the growing popularity of extreme sports (parkour, freestyle). The role of road traffic accidents has not lost its significance in the development of high-energy fractures of the long bones of the lower extremities. The main method of treatment for these fractures has long been skeletal traction, but this approach is associated with prolonged hospital stays for patients [1,3]. Currently, many pediatric traumatologists from leading global clinics recommend minimally invasive metal osteosynthesis using elastic rods [2,4]. Stable osteosynthesis with elastic nails was first proposed in the 1980s by J.-P. Metaizeau and J. Prévot. Many researchers recommend this type of fixation for children aged 5–14 years, as it ensures shorter hospitalization and rapid functional recovery after trauma [2,4].

Materials and Methods.

At the Pediatric Traumatology Clinic of the Research Institute of Traumatology and Orthopedics, 27 children with fractures of the long bones of the lower extremities were treated from 2020 to 2025. Of these, 11 had femoral fractures and 16 had fractures of the bones of the lower leg. Among them, diaphyseal fractures of the femur occurred in 6 children, and diaphyseal fractures of the lower leg occurred in 12 children. Metadiaphyseal fractures of the femur were observed in 5 children, and those of the lower leg in 4 children. Boys accounted for 8 cases of femoral fractures and 10 cases of lower-leg fractures; girls accounted for 3 and 6 cases respectively. The age distribution was as follows: 5–7 years — 7 patients, 8–10 years — 11 patients, and 11–16 years — 7 patients. Right-sided injuries predominated, totaling 18 children. All patients underwent standard radiographic examinations. Five children with metadiaphyseal femoral fractures underwent multislice computed tomography to assess metaphyseal integrity. In all diaphyseal fractures, osteosynthesis was performed under fluoroscopic guidance. When selecting elastic rods, the standard was followed that the implant should fill 40% of

the diameter of the medullary canal. To ensure a stable-elastic configuration, the curved portions of the rods had to cross at the fracture site and be positioned opposite each other. A standard adapted set of surgical instruments was used for osteosynthesis. In mid-shaft fractures, the rods were inserted retrograde, whereas in metadiaphyseal fractures, the elastic rods were introduced antegrade.

All digital data were subjected to statistical analysis.

Results and Discussion. The indications for this type of osteosynthesis include unstable oblique or comminuted diaphyseal and metadiaphyseal fractures of the femur and bones of the lower leg, transverse diaphyseal fractures with displacement, and fractures with soft-tissue interposition. The contraindications for this method include spiral fractures with a long fracture line, double fractures, active bone infections, or infectious processes in the area where the rods are inserted. In the preoperative period, patients underwent diagnostic evaluation according to standard protocols for surgical intervention: general clinical laboratory tests, standard radiographic examinations, and multislice computed tomography. In the postoperative period, general clinical parameters were monitored dynamically. Radiographic imaging was used to verify the degree of fragment reduction, the position of the implants within the medullary canal, and the progression of bone healing.

The outcomes were assessed in all patients over a healing period of up to three years. The results were evaluated using a three-point scale.

Results	Good	Satisfactory	Unsatisfactory
Femur:	8	3	-
Lower Leg:	9	3	-

The advantage of this technique lies in its minimally invasive nature compared to existing methods; in addition, it is characterized by a low rate of purulent complications. The absence of additional immobilization and the restoration of weight-bearing capacity within 2–3 months allow the child to return to normal life earlier. Reduction of bone fragments under fluoroscopic control and the insertion of elastic nails through small incisions determine the priority of this osteosynthesis method in pediatric practice. In cases of highly comminuted fractures, pathological fractures, and in patients with polytrauma in urgent conditions, the use of a low-trauma intervention is considered reasonable. The absence of surgical aggression in the fracture zone creates favorable conditions for bone consolidation. Sufficient stability of the bone fragments eliminates the need for additional external immobilization with a cast or splints. Beginning from the first month after osteosynthesis, the child is allowed to load the injured limb, which mechanically stimulates fracture consolidation. A clinical case is presented. Patient U., 13 years old, sustained an injury as a result of a traffic accident. Diagnosis: “comminuted fracture of the lower metadiaphysis of the right femur with displacement of bone fragments” (Fig. 1a). On the third day, the patient underwent stable-elastic osteosynthesis with titanium rods (Fig. 1b). Reduction was performed under C-arm guidance, and the surgery proceeded smoothly. The duration of hospital stay was 8 days. The patient began walking one month after osteosynthesis. During follow-up, a control radiograph demonstrated complete consolidation of the bone fragments within one year, after which the rods were removed without significant technical difficulty.

difficulties. (Fig. 1c). In this case, during the repositioning of the bone fragments no additional external traction devices were used. With sufficient stable elasticity the comminuted femoral fracture consolidated well within one year. In this case we did not observe any shortening of the femur. The knee joint function is fully preserved

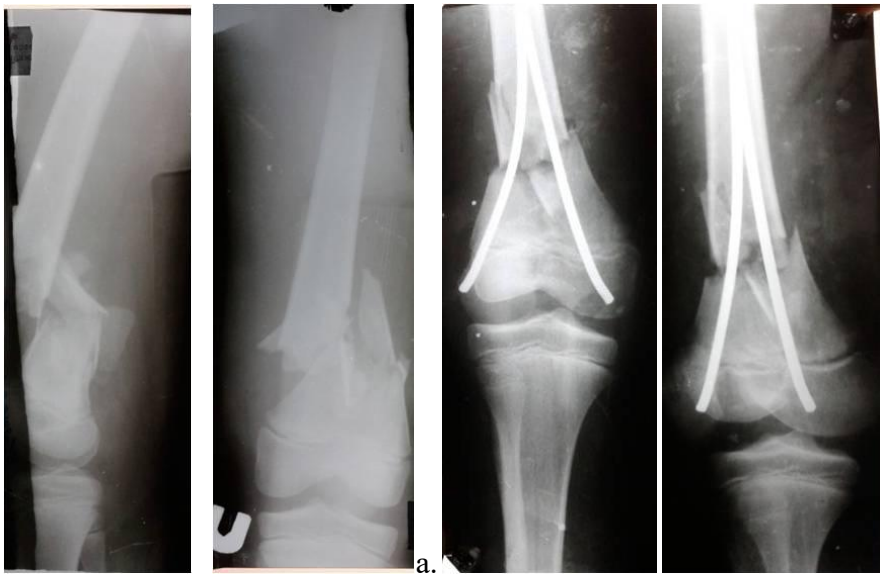
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Fig. 1. Patient A., 13 years old. Diagnosis: “Closed comminuted fracture of the distal metadiaphysis with displacement of bone fragments (a), postoperative condition after osteosynthesis (b), result after one year (c).

Like all other types of osteosynthesis, this method also has its own specific features when performing osteosynthesis of the bones of the lower extremities. In diaphyseal fractures of the femur, closed reduction of bone fragments without traction devices creates certain technical challenges when aligning the fragments due to the massive musculature of the thigh; however, insertion of the rods is performed without significant technical difficulty. In distal fractures, reduction of bone fragments is achieved without technical problems, but insertion of the rods presents certain challenges, since the metaphyseal portion of a child’s bone is very soft and requires caution during osteosynthesis. To avoid complications, a bone channel is first created in the femoral epiphysis at a 45° angle relative to the long axis of the femur. Then, a 40–45° bend is formed at the end of the nail being inserted, and the rod is guided into the medullary canal. In all cases, the bends of the rods should be positioned opposite each other and should cross near the fracture line in order to create an elastic, tensioned configuration. This elastic tension, which is also present in other types of osteosynthesis, actively stimulates the reparative bone process at the fracture site — a principle proven by the scientific school of G.A. Ilizarov. This technique has also proven effective in fractures of the bones of the lower leg. Clinical example: Patient K., 14 years old, sustained an injury during parkour training. In the preoperative period, a skeletal traction system was applied (Fig. 2a). Then, according to the above-mentioned indications, osteosynthesis with elastic rods was performed. Under intravenous anesthesia, reduction of the bone fragments and stable-elastic osteosynthesis with rods were carried out (Fig. 2b). The duration of hospitalization was 8 days. The patient began weight-bearing on the injured limb three

weeks after osteosynthesis. He returned for follow-up one year later. Control radiography showed complete consolidation of the bone fragments, after which the elastic rods were removed (Fig. 2c).

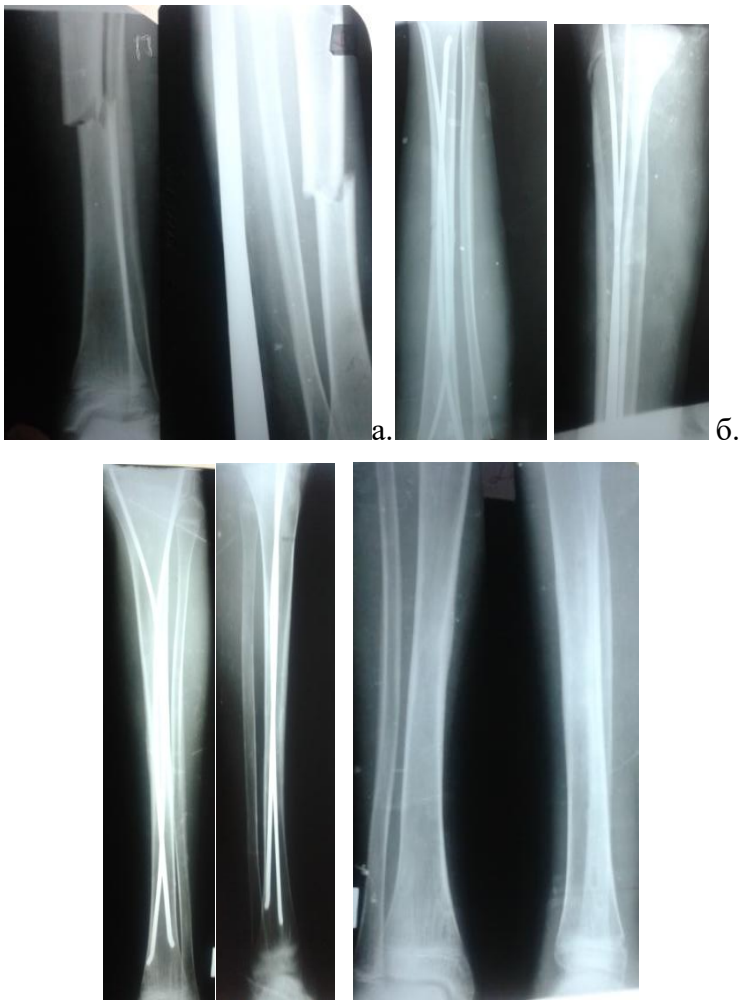

Fig. 2. Patient K., 14 years old. “Closed fracture of the middle third of the bones of the right lower leg with displacement of bone fragments” (a). Post-osteosynthesis condition (b). Long-term result one year later and after implant removal (c).

Thus, fractures of the long bones of the lower extremities, due to the specific characteristics of bone fragments and their consolidation, create certain challenges in treatment and rehabilitation. Skeletal traction is considered a more physiological method of treating fractures of the lower extremities, but the prolonged period of forced immobilization is not always acceptable for children. Pediatric traumatologists have several minimally invasive osteosynthesis techniques at their disposal. Among these surgical methods, we consider stable-elastic osteosynthesis with titanium rods to be the most appropriate option. The advantages of this type of osteosynthesis include its minimal invasiveness, short duration of hospitalization, and the possibility of early mobilization of patients. The difficulties associated with elastic rod osteosynthesis are similar to those encountered with other osteosynthesis techniques; naturally, stabilization of fragments cannot be achieved without overcoming them. It is especially important to achieve osteosynthesis and stability of bone fragments in unstable fracture patterns, where additional rods or supplementary external immobilization may sometimes be required—this does not in any way diminish the value of any particular method. During elastic osteosynthesis, we believe that dynamic radiographic control is necessary to assess the degree of elastic tension, since in some cases, elastic stress—especially when the patient begins walking—may cause diastasis of bone fragments. This may require adjusting the length of the rods by changing their point of contact. Of course, this can reduce the rigidity of the “bone–fixator” system and sometimes mandates supplementary fixation. Despite its many advantages, elastic intramedullary rod osteosynthesis should not be positioned in opposition to other minimally invasive osteosynthesis

methods, especially external wire-rod fixation systems, which also possess significant advantages over traditional osteosynthesis techniques. In adult metal osteosynthesis treatment protocols, patient comfort is considered an important factor. We believe this principle should equally be applied to children. In this context, elastic intramedullary osteosynthesis—on top of all its previously mentioned benefits—holds undeniable superiority. An equally important element in fracture healing is the restoration of the function of adjacent joints. In this regard, the above-mentioned fixation methods are not inferior to each other, since in both types of osteosynthesis the joints are either not immobilized or immobilized only for a short period, ultimately creating favorable conditions for early functional recovery. With external fixation systems, joint function may be limited due to muscle compartment fixation, and inflammatory reactions around the rods may occur, requiring prolonged treatment or replacement. Elastic intramedullary osteosynthesis also has such drawbacks, but joint function remains unaffected. The rods must be positioned in such a way that they do not protrude beyond the bone, yet should not be inserted too deeply, as this reduces the degree of elastic tension and creates technical difficulty during removal. Therefore, elastic intramedullary rod osteosynthesis is also a dynamic system that requires continuous medical supervision throughout all stages of consolidation.

Conclusion.

Thus, osteosynthesis of diaphyseal fractures in children requires careful selection of indications for surgical treatment and an appropriate choice of osteosynthesis method that corresponds to the anatomical and functional characteristics of the growing organism. Minimally invasive surgery, preservation of joint function, and patient comfort with metallic implants are particularly important attributes in the fixation of bone fragments in pediatric patients. In this context, intramedullary osteosynthesis with elastic rods surpasses the currently existing methods of fixing diaphyseal fractures of the lower extremities. Our results demonstrate that this technique can be widely used in various pediatric clinics.

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