

УДК 616.718.4-001.5-089.2-053.2(045)

DOI: <http://dx.doi.org/10.15674/0030-59872021210-16>

Osteosynthesis in children with femoral neck and proximal femur fractures

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Proximal femur fractures are uncommon injuries in children, accounting for less than 1% of all fractures per year, but usually result in hospitalization and are at risk of complications. We have designed a device for bone fragments fixation in the case of proximal femur fractures and the method of its application in adults. The device consists of rods that are screwed into the cap of the head, the diaphyseal part and the module, which is located in the subtrochanter area. The rods can be connected to the module at any angle in the frontal plane. The device provides a certain stage of installation of the elements, which allows you to effectively place it with minimal bone destruction. Objective. Share your own experience in the treatment of femoral neck and proximal femur fractures in children. Material. The experience of treatment of 28 children with femoral neck fracture or proximal femur fractures for the period 2005–2020 is presented, 11 of them were treated conservatively with the skeletal traction. Osteosynthesis by the author's device was performed in 17 patients: 15 closed reduction, 2 in case of intertrochanteric fracture, — open reduction. The method of osteosynthesis and postoperative management of patients is described in detail. Results. In children who were treated conservatively, the fracture consolidation was achieved within 5–7 months, in one of them — in the position of varus deformity. In contrast to conservative treatment, children began to walk with crutches after a few days after surgery, with partial weight-bearing on injured limb. The device was removed in 16 patients after 5–8 months, and complete fracture consolidation of the fragments in their anatomical position was noted. There were no pathological tissue reactions to the metal device. Conclusions. The proposed device and method of closed osteosynthesis with its usage in the case of proximal femur and femoral neck fractures in children can be recommended in the practice of pediatric traumatology. Key words. Children, fracture, proximal femur, treatment, device for osteosynthesis.

Переломи проксимального відділу стегнової кістки — нечаста травма в дітей, що становить менше ніж 1 % від усіх переломів на рік, проте, зазвичай, обумовлює госпіталізацію та супроводжується ризиком розвитку ускладнень. Нами створено пристрій для з'єднання відламків у разі переломів проксимального відділу стегнової кістки та методику його застосування в дорослих. Пристрій складається зі стрижнів, які загвинчують у шийку головки, діафізарну частину і модуль, який розташовують у підвертлюговій зоні. Стрижні можна з'єднати з модулем під будь-яким кутом у фронтальній площині. Пристрій передбачає певну етапність установлення елементів, що дозволяє ефективно його розташувати з мінімальним руйнуванням кістки. Мета. Викласти власний досвід лікування переломів шийки або вертлюгової зони стегнової кістки в дітей. Матеріал. Наведено досвід лікування 28 дітей із переломом шийки або вертлюгової ділянки стегнової кістки за період 2005–2020 рр., 11 із них проліковано консервативно зі застосуванням скелетного витягнення. Osteosynthesis авторським пристроєм виконано 17 пацієнтам: 15 проведено закрити репозицію, 2, у разі міжвертлюгового перелому, — відкрито. Детально описано методику остеосинтезу та післяопераційного ведення пацієнтів. Результати. У дітей, яких лікували консервативно, зрощення відламків досягнуто в терміни 5–7 міс., у одного з них — у положенні варусної деформації. На відміну від консервативного лікування після остеосинтезу діти через декілька днів починали ходити за допомогою милиць, дозовано приступаючи на ушкоджену кінцівку. Видалення пристрою проведено 16 пацієнтам через 5–8 міс., констатовано повне зрощення відламків в анатомічному їхньому положенні. Патологічних реакцій тканин на металевий пристрій не було. Висновки. Запропонований пристрій і методику закритого остеосинтезу з його використанням у разі переломів вертлюгової зони в дітей можна рекомендувати в практику дитячої травматології.

Key words. Children, fracture, proximal femur, treatment, device for osteosynthesis

Introduction

Fractures of the proximal femur are rare injuries in children and account for less than 1 % of all fractures per year, but usually result in hospitalization and are associated with the risk of complications (osteonecrosis, *coxa valga*, premature closure of the growth zone, nonunion) [1]. Such fractures in children occur mainly due to high-energy injuries, e. g. traffic accidents, falls from a height, sports, etc. [2].

Historically, the main method of treatment of fractures of the proximal femur in pediatric patients was conservative [3, 4], which is the major focus for pediatric traumatologists in Ukraine. However, the risk of late displacement of fragments resulted in the use of surgical approaches to the treatment of such patients [5]. Closed or open repositioning with internal stable fixation using various devices is becoming an increasingly used technique in the case of fractures of the femoral neck in children [6–8], but there is no sufficient experience in the treatment of these fractures.

We have created a device for connecting fragments in the case of fractures of the proximal femur and the method of its use in adults [9, 10] (Fig. 1). It consists of titanium rods (Fig. 1, 1) with a diameter of 6 mm and threading at one end, which are screwed into the neck and head of the femur, short rods for the diaphyseal part (Fig. 1, 2), titanium module (Fig. 1, 3), which repeats the outer contour of the submandibular zone of the femur with holes for the retainers of the rods (Fig. 1, 4).

The rods can be fixed to the plate at any angle in the front plane. The device provides a certain stage of installation of the elements, allowing to effectively place it with a minimum amount of bone destruction. The device and method of treatment have shown high clinical efficacy in conditions of transvertebral fractures of the femur in adults [11, 12].

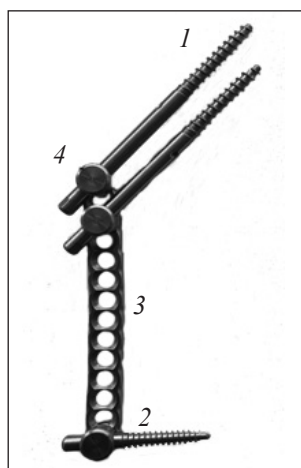


Fig. 1. View of the device for tight connection of fragments in fractures of the proximal femur

The aim of the study: to present own experience in the treatment of fractures of the neck or trochanter area of the femur in children.

Material and methods

The materials of the article were considered at the meeting of the Committee on Bioethics of the Sytenko Institute of Spine and Joint Pathology National Academy of Medical Sciences of Ukraine and received a positive decision (Minutes No. 216 of 26.04.2021).

During the period 2005–2020, 28 children with a fracture of the neck or acetabulum of the femur aged 5–16 years were treated in the pediatric trauma department of Kharkiv Trauma Hospital. Usually, fractures occurred due to a fall from a height, from a sports tool or on a slippery surface, when the force acted directly on the trochanter area.

According to the Delbet classification [2], fractures were divided as follows: of femoral neck (type I–II) in 22 children, transtrochanteric in 6. One patient, in addition to a fracture of the femoral neck, was diagnosed with a fracture of the iliac wing on the opposite side.

Methods of treatment. All patients were found to have primary displacement of fragments in the form of angular deformation. Due to this, they immediately were administered a system of skeletal traction beyond the supraepiphyseal area of the femur. In most patients (21) this method of treatment made it possible to join the fragments, and in 7 the displacement remained.

In 11 patients who stayed in the department in 2005–2013, treatment was carried out conservatively. For 1.5–2 months a system of skeletal traction for the supraepiphyseal area of the femur was applied, followed by fixation with a spica cast bandage.

After 2014, fragments were fixed using the above-mentioned device. 17 children were treated in this way. Among them, in 14 closed joining of fragments was achieved on the skeletal traction system for 2 days, followed by closed osteosynthesis. In 3 patients, traction did not eliminate displacement of the fragments, requiring closed repositioning under general anesthesia and closed osteosynthesis with the device. In most subjects (15) the operation was performed on the 3rd–6th day after the injury, in 2 on the 7th–9th day.

Let us dwell in detail on the method of performing osteosynthesis after a closed joining of fragments. During the operation, it is advisable to use radiography with an electron-optical transducer (EOT). If the patient is on the traction system, it is removed and,

maintaining the traction of the limb along the axis, delivered to the operating room. The intervention is performed in the supine position; the limb is placed in the average physiological position. All manipulations for administration of the spokes and rods are performed in a horizontal position of the pelvis. An orthopedic pillow about 10 cm high is placed under the shin, and the limb is kept from external rotation. Experience has shown that the position of the fragments is maintained under the action of moderate traction on the limb. During the treatment of the operating field, the shin is wrapped with a sterile cloth, tightly fixed with a bandage to allow manipulation of the limb.

Tissue is incised at the level of the subtrochanteric area, externally, up to 10–12 cm long, according to the length of the extra-cortical module of the device. Under a large swivel use perforation of a compact bone is perforated under the greater trochanter with a drill of 5 mm in diameter.

The location of the perforation differed depending on the side of the injury (right or left femur). The fact is that the design of the device involves connecting the module to the rod with a threaded clamp. In order for the force acting on the rod from top to bottom not to untwist, but to tighten the latch, the rod on the right should be located on the anterior surface of the module and on the left on the posterior one. Thus, in the case of a fracture of the right femur, the hole is shifted forward, and in case of the left femur it goes backward (Fig. 2).

This is done to place the module in the middle of the outer surface of the femur.

A needle, which should pass through the neck, is wound through the hole into the upper part of the head (Fig. 3, a). This procedure requires per-

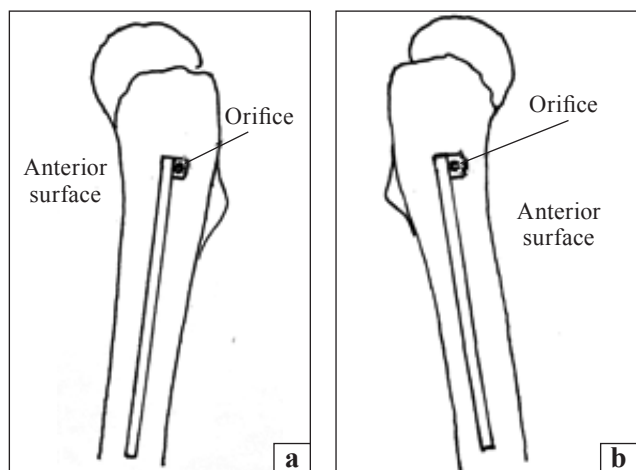


Fig. 2. The place of femur perforation in the (a — left, b — right) subtrochanteric area for the introduction of the first rod

fectly straight needles 1.8 mm thick and 160–200 mm long. It is necessary to have 2-3 pieces of the same length. The needle is wound at low speed and without pressure, so as not to cause its arcuate deformation, which can change the selected direction. During the winding of the needle, the assistant performs traction of the limb. The position of the needle is controlled radiologically, first in the anterior-posterior projection, and, if it is satisfactory, in the lateral one. To do this, it is necessary to bend the limb at the knee and hip, maintaining traction, to an angle of 60°–90° and abduct the thigh at 45° (Lauenstein position). The central beam is directed to the neck (Fig. 3, b).

If the anterior-posterior radiography shows that the position of the needle is unsatisfactory, it is repeated.

During the winding of the needle it is required to determine the length of its part, located in the bone fragments. To do this, take a second needle of the same length and attach it to the part that protrudes from the bone. Measure the difference between it, which is equal to the length of the needle in the bone tissue. Taking into account this value and the position of the needle on the control radiography, calculate the required length of the rod, choose its size and fix it to the wrench.

A channel is drilled with a tubular drill with a diameter of 4.5 mm to a depth corresponding to the length of the part of the rod to be placed in the bone fragments. Next, the needle is removed and screwed into the channel rod. At this point it is necessary to maintain the traction of the limb. The depth of the insertion is controlled using an X-ray machine in two projections. The outer end of the rod should protrude by 15-20 mm.

The module with a clamp in the uppermost hole is put on the end of the screwed rod and placed on the outer surface of the femur. The fascia is pre-dissected and the outer portion of the quadriceps muscle is exfoliated. The upper latch is clamped. Through the hole of the clamp, located in the lower part, drill the shaft with a 4.5 mm drill and screw a short rod (Fig. 3, d).

At the next stage, through the hole of the retain-er on the third hole of the module drill a compact bone with a 5 mm drill, wind a needle through it on the lower part of the neck in the head of the femur and monitor its position radiologically (Fig. 3, e). You should try to hold the needle parallel to the already screwed rod. Select the rod of the required length and after drilling the channel on the wound needle with a tubular drill screw it into the neck and head of the femur (Fig. 3, f). Perform radiography in

two projections. Finally, tighten the nuts of all three clamps as much as possible.

The wound is sutured tightly in layers. The module is located in the muscle under the fascia.

Because most of the children were adolescents, they were allowed to walk on crutches a few days after the operation, with a dosed approach to the in-

jured limb. The value of the support corresponded to the weight of the limb. An educator or a doctor taught the children to walk properly with crutches with dosing loads and then they were discharged for outpatient observation. Walking with crutches lasted 3 months, after which they switched to using one crutch for several weeks and then were allowed to

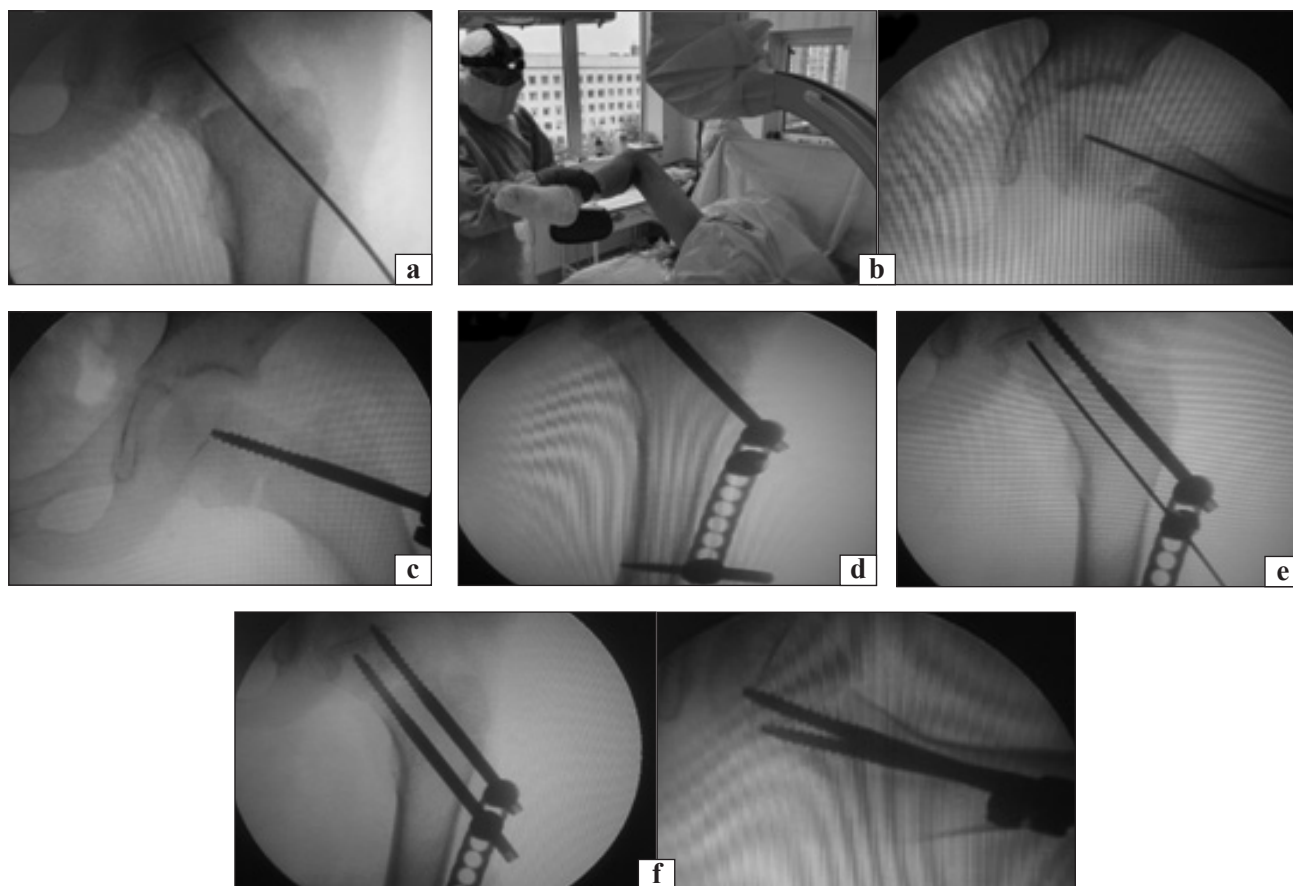


Fig. 3. Stages of osteosynthesis of the fracture of the femoral neck in a 9-year-old child P.: a) introduction of the guiding needle and radiological control in the anterior-posterior projection; b) radiological control in lateral projection; c) winding the rod after drilling the channel on the guiding needle; d) fixing the module to the inserted rod and introducing the rod into the femoral shaft after its previous drilling; e) introducing the guiding needle for the second rod and radiological control of its position in the anterior-posterior projection; f) winding and fixing of the second rod to the module

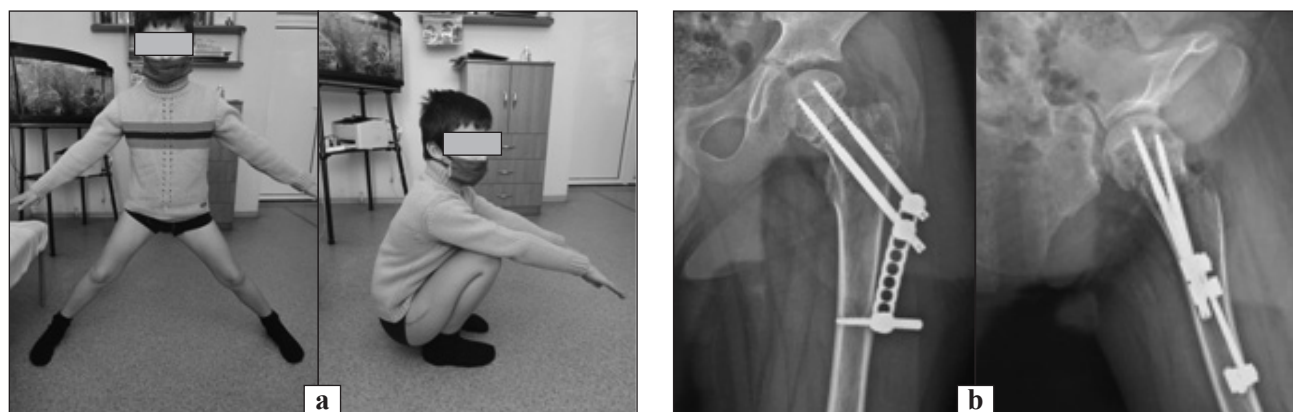


Fig. 4. Demonstration of joint function (a) of a patient P. and radiological images (b) in 5 months after the surgery

walk without additional support. During this time, children naturally restored the function of the joints of the injured limb and their inherent motor activity.

Clinical example No. 1

A 9-year-old patient P., his results of radiography in 5 months after osteosynthesis operation, the stages of which are demonstrated above (Fig. 4).

Results and their discussion

All patients during the treatment, including the stage of removal of the internal fixator or removal of the plaster cast and subsequent restoration of limb function, were supervised in the pediatric trauma department, personally by the Head of the department S. B. Dovgan.

In 11 patients, who were treated conservatively, the fragments were fused within 4 to 7 months. In 10, the anatomical shape of the proximal femur was restored. One patient had fusion in the position of varus deformity. Especially problematic was the treatment of children in whom the fragments on the skeletal traction system were not fixed, so we were forced to additionally perform their closed joining under general anesthesia (this occurred in 4 patients). After the procedure, it was necessary to maintain the holding position of the limb, which was the abduction and internal rotation, which was a technical difficulty and inconvenience for the child. In the case when the position of the limb was violated, there was a need for additional X-ray examination. The period of stay on the skeletal traction system was 1.5–2 months. The limb was then fixed with a spica plaster cast. As a result, in one of these patients, after removal of the cast, a fusion was found in the position of the varus deformity of the femoral neck.

The technique of closed osteosynthesis with the developed device [10] was used in 17 children. Let us analyze the details of significant stages. Closed screwing of the rods into the neck and head of the femur is an important point essential for the further course of fracture healing.

Next stage is the insertion of the needle-landmark. Its deviation from the direction set by the surgeon is due to the use of a thin standard Kirchner needle, which bends when drilling a compact bone. Therefore, to maintain the chosen direction, it is necessary to use the thickest needle possible, shortened to the minimum size, and wind it through a pre-made hole in the compact bone. Then it is possible to predict the needle direction and wind it at low speed. If it went wrong, the hole can be used to hold another needle in the desired direction.

The drilling of the channel should be carried out to the full depth, including the appropriate area on the head of the femur. If it is «under-drilled», there are difficulties during the rod conducting. Cancellous bone in children is quite dense and screwing the rod requires considerable effort, which can displace the head of the femur or form a diastase between the fragments.

When conducting the two upper rods, it is necessary to gradually control their position with the help of EOT. The first check was made when it went deep about 2/3 of the length to make sure that its direction in the frontal plane was where the needle was. The second and third ones were made to deepen the rod into the head and not go beyond it.

In most patients (13 subjects) the method was performed using EOT, in 4 without it, because initially there was no such equipment in the hospital. The use of traditional radiography took a long time, and an attempt to speed up the process led to an insufficiently rational insertion of the rods.

Clinical example No. 2

A 15-year-old patient R., received a fracture of the femoral neck as a result of falling from a gymnastic bar. The fragments were joined with the skeletal traction system on the 4th day after injury; closed osteosynthesis was performed using a conventional mobile X-ray machine. The reference needle did not go according to the plan, which provided for its introduction into the upper outer part of the femoral head (Fig. 5, a). Given the limitations of radiological control, we decided to use this needle to insert the lower rod (Fig. 5, b).

The rod was first inserted along the lower part of the neck and head, and the module was fixed to it. To do this, we used the third hole at the top. In the lower part the module was fixed to the diaphysis with a short rod. Finally, the rod was screwed on the upper part of the femoral neck without prior reference needle. The neck and head were drilled in the direction parallel to the inserted rod. The control radiography showed that the upper rod was not located in the best way (Fig. 5, c). We considered it inexpedient to re-insert it because of the possibility of additional bone destruction. However, there was still a sense of error. It was necessary to first conduct a reference needle, and then to drill the channel along it. But despite this error, the treatment process proceeded without complications and in 3.5 months the fracture has fused (fig. 5, d).

Assessment of the reaction of tissues and the patient to the device immersed in the paraosseous zone.

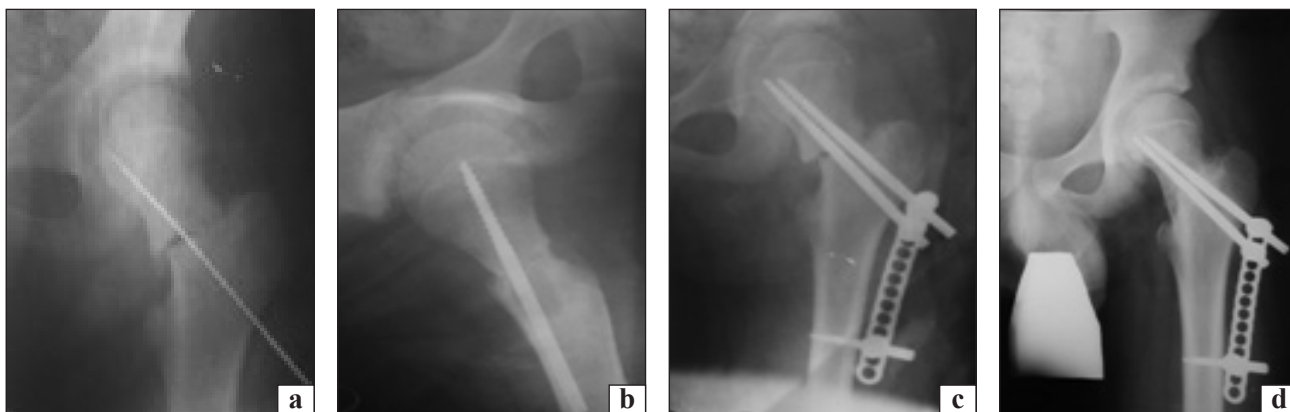


Fig. 5. Radiological images of a 15-year-old patient R.: on the operating table after introduction of the guiding needle (a); profile after winding the first rod (b) and after connecting the fragments by the device (c); in 3.5 months (d)

As we can see, the peculiarity of the design is the location outside the bone. Therefore, we purposefully clarified the patient's presentation and function of the limb for the negative effects of the clamp. The only thing we managed to find was the complaints of two teenagers about the inconvenience when they were lying on the operated side on a hard surface. A 5-year-old girl had a Duchenne-Trendelenburg symptom while walking, which was probably associated with impaired stabilization of the iliotibial tract. After removing the device, this pathological symptom disappeared. It should be noted that the design of the external unit and the method of installation provide for the location of the upper edge in the fossa under the greater trochanter. In this case, the whole structure is in the thickness

of the muscle under the fascia and, as we found out, does not cause harmful effects.

Removal of the device was performed in 15 patients in the presence of bone fusion of fragments in 5-8 months after its installation. There were no abnormal signs in the form of metallosis. Two children continue to walk with implanted devices.

Fusion of fragments in the anatomical position of the fragments was observed in 16 subjects, one is in the process of treatment.

Conclusions

The proposed device and method of closed osteosynthesis with its use in the case of fractures of the trochanter in children can be recommended in the practice of pediatric traumatology.