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# OSTEOARTHRITIS



# Arthritis-Etiology, Diagnosis, Treatment

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## Introduction

The presence of joints in the human body is an important element for life. But with age, as well as under the influence of damaging factors (injuries, infection, metabolic disorders, etc.), pathological changes can develop in the joints that make it difficult to move in them. Currently, a common method of treating osteoarthritis is endoprosthesis, which has been used since adolescence.

The aim of the study is to develop minimally invasive, highly effective methods of treating osteoarthroses.

## Material and methods

In an experiment on puppies and adult animals, developing processes were investigated in tunneling (osteoperforations) of the parts of the bones that make up the joint.

## Results

The results of experimental studies are adapted for clinical use. The clinic uses fan-like tunneling of the distal end of the thigh and the proximal joint end of the tibia for knee gonarthrosis in the elderly. In young children with hip dysplasia, osteosynthesis is performed by Ilizarov's apparatus for joint decompression, osteoperforation of the neck and femoral head. In adolescents with deforming coxarthrosis, developing after Pertes disease, osteosynthesis is carried out with an Ilizarov apparatus for decompression of the hip joint and triple osteotomy of the pelvic bones. Use of developed minimally invasive technologies for joint diseases, shown in childhood and adolescence as a prevention of the development of deforming arthrosis in the early years of life of children.

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It is known that the pathology of large joints of the lower extremities is the cause of primary disability in the able-bodied population and belongs to the most pressing social and economic problem. So, according to international statistics, osteoarthritis suffers from 10% to 12% of the world's population, or 9.5 cases per 1000 population, among all diseases of the musculoskeletal system [1,2]. According to official figures, in Russia there are more than 10 million patients with arthrosis (about a third of them have severe disabilities). The prevalence of arthrosis is consistently increasing. So, for the period 2015-2019, the incidence of arthrosis increased by 48%. Arthrosis occurs in one in three patients aged 45 to 64 years and in 60-70% - over 65 years [3,4].

Diagnosis of arthritis is based on a combination of clinical symptoms, physical signs, radiological data, ultrasound diagnostics, results of cytological and microbiological analysis of synovial fluid. The main diagnostic study in arthritis is the radiography of joints in standard (straight and lateral) projections. If necessary, instrumental diagnosis is supplemented by tomography, arthrography, electrorentgenography, magnifying radiography (for small joints) [5].

All this served as the basis of the World Health Organization to declare the decade 2000-2010 the "International Decade of Bone and Joint Diseases" and a period of targeted diagnosis, methods of treatment and prevention of these diseases [6-8].

Within the framework of this decade, at the Russian Scientific Center "Restorative Traumatology and Orthopedics named after Academician G.A. Ilizarov," PhD N.V. Sazonova conducted a study of medical records and a continuous examination of patients with filling in the primary circulation coupon. The total number of materials studied was 37981 units. According to our data, the greatest reversibility falls on gonarthrosis - 16.2 per 1000 (n - 7391) of the adult population, then there is polyosteoarthrosis 8.8 (n - 8455), coxarthrosis 2.8 (n - 2291) and other arthroses 8.8 (n - 9082).

Among the patients, examined men were 26.6% (7,236 people), women - 73.4% (19,983 people), people aged 50-59 years (26.3%), 60-69 years (22.2%) and 70-79 years (21.2%) prevailed. Groups of patients aged 20-29 and 18-19 years were 3.3% and 1.1%, respectively. People of retirement age are more likely to apply for medical care for joint diseases - 59.9%, women are more likely to turn 4.5 times. A sociological survey using the questionnaire method was conducted among 2,297 respondents aged 18 to 83 years, employed in various areas of public life: Healthcare, education, industry, culture, agriculture and not working at the time of the survey (Table 1).

**Table 1:** Distribution of respondents by gender and employment.

Areas of employment	Men		Women		Total	
	Number	%	Number	%	Number	% к итогу
Health	126	19,3	489	29,8	615	26,8
Education	149	22,8	398	24,2	547	23,8
Culture	49	7,5	84	5,1	133	5,8
Industry	260	39,7	356	21,7	616	26,8
Agriculture	56	8,6	300	18,2	356	15,5
Not working	14	2,1	16	1,0	30	1,3
Total	654	100	1643	100	2297	100

The results of the population survey and the high incidence of articular pathology served as the basis for the development of conservative, palliative and radical operational methods of treating these patients [9]. Currently, joint diseases more often perform operations aimed at replacing the sick joint with artificial metal or ceramic. The search for effective conservative treatment of osteoarthritis led us to develop a technique for the local targeted introduction of drugs (chondro- and osteoprotectants) into the zone of pathological changes in the articular lip of the acetabulum cavity. This technique was used in the treatment of 98 patients (74 women, 24 men). The average age of women was  $48 \pm 6$  years, of men -  $37 \pm 10$  years. The average weight and body mass index in women were  $70 \pm 6$  kg and  $27 \pm 2$  c.u., in men -  $81 \pm 11$  and  $26 \pm 3$  c.u. accordingly. With stage I osteoarthritis (OA) there were 52 patients (53.6%), with stage II - 46 (46.4%) patients. The average duration of the disease is  $3 \pm 2$  years: in women  $3.4 \pm 2.7$  years, in men -  $2.8 \pm 1.5$  years.

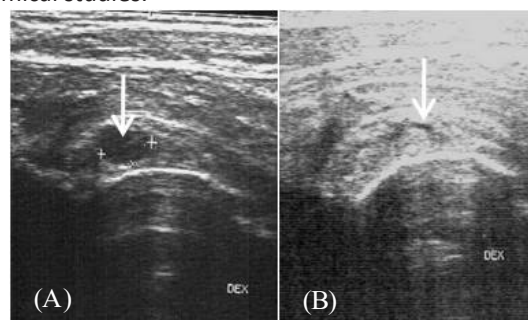
To introduce the chondroprotector, an ultrasound sensor was installed on the anterior surface of the thigh, longitudinally long axis of the segment above the supraacetabular area. Using the General Measurements program in the H Histogram mode, the available portion of the articular lip was viewed for degenerative changes or bone cavities. In the presence of a bone cyst, a chondroprotector was introduced into its cavity under local anesthesia 1 once every three days. For the course of treatment of one joint, 3-5 injections were required. The course of treatment was 9-15 days.

#### Clinical example

Patient Sh. (M. R. No. 401), 59 years old, complained of periodic napping pain in his right hip joint that appeared after walking and minor physical activity. At ultrasound examination of hipjoints on the device "Sonoline" SL-450, presence in him of a large degenerative cyst is revealed (Figure 1a). The patient underwent a course of conservative treatment with aflutop, which was introduced into the cyst cavity 1 once every three days. A total of 5 injections were made. As a result, joint pain disappeared, the patient returned to an active lifestyle.

Sonographically, the cyst cavity is not determined (Figure 1 a,b). Control examination 2 years after treatment. During ultrasound examination of the joint, the previously existing bone cavity is not determined. The patient is satisfied with the treatment result.

When examined in the near and distant terms after local administration of aflutop, all 28 patients showed excellent treatment results, which is confirmed by instrumental and biochemical studies.

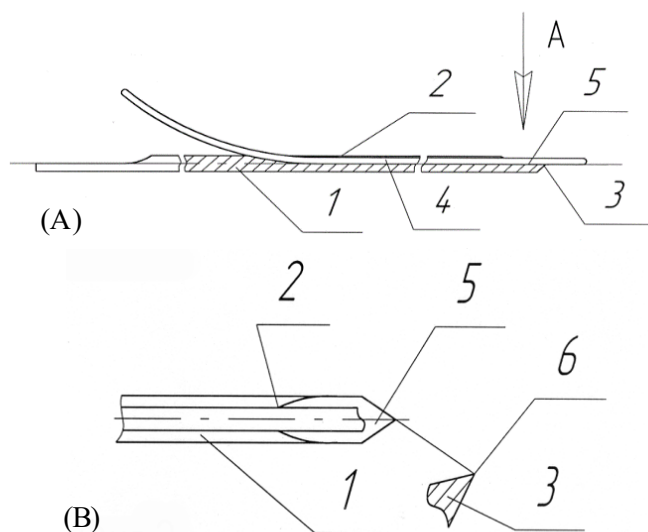


**Figure 1:** (A) Copy of the hip sonogram of patient Sh., 59 years old (m.k. No. 401), with stage I coxarthrosis (transverse scan): A - before treatment (arrow indicates cartilaginous lip cyst of the acetabulum cavity). (B) after treatment (arrow indicates cyst cavity filled with fibrous tissue).

**Minimally invasive surgical interventions in gonarthrosis**

These interventions are based on decompression-drainage tunneling of the articular parts of the bones constituting the knee joint, and drainage of the bone marrow cavity of the tibia under the control of intraosseous pressure [10,11].

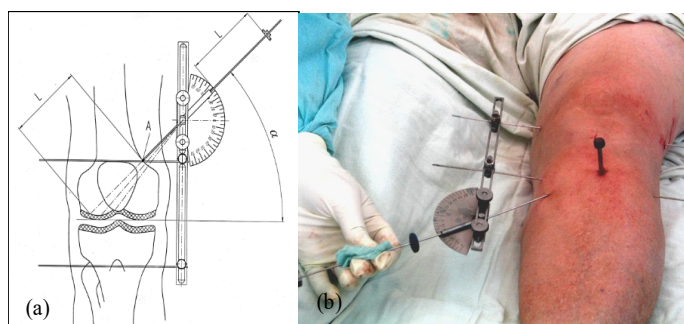
For tunneling in 2005, a bone perforator (wire) was proposed, which had a longitudinal slot to the cutting edge of the end of the spoke. In the slot there was a pusher made in the form of a flexible rod \*. Bone perforator comprises wire 1 with longitudinal groove 2 and cutting part 3 (Figure 2a). Pusher 4 is arranged in slot 2. Ends of pusher 4 are rounded. Slot 2 has outlet to front surface 5 of cutting part 3 with cutting edge 6 (Figure 2b).



**Figure 2:** Bone perforator (A) General view (B) Cutting part of perforator.

\* Patent 50101 Russian Federation, MPK7 A 61 B 17/56. Bone perforator. Makushin VD, Chegurov OK, Biryukova M.Yu. - No. 2005116553/22.

To standardize the implementation of the technique, the device "Guide for wire \*\* (Figure 3 a,b) is used to maximize the volume coverage of the subchondral departments and evenly distribute tunnels in condylae of the femur and tibia.



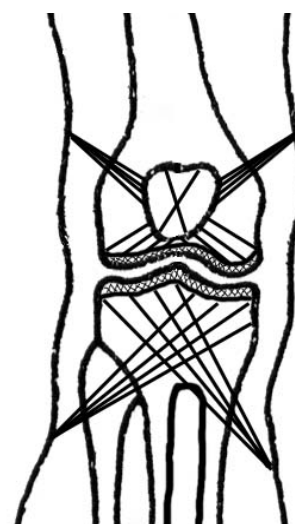
**Figure 3:** Scheme of tunneling using the guide.

(a): A photograph of the wires and the position of the guide during the operation (a bolt-retainer is visible for drainage of the bone marrow cavity and measurement of intraosseous pressure.

(b): Tunneling is carried out using a drill with a variable speed of rotation with a wire with a diameter of 1.8 mm. The formation of tunnels is carried out with a controlled insertion angle and depth of the wire in the bone. Essence of new medical technol-

ogy consists in targeted effect on basic etiopathogenetic links of pathological process, by means of trophostimulating effect in zones of active remodeling. The technique and its variants are applied in compensated and subcompensated stages of degenerative-dystrophic process in knee joint in pronounced pain syndrome without disturbance of biomechanical axis of extremity. Under epidural anesthesia 20-30 ml of 0.25% novocaine solution is introduced into upper cavity of knee joint through to elastic-tension of tissues. After that knee joint is passively flexion and extension 3-5 times. Joint puncture is performed in upper-outer, upper-inner and lower-outer edges of patella. 400 ml of physiological saline and 400 ml of 0.25% novocaine solution are injected from these points under pressure until pure washing waters are obtained. After fluid is evacuated from the joint cavity, the needles are removed. Frontally, in the projection of the epiphyses of the femur and tibia with a wire, fan subchondral tunnelizations (osteoperforation) in the form of a cone are performed (Figure 4).

\*\*Patent 53138 Russian Federation, MPK7 A 61 B 17/58 Guide for wires. Makushin VD (RU), Chegurov OK. (RU), Biryukova M. Yu (RU), RNC "WTO" named after Akad. G. A. Ilizarova (RF). - No 2005136227.



**Figure 4:** Fan-like osteoperforation subchondral knee joint scheme.

In order to prevent damage to articular cartilage during subchondral tunneling, the depth of the wire immersion in bone tissue is limited by the support area present on the wire with stoppe or by a rubber plug applied to the wire. In all cases, patella tunneling is performed. With pronounced pain in the knee joint that does not subside after taking analgesics, osteoperforation of the articular ends is supplemented by drainage of the bone marrow cavity of the tibia with a cannulated screw-fixer for measurement intraosseous pressure. Intraosseous hypertension of 15 mm Hg is a direct indication of the enhancement and prolongation of the analgesic effect. Potentiation of the analgesic effect is carried out for 5 days, by sequential and slow administration of the anesthetic to the bone marrow canal of the tibia (0.25% novocaine solution 5.0 ml). It also contains vascular preparations possessing anticoagulant, angioprotective, immunomodulatory action (2% solution of pentoxifylline, trental 5.0 ml or 0.5% solution of persantin (analogue of curantyl), dipyridamol for intravenous administration) 2.0 ml. On the fifth or sixth day after the operation, the cannulated retainer screw is removed and the wound is closed with an aseptical bandage.



### Clinical example

The patient G., 62 years old, entered the clinic of the Center with complaints of painful, debilitating pain with functional loads of the right knee joint, constant night pain that disturbs sleep, and pain when changing the weather. Pain was disturbed for 6 years. Repeatedly treated conservatively at the place of residence - without effect. Clinically: When examined, the contours of the knee joint are slightly smoothed, not deformed, the axis of the limb is correct, when walking, it limps on the right leg. With muscular strength, 3 points is a deficit of active extension of the right knee joint  $10^\circ$  in comparison with the left. According to ultrasound - signs of infrapatellar bursitis on the right, moderate thickening of the synovial shell (up to 3.2 mm)

On standard radiographs of the right knee joint (Figure 5) In a direct projection, a decrease in the height of the articular slit in the medial part of the joint up to 5 mm (in the lateral - 7 mm), sharpening of the intercondylar elevations, uniform enhancement of subchondral tibial sclerosis. Small osteophytes are determined along the lateral edges of the articular surface of the condyles of the femur and tibia up to 1-2 mm. On the lateral projection is the high standing of the patella with an uneven articular surface and a slight sharpening (entesophytes 1-2 mm in size) of the upper and lower edges of its articular surface.

Diagnosis: Idiopathic gonarthrosis of the right knee joint of a compensated stage (type A) with pain syndrome.

In the clinic of the Center under epidural anesthesia, surgery was performed: Fan-like subchondral tunneling of the articular parts of the femur and tibia and longitudinal tunneling of the patella of the right knee joint. After that, for measuring intraosseous pressure introduced a cannulated retainer screw for osteosynthesis (M 16.10.004.000) is through the cortical layer of the tibia below 2 cm from the bone tuberosity (Figure 5).



**Figure 5:** Radiographs of the right knee of the patient G., 62 years old, before treatment:

**(a)** In a direct projection - with a standing load (a slight decrease in the height of the articular gap in the medial section, a uniform increase in subchondral sclerosis). **(b)** In lateral projection - with maximum extension on the 4th day after the operation (high standing of the patella, position of the cannulated retainer screw in the projection of the upper bone marrow cavity of the tibia)

When measuring intraosseous pressure (IOP) on the operating table, it was 15 mm Hg (hypertension exceeding the normal IOP digits by 3 times (with a norm of 4-5 mm Hg). Osteoperforation was carried out with a wire with a diameter of 1.8 mm, fan-like through the metaepiphyseal departments with the formation of 6-8 channels in each bone. At the same time, three

crossing channels are made in the patella. Introduction of 0.25% solution of novocaine 5.0 ml and pentoxifylline 2% - 5.0 ml, into the bone marrow cavity of the tibia improves microcirculation and rheological properties of blood, causes vasodilatory effect, reduces platelet aggregation and blood viscosity. As a result, intraosseous pressure on the operating table decreased to 12.5 mm Hg. or 83% of the source level. Within 5 days of the operation, 0.25% novocaine 50 ml and 0.5% persantin 2.0 ml (or curantyl, dipyridamol) were injected into the bone marrow cavity of the tibia. These drugs are known to have angioaggregate, angioprotective and immunomodulatory effects. In the postoperative period, a 0.25% novocaine solution of 50 ml and a 0.5% persantin solution of 2.0 ml (or curantyl, dipyridamol) were injected into the bone marrow cavity for 5 days. After treatment according to this procedure, IOP decreased to 5 mm Hg for 5 days, which corresponds to the norm.

There are no complaints at the inspection 1 year after the operation. The patient is satisfied with the result of the treatment. According to ultrasound, there is no free fluid in the joint cavity. On standard radiographs of the right knee joint in two projections: Progression of degenerative-dystrophic processes in the tissues of the knee joint is undetected.

Thus, the pronounced analgesic effect of osteoperforations in combination with an intraosseous blockade anesthetic is an active directed effect on hypertension, which leads to a decrease in IOP [10-12]. This is a pathogenetically sound treatment. As a result, the ischemic cycle of the disease and impaired metabolic processes in the tissues of the knee joint are excluded.

The medical technology of total subchondral tunneling of the joint departments developed at the RSC RTO and its variants were used to treat gonarthrosis in 124 patients (133 joint) at the age of  $56.8 \pm 1.5$  year. There were 83 female patients, 41 male. Compensated stage gonarthrosis was in 84 patients (89 joints), subcompensated in 39 (42 knee joints), and decompensated in one patient with bilateral pathology.

Long-term treatment results ranging from one year to 7 years were studied in 88 patients (97 knee joints) with gonarthrosis - 73% of cases. Positive results of rehabilitation were obtained in 96.9% of observations. At the same time, good treatment results amounted to 77.3%, satisfactory - 19.6%. Unsatisfactory treatment results were observed in two patients (three joints), which was 3.1% [12-14].

The obtained positive results in the treatment of gonarthrosis served as the basis for experimental studies. The purpose of the experiments is to study the effect of bone tunneling on osteo- and angiogenesis, which will help to understand the processes taking place at perforation sites. The experiments were carried out in accordance with the ethical standards and humane attitude to animals set out in the "European Convention for the Protection of Vertebrate Animals Used for Experiments or for Other Scientific Purposes." The object of the studies was 53 acetabulum troughs of 33 puppies 5-9 months old, and 3 acetabulum troughs of 3 dogs 2 years old. Animals are divided into three groups.

In the dogs of the first series of experiments, only tunneling of the over acetabular region was carried out. In the second series, autologous bone marrow cells were introduced into the resulting tunnels from the spokes, and in the third series, autologous bone marrow cells were introduced into the channels from the introduction of spokes and under the periosteum.

The response of tissues to these interventions was examined 3 hours after the operation, subsequently after 12 days, 1. 3. 6. 12 and 18 months radiologically, histologically. The features of the microcirculatory bed were examined using a scanning electron microscope. We will not detail the results of experimental studies. This is the subject of an individual message. Note only some interesting data [15].

So, the periosteal reaction, more pronounced in the third series, was detected radiologically. Histologically, after 1 year and 9 months, identified a network of medium and large trabeculae and a compaction of periosteal layers in the area of the acetabulum vault tunnels. Having obtained convincing data on the activation of angiogenesis and pronounced periosteal layers at the tunneling of the over acetabular region, we adapted data from experiments in a pediatric clinic to treat some congenital hip diseases.

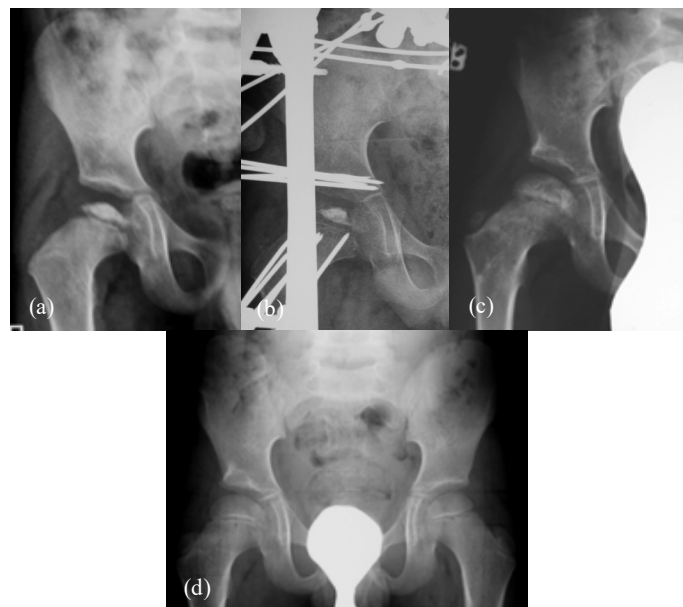
An example is patient M., 8 years old, admitted to the clinic with a diagnosis: Pertes disease, group 3 according Catterall leading to hip contracture [16]. The patient made complaints about limp, joint pain, increasing at night. On the radiograph, upon admission, fragmentation of the epiphysis and narrowing of the articular slit are noted. Osteosynthesis by Ilizarov's apparatus. To stimulate osteo- and angiogenesis, subchondral tunneling of the neck and thigh head with a bundle of spokes and two rods was performed. Cell-tissue mixture is introduced into obtained tunnels [17].

On the operating table, the leg is set to a retraction position of 105°, a distraction of 10 mm is given. Fixation by the apparatus lasted 45 days. In the postoperative period, full functional load on the limb was allowed, additional therapy was carried out, including angio- and osteoprotectants. Complete restoration of epiphysis integrity and shape has been achieved (Figure 6).



**Figure 6:** Radiographs of the patient M. 8 y. (a) Before treatment. (b) During treatment. (c) 6 m after removal of the AEF. (d) 17 m after removal of the AEF. (e) 3,5 y. after removal of the AEF (Stulberg II).

In case of hip dysplasia with insufficient hip head coating, both the head and roof of the acetabulum cavity are tunneled. An example is patient K., 6 years old, admitted to treatment with a diagnosis: Pertes disease. Complaints of pain in the joint when walking, limp. Sick for 1 year. On the radiograph, the epiphysis is significantly reduced in size. Osteosynthesis by Ilizarov's apparatus with tunneling of acetabulum cavity and femoral neck (Figure 7) [18].

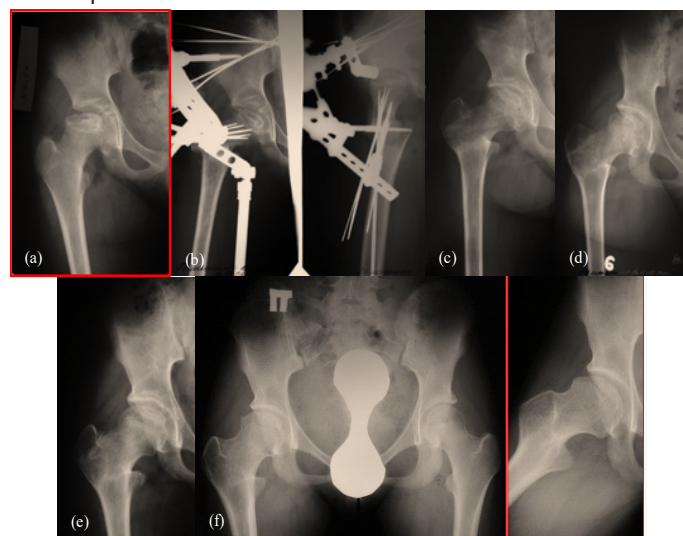


**Figure 7:** Radiographs of the patient K., 6 y. group III according Catterall, group C according Herring. (a) Before treatment. (b) During the treatment. (c) 5 m after removal of the AEF. (d) 1y. 9 m after removal of the AEF (Stulberg I).

The next patient R., 11 years old, entered treatment with complaints in the right hip joint at rest, increasing at functional load. A history of Pertes disease, which was diagnosed at the age of 7 years. He was treated conservatively.

Objectively: The leg in the position of bringing 95°, shortening the limb by 2.5 cm, movements in the joint are painful, with a restriction of retraction and flexion. On the X-ray of a hip osteochondropathy 4b the Veselovsky type. (Grade 4 Catterall, C Hereng) [19]. Sick 6 months. Hip gap narrowed, in the joint cavity determined plus – tissue (Figure 8). In this situation, the technique of centering intertrochanteric femoral osteotomy and hardware hip decompression is shown.

The technique is carried out as follows: Osteosynthesis is carried out by the Ilizarov apparatus from two supports: One on the pelvic wing and the second in the supra-condylar region. Tunneling of the neck and head of the femur is carried out by fan-shaped introduction of 5 wires and a rod.

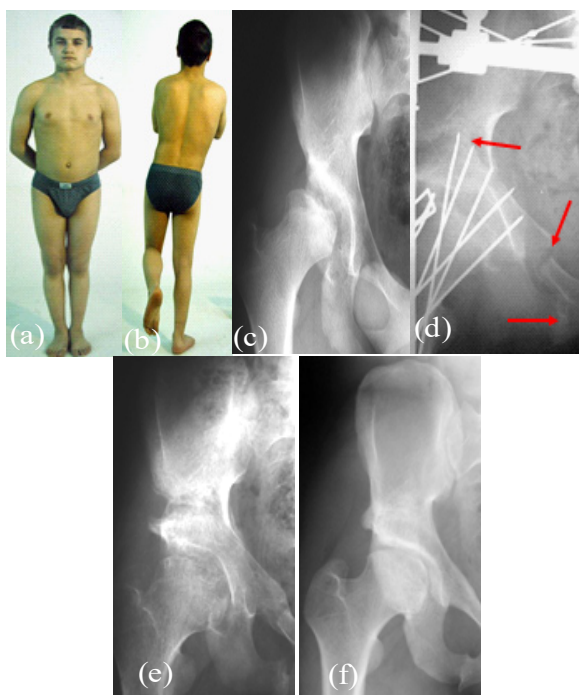


**Figure 9:** Radiographs of the hip joint of the patient R., 11 years old. (a) Before treatment. (b) In the process of treatment. (c) After removing the device. (d) After 3 months. (e) After 14 months. (f) After three years.



After intertrochanteric hip osteotomy his set at an angle of 90° to the pelvic plane. On the second day after the operation, the patient is verticalized. The functional load within two weeks reaches normal values.

Next patient T., 15 years old. Diagnosis: Deforming arthrosis of the right hip joint, developed after Porges disease. Complaints of joint pain after loading, limp. Objectively: The length of the limbs is the same, with a load a positive symptom of Trendelenburg. On the X-ray pattern, the femur head in the subluxation position in the acetabulum cavity is determined as plus tissue. Performed osteosynthesis by Ilizarov apparatus. The hip is given a retraction position of 105°. Fan-like 5 spokes are passed through neck and femur head with their introduction into roof of acetabulum cavity. Osteotomy of pelvic bones (iliac, pubic and sciatic) was performed\*. After that, by bringing the femur to 90°, the coating of the thigh head and its reduction to the acetabulum cavity was achieved (Figure 9). In the postoperative period, the functional load on the operated limb was gradually restored and after 1.5 months the apparatus was removed.



**Figure 9:** (a, b, c) Photo patient T. and his radiograph before treatment. (d, e, f) On the operating table, after removal of the device and 3 years after treatment. In the photo - Hip function 3 years after treatment.

\* Patent of the Russian Federation 2 282 413 S2 A61B 17/56 Method of correction of acetabulum dysplasia. Shevtsov VI (RU), Teplenky MP (RU), Atmansky IA (RU). RSC WTO named after G.A. Ilizarov (RF). - No. 2003112581/14.

### Conclusion

Thus, articular end tunneling in chronic arthroarthrosis is a highly effective technique. In some cases, it can be used as an alternative to endoprosthesis in adolescents and in patients under 30 years of age [20].

### Recommendations for using the described technologies

The techniques developed by the RTO RSC for fan-shaped tunneling of the joint ends of the knee joint are shown to elderly people with the first - second stage of compensated gonarthrosis. In childhood, with hip roof dysplasia, methods of supraacetabular osteoperforations are shown. In the case of acetabulum roof and femoral head dysplasias, osteoperforations of the trough roof are shown, subchondral tunneling of the neck and femoral head. Methods of centering intertrochanteric hip osteotomy and hardware hip decompression are indication in fragmentation of the epiphysis with decentralization of the femoral head (IV a, b classification of St. Veselovsky); III - IV group Catterall, group B/C, C by Herring. These operational interventions are used in older age groups of children.

In adolescence, after Porges' disease, deforming arthrosis of the hip joint with a subluxation of the femoral head often develops. In such a situation, it is necessary to use triple pelvic osteotomy with rotation of the resulting bone block in order to restore the coating of the thigh head. These surgical interventions stimulate angio- and osteo- and chondrogenesis, which leads to the restoration of cartilaginous coating of articular surfaces. Our efforts are aimed at using the internal capabilities of the body for the rehabilitation of sick joints.

### Informed consent

Patients gave voluntary informed consent to participate in the study.

### Conflict of interest

The authors declare that there is no conflict of interest.

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