

## TOTAL HIP ARTHROPLASTY IN CHILDREN WHO HAVE UNDERGONE ARTHROPLASTY WITH DEMINERALIZED BONE-CARTILAGE ALLOCUPS

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**Introduction.** Treating children with degenerative dystrophic diseases of the hip joint has become one of the most acute problems in contemporary orthopedics. Until recently, we performed arthroplasty by demineralized bone-cartilage allocups (DBCA) in the Clinic of the Hip Joint Pathology of the Turner Scientific and Research Institute for Children's Orthopedics for patients showing clinical and radiological signs of irreversible destruction of the hip joint; we carried out this procedure to preserve the function of the lower limb. However, over the last 8 years, we have changed our protocol for children older than 12 years of age and have replaced DBCA with total hip replacement. In a number of cases, total hip replacement was performed after a previous intervention involving arthroplasty with DBCA.

**Objective.** To determine the technical peculiarities of total hip replacement after a previous intervention involving arthroplasty with DBCA.

**Material and methods.** We analyzed the results of treatment involving various types of hip pathology in 13 children (100%) aged between 15 and 16 years [8 girls (61.5%) and 5 boys (38.5%)]. The medical histories of all 13 children (100%) showed repeated operations on the hip joint, ultimately resulting in arthroplasty with DBCA. All 13 children (100%) underwent a total hip replacement. Upon hip replacement, all 13 patients (100%) showed a pronounced thinning and hardening of the edges and the bottom of the acetabulum, which created some difficulties in the process of acetabular component implantation. The transformation of DBCA was not evident in any of the 13 cases (100%).

**Results.** During the observation period of 3–5 years following total hip arthroplasty, all 13 cases (100%) showed recovery in the range of motion and absence of pain. An important criterion for evaluating the quality of care was the complete social and domestic adaptation of all 13 children (100%) during the period from 6 to 9 months following total hip replacement surgery.

**Conclusions.** The main feature of the implementation of total hip replacement, following a previous intervention involving arthroplasty with DBCA, was a pronounced deficit of the pelvic bone in the joint component. This significantly complicated the subsequent implantation of the acetabular prosthesis component, and in some cases required the use of a cemented acetabular component. Our experience suggests that patients under 11 years of age who show clinical and radiological signs of coxarthrosis can be treated with arthroplasty with DBCA in order to save the lost function of the hip joint and maintain the function of the periarticular muscles.

**Ключевые слова:** children, arthroplasty with demineralized bone-cartilage allocups, total hip arthroplasty.

## ОСОБЕННОСТИ ТОТАЛЬНОГО ЭНДОПРОТЕЗИРОВАНИЯ ТАЗОБЕДРЕННОГО СУСТАВА У ДЕТЕЙ ПОСЛЕ АРТРОПЛАСТИКИ ДЕМИНЕРАЛИЗИРОВАННЫМИ КОСТНО-ХРЯЩЕВЫМИ АЛЛОКОЛПАЧКАМИ

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**Введение.** Проблема лечения детей с дегенеративно-дистрофическими заболеваниями тазобедренного сустава является одной из самых актуальных в современной ортопедии. До недавнего времени в клинике патологии

тазобедренного сустава ФГБУ «НИДООИ им. Г.И. Турнера» при наличии клинко-рентгенологических признаков необратимой гибели тазобедренного сустава и с целью сохранения функции нижней конечности выполнялась артропластика деминерализованными костно-хрящевыми аллоколпачками (ДКХАК). За последние 8 лет у детей старше 12 лет артропластику ДКХАК полностью заменило тотальное эндопротезирование тазобедренного сустава. В ряде случаев эндопротезирование выполнялось после ранее произведенной артропластики ДКХАК.

**Цель работы** — определить технические особенности тотального эндопротезирования после ранее выполненной артропластики ДКХАК.

**Материалы и методы.** Проанализированы результаты лечения патологии тазобедренного сустава различного генеза у 13 детей в возрасте от 15 до 16 лет. Из них 8 девочек (61,5 %) и 5 мальчиков (38,5 %). В анамнезе у всех 13 детей (100 %) отмечались предшествующие неоднократные операции на тазобедренном суставе, итогом которых была артропластика ДКХАК. Всем 13 детям (100 %) выполнено тотальное эндопротезирование тазобедренного сустава. При выполнении эндопротезирования у всех 13 пациентов (100 %) отмечалось выраженное истончение и склерозирование краев и дна вертлужной впадины, что создавало определенные сложности при установке ацетабулярного компонента. Ни в одном из 13 случаев (100 %) не отмечено трансформации ДКХАК.

**Результаты.** В сроки наблюдения от 3 до 5 лет после тотального эндопротезирования тазобедренного сустава в 13 случаях (100 %) отмечалось восстановление амплитуды движений и отсутствие болевого синдрома. Важным критерием оценки качества лечения являлась полная социальная и бытовая адаптация всех 13 детей (100 %) в сроки от 6 до 9 месяцев после замены сустава.

**Выводы.** Главной особенностью выполнения тотального эндопротезирования тазобедренного сустава после ранее проведенной артропластики ДКХАК является выраженный дефицит костной массы тазового компонента сустава, что в последующем значительно осложняет имплантацию вертлужного компонента эндопротеза и в ряде случаев заставляет использовать цементную фиксацию ацетабулярного компонента. Наш опыт позволяет считать, что у пациентов в возрасте до 11 лет при наличии клинко-рентгенологических признаков коксартроза одним из возможных способов сохранения утраченной функции тазобедренного сустава и поддержания функции околоуставных мышц остается артропластика ДКХАК.

**Ключевые слова:** дети, артропластика деминерализованными костно-хрящевыми аллоколпачками, тотальное эндопротезирование тазобедренного сустава.

## Introduction

The problem of treating pediatric patients with degenerative and dystrophic diseases of the hip joint is one of the most relevant in modern orthopedics. In 37%–85% of patients, the cause of coxarthrosis is congenital and acquired diseases of the hip joint [1,2]. In the overwhelming majority of cases, the causes of deforming arthrosis of the hip joint in childhood are dysplasia of the hip joints, congenital hip dislocation, Legg–Calvé–Perthes disease, slipped capital femoral epiphysis, the effects of acute hematogenous osteomyelitis, the effects of rheumatoid arthritis, and different variants of epiphyseal dysplasia. We identified a group of pediatric patients who underwent multiple unsuccessful surgeries to restore the lost anatomical and biomechanical arrangements in the hip joints [3]. At the time of admission to our clinic, these patients had major static and dynamic disorders due to pronounced limitations in the amplitude of movement in the hip joints, pain, and differences in the sizes of the lower extremities. Until recently, hip arthroplasty using demineralized osteochondral

allografts (HADOA) was performed in children and adolescents to restore the function of the lower extremities at the Department of hip joint pathology in the Turner Scientific and Research Institute for Children's Orthopedics in the presence of clinical and X-ray signs of irreversible hip joint degeneration. The first arthroplasty in Russia was performed in 1869 by I.N. Novatsky for the mobilization of an ankylosed hip joint. The use of various biological, metal, and synthetic gaskets for arthroplasty, as a rule, does not provide the expected long-term results due to the relapse of contractures, ankylosis, fibrous, and bone ankylosis at the faulty position in the limb [4,5]. The aim of arthroplasty of the hip joint is to form a supportive, painless diarthrosis with the minimum functional capabilities necessary [6]. The replacement of degenerated hyaline articular cartilage remains an actual problem today [7]. Until recently, HADOA was considered a promising treatment method because the caps have minimal antigenic activity [8–10]. After demineralization with acid solutions, the cap becomes elastic, changes its shape quite

easily, and retains sufficient mechanical strength. These features are very important for fitting the graft to the maternal bed of the residual limb in the proximal region of the thigh bone or cotyloid cavity during surgery [11,12]. Despite these advantages, good medium-term outcomes with HADOA are observed in only 50% of cases. Principal changes to the solution for restoring the lost hip joint function in Russia occurred after K.M. Sivash (1956) proposed the use of total hip arthroplasty. The choice of the method for surgical treatment remains at the sole discretion of the surgeon. In the specialized department of hip joint pathology at the Turner Scientific and Research Institute for Children's Orthopedics, hip arthroplasty has been the method of choice since 2009 for patients with clinical and X-ray signs of stage III coxarthrosis.

**The aim of the study** was to determine the technical features of total arthroplasty after a previous HADOA.

## Materials and methods

For the period from 2009 to 2014, the results of treatment for 13 pediatric patients, 8 girls (61.5%) and 5 boys (38.5%), aged 13–16 years (13 hip joints in total) were analyzed. The cause of deforming arthrosis was congenital dislocation of the hip in 5 patients (38.5%), slipped capital femoral epiphysis in 3 patients (23%), and the effects of acute hematogenous osteomyelitis in 5 patients (38.5%). Before entering the clinic, all the patients underwent repeated extraarticular and intraarticular surgeries (open repositioning of the hip, corrective osteotomy of the hip) on the hip joint. All of the patients showed clinical and X-ray signs of deforming arthrosis at stages IIB–III according to the classification for dysplastic coxarthrosis in children and adolescents developed at the Turner Scientific and Research Institute for Children's Orthopedics. In our opinion, technical errors in the course of surgical intervention were the cause of unsatisfactory results for the treatment of congenital hip dislocation and slipped capital femoral epiphysis in 8 patients (61.5%). In 5 patients (38.5%) with acute hematogenous osteomyelitis, the severity of the damage to the pelvic and femoral components of the joint led to unsatisfactory treatment results. All of the patients were between the ages of 7 and 14 years when they first underwent HADOA. Two to 7 years

after the initial surgery, ankylosis developed in all patients due to the progression of the degenerative process. Pain syndrome and major disorders of the static and dynamic function occurred, which was an indication for total arthroplasty to return the children to a normal life.

The patients underwent total hip arthroplasty using the Gibson–Kocher posterolateral approach after signing a voluntary informed consent form to participate in the study and to receive surgical treatment. When examining the joint cavity after arthrotomy, DOA fragmentation was observed in both the cotyloid cavity and the femoral head. Free-lying or intimately adherent scar tissue fragments from the cap were found in the joint cavity, with sizes no larger than  $2 \times 1$  cm. The transformation of allografts occurred in none of the patients. After excision of the scar tissue and removal of the DOA fragments, thinning and expressed sclerosis at the edges and bottom of the cotyloid cavity were noted. After delicate treatment of the cotyloid cavity with milling cutters, a cementless screw cavity, Bicon Plus with a Zweimuller design and a cross-link polyethylene insert, was implanted in 9 patients (69.2%). The acetabular fragment was selected due to the design, which provides reliable stable fixation even if 2/3 of the surface is in contact with bone. The acetabular component of the Muller cement fixation plate was required for the implant in 4 patients (30.8%) due to thinning and pronounced sclerosis in the edges and bottom of the cotyloid cavity greater than 2 mm and the inability to achieve stable fixation with the cementless screw cavity Bicon Plus. The SL-plus leg was implanted in all 13 patients. In 9 patients (69.2%), a ceramic head was used, and in 4 patients (30.8%), Oxinium was used. In the pathomorphological study, the macroscopic fragments of HADOA were seen as slightly curved, rather small plates of different sizes and shapes, of a cartilaginous-looking tissue 0.1 to 0.7 cm in thickness of reddish, grayish-reddish or gray color (after fixation in 10% neutral formalin solution) (Fig. 1(a)). Microscopic examination of the histological preparations showed that the fragments of the DOA (Fig. 1(b)) were formed by hyaline cartilage tissue in a state of areactive necrosis. The cartilage tissue was replaced by a low-vascularized dense fibrous (scar tissue) tissue or by tissue corresponding to fibrous cartilage according to the structure. Narrow and unevenly

expanded lacunae were somewhat irregularly distributed in a homogeneous, oxyphilic or low-basophilic intercellular matrix. The gaps in the lacunae were partly optically empty or contained a different number of amorphous low-basophilic masses (“remnants” of necrotic chondrocytes). The inflammatory reaction was completely absent in the DOA fragments.

To assess the functional state of the hip joint, a clinical research method was used involving the modified Harris Hip Score scale and a scale developed at the Turner Scientific and Research Institute for Children’s Orthopedics [13]. The position of the acetabular and femoral components and the degree of fixation for the cup were assessed radiographically. Excellent results corresponded to 91–80 points, good results corresponded to 71–80 points, satisfactory results corresponded to 61–70 points, and poor results corresponded to less than 60 points according to the modified Harris Hip Score scale. According to the scale developed at the Turner Scientific and Research Institute for Children’s Orthopedics, excellent results corresponded to 0–1, good results corresponded to 2–3, satisfactory results corresponded to 4–5, and unsatisfactory results corresponded to 6 and above. The data obtained during the study was processed using Statistica for Windows (version 6.0).

## Results

Clinical examination enabled the determination of the dominant symptoms of deforming coxarthrosis. The relative shortening of the

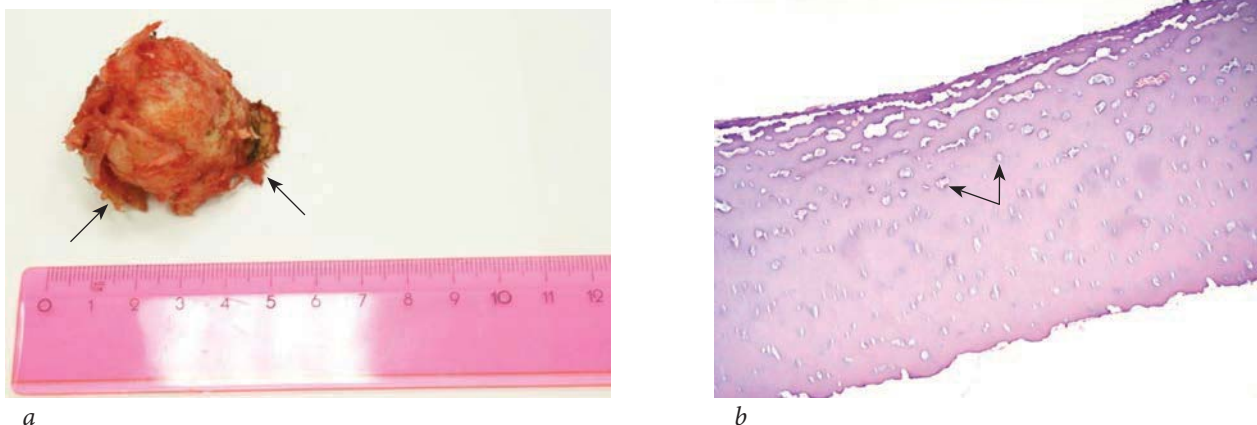
lower limb was  $3.5 \pm 1.2$  cm. Adduction–flexion contracture in the hip joint was noted in 9 patients (69%), while limited retraction amplitude and sharply positive impingement test results were noted in 10 patients (76.9%). Positive Duchenne–Trendelenburg symptoms were diagnosed in 10 patients (76.9%). Using the data obtained from the radial methods of study, the true ratios of the pelvic and femoral components of the joint, the thickness of the cotyloid cavity walls, and deformity in the medullary canal of the thigh bone were evaluated. All 13 patients had pronounced deformity in the proximal region of the thigh bone and acute thinning at the edges and bottom of the cotyloid cavity due to the previous HADOA. Indications for total hip arthroplasty were the following:

- 1) Persistent pain;
- 2) Pronounced restriction of movements in the hip joint, with the formation of a faulty lower limb position, resulting in an inability to provide support, which together led to domestic and social restrictions in the child’s life.

In addition, the possibility of performing total hip arthroplasty was evaluated, taking into account the completion of bone growth and the use of standard sizes for the required grafts.

Clinical examples are shown in Figs. 2 and 3.

During the observation period of 3 to 5 years after total hip arthroplasty, all patients responded positively regarding the efficacy of the treatment. All the results were evaluated as excellent. After total hip arthroplasty, the average scores on the modified Harris Hip Score scale and the scale developed at the Turner Scientific and Research Institute for

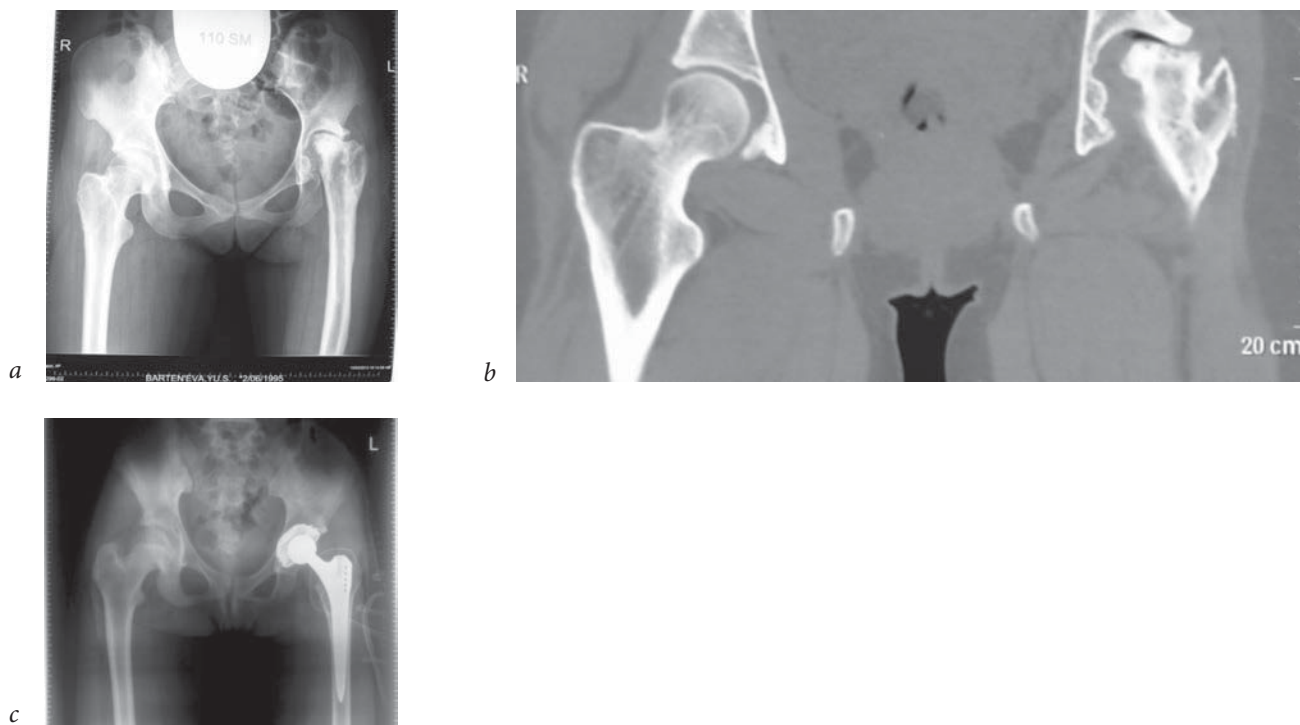


**Fig. 1.** Macro- and microscopic picture of the resected femoral head of demineralized osteochondral allograft fragments: (a) is the appearance of the resected femoral head (arrows indicate fragments of the demineralized osteochondral allografts) and (b) is the appearance after fixation in 10% neutral formalin (arrows indicate narrow and unevenly expanded lacunae, optically empty or containing “remnants” of necrotic chondrocytes)

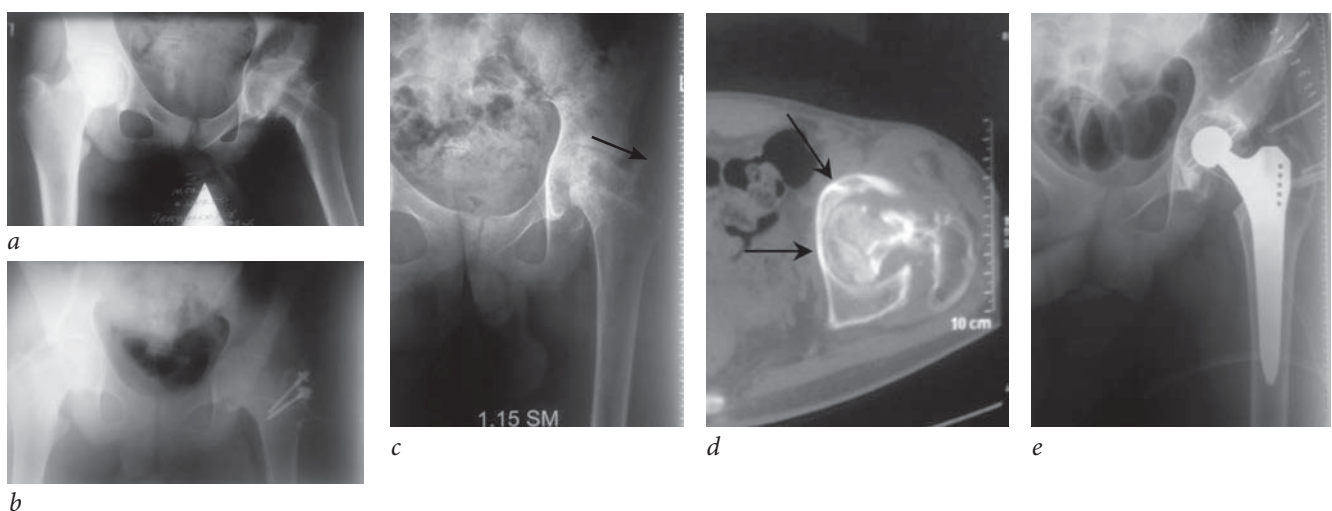


Children's Orthopedics were significantly ( $p < 0.05$ ) different from the preoperative results. The average score on the modified Harris Hip Score scale before the surgery was 41.25 (95% CI 37.9–44.5), and 80.1 (95% CI 75.3–84.9) after surgery. The average score on the scale developed at the Turner Scientific and

Research Institute for Children's Orthopedics before the surgery was 5.95 points (95% CI 5.37–6.53) and 0.11 (95% CI 0.07–0.15) after surgery. In all cases, recovery of the amplitude of movements was noted, as well as the absence of pain. In 9 patients (69.2%), the length of the lower limbs was completely



**Fig. 2.** Patient B., 13 years old: (a) is the roentgenogram of the hip joints after arthroplasty with demineralized osteochondral allocaps; (b) is the computer tomogram of the hip joints after the arthroplasty with demineralized osteochondral allocaps. Severe thinning and sclerosis at the bottom of the cotyloid cavity; and (c) is the roentgenogram of the hip joints after total arthroplasty with the use of a cementless cup Bicon



**Fig. 3.** Patient T., 16 years old: (a) is the roentgenogram of the hip joints before arthroplasty with demineralized osteochondral allocaps; (b) is the roentgenogram of the hip joints immediately after performing the arthroplasty with demineralized osteochondral allocaps; (c) is the roentgenogram of the hip joints 11 months after arthroplasty with demineralized osteochondral allocaps; (d) is the computer tomogram of the hip joints 11 months after arthroplasty with demineralized osteochondral allocaps (arrows indicate pronounced thinning and sclerosis of the bone mass of the anterior column and the cotyloid cavity bottom area); and (e) is the roentgenogram of the hip joints immediately after total arthroplasty with the use of the Muller cement fixation plate

compensated. In the remaining 4 patients (30.8), the residual shortening was  $1.2 \pm 0.3$  cm, which does not require additional surgical correction. An important criterion of assessment of the quality of life was social and personal adjustment 4 to 6 months after surgery. None of the patients had any complications in the early and late postoperative periods.

## Discussion

In our opinion, HADDOA should be performed with the aim of restoring lost function in the lower limb only in cases when total hip arthroplasty is impossible. Taking into account the fact that total arthroplasty after previous HADDOA presents significant technical difficulties, the indications for HADDOA should be limited. The age of the child and a history of surgical interventions should be taken into account due to the possible development of aseptic necrosis of the femoral head [12]. The classic rules for performing arthroplasty are the ratio of the “large cotyloid cavity–small femoral head.” Technically, this is achieved by expanding and deepening the cotyloid cavity to the inner cortical layer using milling cutters [14], modeling resection of the proximal femur. As a rule, the existing surgical approaches for HADDOA enable the excision of the great trochanter or parts of it, together with the attached muscles. This leads to disorders in the vascularization of the proximal femur already “compromised” by the pathological process. During the surgical intervention, the joint components are devitalized due to lack of innervation and blood flow. All this has a negative effect on the trophism of the proximal femur and the cotyloid cavity and further contributes to the progression of the degenerative and dystrophic process. Plaster immobilization within 1 month and weight placement on the lower extremity before 1 year significantly worsen the regeneration in the operated joint and the quality of life for young people. Total arthroplasty of the joints, a variant of artificial non-biological arthroplasty, greatly enhances the restoration of the musculoskeletal system and is one of the top treatment choices for severe forms of coxarthrosis. Walking with crutches with partial load is allowed on the 3rd postoperative day, and after 2–3 months, full load on the operated limb is allowed. Modern prosthetic implants, with the condition of correct

“operation,” ensure consistently good results for 20–25 years. One of the important conditions for making a decision about hip arthroplasty in pediatric patients is the closure of the growth zones of the pelvic and thigh bones [3].

## Conclusions

1. The main characteristic of total hip arthroplasty after previous HADDOA is a pronounced bone mass deficit in the pelvic component of the joint. In the course of HADDOA, the cotyloid cavity is deepened with milling cutters, which subsequently complicates the implantation of the acetabular component of the prosthesis. In some cases, the use of cemented fixation is required for the acetabular component.

2. Based on our experiences, we concluded that in patients under 11 years of age with severe pain, limitations in hip joint movements, major faulty position of the lower limb, and X-ray signs of coxarthrosis, HADDOA remains a feasible option to preserve the lost function in the hip joint, eliminate pain, repair the faulty position of the lower limb, and maintain the function of the paraarticular muscles. This is because performing total hip arthroplasty at this age is impossible due to the functioning Y-shaped cartilage and lack of grafts with the required dimensions.

3. In patients older than 11 years, avoiding HADDOA and performing complex conservative treatment until total arthroplasty can be performed appears to be the better option. In our experience, total arthroplasty is possible at the age of 12 years after the closure of the growth zones of the pelvic and femoral joint components.

## Information on funding and conflict of interest

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