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Our experience of total hip arthroplasty in adolescents with consequences of acute hematogenous osteomyelitis

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BACKGROUND: Currently, the number of adolescents with terminal stages of coxarthrosis of various origins who underwent total hip joint arthroplasty has increased, as the use of modern implant models with a long service life has narrowed the age limit and expanded the indications for this intervention.

AIM: This study aimed to assess the effectiveness of total hip arthroplasty in adolescents with stage 3 coxarthrosis caused by acute hematogenous osteomyelitis.

MATERIALS AND METHODS: The study analyzed preoperative data and postoperative clinical, radiological, and functional examination data of 40 patients aged 13–18 (15 ± 1.2) years with stage 3 coxarthrosis caused by acute hematogenous osteomyelitis. The study group was composed of 21 (52.5%) boys and 19 (47.5%) girls. The control group consisted of 32 patients with stage 3 post-traumatic coxarthrosis, aged 12–18 (15.4 ± 1.7) years, of which 14 (43.75%) were girls and 18 (56.25%) were boys.

RESULTS: The long-term functional results were evaluated using the Harris hip score (14). The average Harris hip scores before and after arthroplasty were 44.87 ± 5.65 and 80 ± 7.61 ($p < 0.05$), respectively. In the comparison group, the mean Harris hip scores before and after surgery were 33.73 ± 4.28 and 89.47 ± 5.60 points, respectively ($p < 0.05$). The postoperative follow-up duration was 5 ± 3 M ± SD (95% confidence interval) years. No complications were observed in the early and late postoperative periods.

CONCLUSIONS: In adolescents, total hip arthroplasty is an effective surgical treatment for complications of acute hematogenous osteomyelitis. It quickly provides attainable, stable, and favorable outcomes, which improve the quality of life and social adaptation of adolescents.

Keywords: hip joint; adolescents; total hip arthroplasty; coxarthrosis; osteomyelitis.

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Наш опыт тотального эндопротезирования тазобедренного сустава у подростков с последствиями острого гематогенного остеомиелита

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Обоснование. В настоящее время у подростков с терминальными стадиями коксартроза различного генеза все шире применяют тотальное эндопротезирование тазобедренного сустава, так как с появлением современных моделей имплантатов, обладающих высокими техническими характеристиками, уменьшились возрастные ограничения и увеличились показания к данному вмешательству.

Цель — оценить эффективность тотального эндопротезирования тазобедренного сустава у подростков с коксартрозом III стадии, развившимся вследствие острого гематогенного остеомиелита.

Материалы и методы. Проанализированы данные пред- и послеоперационного клинико-рентгенологического и функционального обследования 40 пациентов в возрасте от 13 до 18 лет (в среднем — 15 ± 1,2 года), страдающих коксартрозом III стадии, развившимся вследствие острого гематогенного остеомиелита. Из 40 (100 %) пациентов 21 (52,5 %) — мальчики и 19 (47,5 %) — девочки. В контрольную группу вошли 32 пациента с посттравматическим коксартрозом III стадии. Возраст пациентов контрольной группы составил от 12 до 18 лет (в среднем —15,4 ± 1,7 года). Из 32 (100 %) пациентов 14 (43,75 %) — девочки, 18 (56,25 %) — мальчики.

Результаты. Отдаленные функциональные результаты оценены с использованием шкалы Харриса (Harris Hip Score). Средние значения шкалы Harris Hip Score у пациентов основной группы до операции составили 44,87 ± 5,65 балла, после эндопротезирования — 80 ± 7,61 балла ($p < 0,05$). У пациентов в группе сравнения средний балл по Harris hip score до операции составил 33,73 ± 4,28, после эндопротезирования — 89,47 ± 5,60 ($p < 0,05$). Сроки послеоперационного наблюдения — от 1 до 8 лет (в среднем — 5 лет). Осложнений раннего и позднего послеоперационного периода не наблюдалось.

Заключение. Тотальное эндопротезирование тазобедренного сустава у подростков с последствиями острого гематогенного остеомиелита является эффективным методом хирургического лечения, так как данный метод позволяет в короткие сроки и на длительное время восстановить утраченную функцию нижней конечности, что улучшает качество жизни и социальную адаптацию подростка.

Ключевые слова: тазобедренный сустав; подростки; тотальное эндопротезирование; коксартроз; остеомилит.

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BACKGROUND

Acute hematogenous osteomyelitis is one of the major urgent problems of pediatric surgery, with a frequency of 6%–12% among pediatric surgical diseases [1–3]. One of the most severe and disabling complications of acute hematogenous osteomyelitis includes purulent coxitis, accompanied by bone tissue destruction with femoral and pelvic bone growth zone damages, leading to hip joint functional destabilization and suppression (up to complete loss) [4, 5]. Orthopedic complications (dislocations, deformities, limb shortening, contractures, and ankylosis of large joints) are registered in 31%–71% of acute hematogenous osteomyelitis cases [6, 7]. Orthopedic treatment of children with acute hematogenous osteomyelitis consequences consists in restoring not only the support function and axis of the lower limb, but also the range of motion of the hip joint. Treatment should be started with restoration of disturbed ratios in the hip joint, only after the limb axis correction in patients with lower limb lesions due to acute hematogenous osteomyelitis [8, 9].

Choice of surgical treatment method for hip joint function restoration in adolescents with acute hematogenous osteomyelitis consequences has been and remains a difficult task for pediatric orthopedics. This is due to a wide variety of sepsis-induced deformities. Reconstructive, palliative, and radical surgeries are performed to restore the lower limb supportive ability. Some authors perform open-access reconstructive surgical interventions, with arthrotomy, and others perform it in a closed way using external fixation devices if the hyaline cartilage of the articular surfaces of the hip joint is preserved [10, 11]. In case of a complete death of the hyaline cartilage of the femoral head and/or the acetabulum, arthroplasty of the hip joint is performed using various interposing pads (auto-, allo-, xenopads, and other origin). However, long-term study results revealed the inability of these interventions to fully restore the lost hip joint function [12]. Currently, total hip arthroplasty is increasingly used in adolescents with terminal stages of coxarthrosis of various origins since age restrictions have decreased and indications for this intervention have increased due to the emergence of modern models of implants with high technical characteristics [13–17]. To date, only a few publications in literature focused on hip arthroplasty in adolescents with acute hematogenous osteomyelitis consequences [12], which emphasizes the relevance of studies on total hip arthroplasty efficiency in this category of patients.

This work aimed to evaluate total hip arthroplasty efficiency in adolescents with stage III coxarthrosis developed as an acute hematogenous osteomyelitis consequence.

MATERIALS AND METHODS

The study included 40 patients (40 hip joints) who underwent 40 total hip arthroplasty surgeries for secondary coxarthrosis in the terminal stage, which developed as a result of acute hematogenous osteomyelitis (main group), on 2008 to 2018 in the department of hip joint pathology of the H.Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery of the Ministry of Health in Russia. The patients' age ranged from 12 to 18 years (on average 15 ± 1.2 years). Of 40 patients, 21 (52.5%) were males and 19 (47.5%) were females. A clinical comparison group was formed to compare the results, consisting of 32 patients (32 hip joints) with stage III post-traumatic coxarthrosis without gross anatomical and functional changes in the hip joint and lower limb as a whole. The age of patients from the control group ranged from 12 to 18 years (on average 15.4 ± 1.7 years). Wherein, 14 (43.75%) were female and 18 (56.25%) were male.

Inclusion criteria for participants include age from 12 to 18 years, clinical and radiological signs of stage III secondary coxarthrosis, absence of systemic and genetic diseases, voluntary informed consent of patients and their parents for study participation, and absence of inflammatory processes for >2 years. Exclusion criteria for study participants include age under 12 and over 18 years, presence of neurological, systemic, and genetic diseases, and refusal to complete the informed consent form for study participation.

Clinical, radiation, electrophysiological, and statistical research methods were used. The clinical examination included goniometry, limb length measurement, and gait assessment. All patients completed the Harris hip score questionnaire to objectify complaints and obtain the most complete information about hip joint functional status [18]. The Oswestry scale was used to assess dysfunction and pain in the lumbar spine. X-ray examination methods included X-ray imaging of the hip joints in anteroposterior projection and computed tomography, as well as panoramic X-ray imaging of the lower extremities in upright position before and after surgery. X-ray control was performed before surgery and at 3, 6, and 12 months after surgery, and then once every 1.5–2 years. The electrophysiological method of research consisted surface electromyography, which enabled condition assessment of such muscles of the hip joint area as *m. rectus femoris*, *m. adductor longus*, and *m. gluteus medius*. Electromyography results in patients of both groups were compared with healthy children results.

Statistical analysis was performed using Excel 2010 and Statistical Package for the Social Sciences v.23 software, developed by International Business Machines (USA). Arithmetic means (*M*), standard deviations (*SD*), and median (*Me*) with quartiles (25%–75%) were calculated. Comparison between groups was performed using the nonparametric

Mann-Whitney *U* test. Analysis within the study groups was performed using the Wilcoxon test. The result was considered statistically significant at $p < 0.05$.

All patients underwent total cementless endoprosthetics from the Gibson-Kocher approach. Main group patients were distributed into two subgroups depending on the method of total joint replacement. The subgroup 1 consisted of 17 patients (42.5%) with pathological hip dislocation, whose arthroplasty was combined with T. Paavelainen osteotomy of the greater trochanter. The subgroup 2 consisted of 23 patients (57.5%), whose joint ratios were not impaired and who underwent total arthroplasty according to the standard technique, the same as all patients in the comparison group.

In the main clinical group, components of endoprosthesis were implanted, namely acetabular component Bicon Plus (Smith&Nephew) to 39 (97.5%) patients, acetabular component Plasmafit (BBraun Aesculap) to 1 (2.5%) patient; femoral component SL Plus (Smith&Nephew) to 31 (77.5%) patients, Metha (BBraun Aesculap) to 1 (2.5%) patient, and femoral component Wagner Cone (Zimmer Biomet) to 8 patients (20%). As a friction pair, an insert made of high molecular weight polyethylene and a ceramic head was used in 16 (40%) cases, Oxinium head in 14 (35%) cases, and cobalt-chromium head in 9 (22.5%) cases. The acetabular component Bicon Plus (Smith&Nephew) was implanted in 17 (53.1%) patients and Plasmafit (BBraun Aesculap) was used in 15 (46.9%) patients in the comparison group. Constructs from the femoral components were used, namely SL Plus (Smith&Nephew) implanted to 15 (46.8%) patients, BiContact (BBraun Aesculap) implanted to 9 (28.1%) patients, Metha (BBraun Aesculap) implanted to 6 (18.7%) patients, and Wagner (Zimmer Biomet) implanted to 2 (6.25%) patients. The model and design of the aforementioned components of endoprostheses made by listed manufacturers were individually selected for patients of the main and comparison group depending on the specific anatomical situation. All components were implanted without the use of bone cement. Thus, no significant differences were found in the constructions and fixation method in both study groups, which enabled the conduction of adequate comparative analysis of surgical treatment results.

RESULTS

Upon clinic admission, main complaints in all patients of the main group were pain in the area of the affected hip joint and the lumbosacral spine and impaired gait in the form of lameness, as well as a pronounced dysfunction of the hip joint and a vicious position of the lower limb. The mean Harris hip score was 44.87 ± 5.65, and the Oswestry scale score was 26 ± 14.02. Moreover, lumbosacral spinal pain prevailed over hip joint pain (Harris hip score of 48 ± 4.45 and Oswestry score of 40.35 ± 4.45) in patients of the subgroup 1, which, in our opinion, was due to compensatory pelvic torsion caused by the complete separation of the articular surfaces of the femoral head and the acetabulum. Concurrently, the opposite situation was noted in patients of the subgroup 2, where hip joint pain prevailed (Harris hip score of 40 ± 4.05 points and Oswestry score of 15.52 ± 6.50 points).

The study of anamnestic data revealed that 18 (45%) patients received a conservative treatment during the course of acute hematogenous osteomyelitis. It consisted of antibiotic and detoxification therapy, physiotherapy procedures, and limb immobilization. Surgical treatment was performed in 12 (30%) patients. Femoral epimetaphysis osteoperforation was performed in four cases, abscess opening and drainage in four cases, and joint puncture in two patients, including phlegmon opening in one case. At an older age, 38 patients (95%) underwent various reconstructive surgical interventions (corrective osteotomy of the hip; greater trochanter pull-through; pelvic osteotomy [Chiari, Salter, double, and triple]; and arthroplasty with demineralized osteochondral allocaps) to restore the congruence of articular surfaces and stabilize the hip joint due to development of pathological subluxation or dislocation of the hip and/or multiplanar deformities of the proximal femur.

The main complaint of all patients in the comparison group was persistent pain in the hip joint and a pronounced range of motion limitation. The average Harris hip score was 33.73 ± 4.28. In addition, three patients complained of recurrent lumbosacral spinal pain. The mean score on the Oswestry scale was 13 ± 2.64. Anamnesis data revealed that the cause of terminal stage development of coxarthrosis was trauma (femoral neck fracture as a result of catatrauma in 25 patients [78.1%] and sports trauma resulting in aseptic necrosis of the femoral head in 7 patients [21.8%]) in all patients in the comparison group.

Clinical examination of patients in both groups was performed according to the scheme generally accepted for this category of patients, namely visual gait assessment, limb length and hip circumference measurement, and goniometry.

A visual gait assessment stereotype in patients of the main group revealed gross disorders, which primarily depended on hip joint contracture fixed in a physiologically disadvantageous position and a pronounced limb shortening. All patients in the comparison group also had gait disorders in the form of lameness, but manifested a lesser extent, which was caused by hip adduction contracture, pelvic torsion, and decreased lower extremity hauling phase period with load inversion on the parts of the foot. The value of relative lower limb shortening in patients of the main group averaged 4.1 ± 1.90 cm, whereas that in the comparison group was 2.35 ± 1.57 cm ($p < 0.05$). A quantitative assessment of muscle hypotrophy in the hip joint area

revealed that thigh circumference was less on average by 50% than on the contralateral side in patients of the main group. In addition, hypotrophy of the thigh muscles averaged no >25% in patients of the comparison group. Moreover, all patients of the main group had multiple postoperative scars along the lateral, anterior, and posterior surfaces of the hip joint, as well as the thigh in its middle and lower thirds. Results of goniometry in patients of both groups are presented in Table 1.

Based on Table 1, patients in both groups had clinical signs of significant joint dysfunction (grade IV).

Radiation examination revealed signs of stage III deforming coxarthrosis in patients of both groups, which was expressed in patients of the main group subgroup 1 as a gross deformity of articular surfaces of the femoral head and acetabulum in combination with their complete separation. Gross deformity of the pelvic and/or femoral joint components with a total narrowing of joint space and osteophytes was noted in patients of the main group subgroup 2. The femoral component was deformed to a greater extent, and acetabular deformities were of a secondary nature and manifested mainly as marginal osteophytes in all patients in the comparison group.

Table 2 presents the data of superficial electromyography of the main muscles of the hip joint.

As a comparison, data obtained in healthy patients of this age were used, which are 352.6 ± 60.3 μV for *m. gluteus medius*, 253 ± 51.6 μV for *m. adductor longus*, and 387.3 ± 54.7 μV for *m. rectus femoris*. Table 2 shows that a typical change in electrogenesis of the aforementioned muscles decreased by 40%–60% of the age norm in patients of the main group. Apparently, this is associated not only with pain and gross dysfunction of the joint, but also with repeated surgical interventions on the hip joint components and traumatic effects on its muscular apparatus. The average amplitude of electrogenesis potentials of the studied muscles on the affected side was reduced by 20%–35% of the age norm in patients of the control group.

Clinical and functional results were assessed no earlier than 24 months after surgical treatment.

Patients of both groups noted complete pain relief in the affected hip joint area. The mean Harris hip score in patients of the main group subgroups 1 and 2 was 83.65 ± 6.49 and 77.57 ± 7.22, respectively, which did not significantly differ. The mean Harris hip score was 89.47 ± 5.60 in patients of comparison group (Fig. 1). According to the intergroup statistical analysis (questionnaire survey on a specialized scale), no significant differences were found in the functional state of the hip joint.

Nevertheless, lumbosacral spinal pain (mean score on the Oswestry scale 14.75 ± 5.84) persisted in a number of patients in the main group, which, in our opinion, was associated with the operated lower limb residual shortening. Time changes in the affected limb shortening, before and after surgery in patients of the main and control groups, were analyzed (Fig. 2).

As a result of comparison between the shortening magnitude of the affected limb before and after surgery, statistically significant differences were revealed in patients of the study groups ($p < 0.001$ and $p < 0.001$, respectively). The magnitude of the lower limb relative shortening before the surgery was 2.35 ± 1.57 cm and 0.47 ± 0.55 cm after the surgery in patients of the control group; 3.80 ± 0.95 cm before and 1.76 ± 1.01 cm after surgery in patients of the main group subgroup 1; and 3.58 ± 1.10 cm before and 1.79 ± 1.10 cm after surgery in patients of the main group subgroup. Accordingly, shortening amount in patients of the control group decreased by 80% after surgery. It was possible to reduce the amount of shortening by 53.68% in patients of the main group subgroup 1 and 50% in patients of the main group subgroup 2.

One patient in the comparison group had lumbosacral spinal pain that arose after intense physical exertion.

A visual gait analysis revealed that 36 patients (90%) of the main group had lameness, which directly depended on the amount of operated lower limb shortening and paraarticular

Table 1. Goniometry data of patients of both groups before surgery

Movement nature (from the middle position — 0°)	Main group patients (*M* ± *SD*) *Me* (25%–75%)		Comparison group patients (*M* ± *SD*) *Me* (25%–75%)
	subgroup 1	subgroup 2	
Flexion, deg.	36.41 ± 10.17 40 [25–44]	21.48 ± 11.09 20 [14–30]	31.43 ± 11.61 30 [20–41]
Extension, deg.	7.47 ± 4.41 10 [5–11]	1.87 ± 2.39 0 [0–5]	3.33 ± 4.04 0 [0–6]
Abduction, deg.	4.59 ± 7.0 4 [0–5]	7 ± 5.25 8 [0–10]	3.60 ± 4.59 2 [0–5]
Internal rotation, deg.	9.53 ± 6.18 8 [5–15]	6.43 ± 5.2 6 [0–10]	6.80 ± 5.78 5 [0–10]
External rotation, deg.	11.94 ± 7.24 15 [5–15]	1.83 ± 3.65 0 [0–1]	9.37 ± 7.10 10 [5–12]

Table 2. Amplitude of electrogenesis of the main muscles of the hip joint in patients of both groups before surgery

Muscles under study	Main group patients *M* ± *SD* *Me* (25%–75%)		Comparison group patients, *M* ± *SD* *Me* (25%–75%)	Healthy children, *M* ± *SD* *Me* (25%–75%)
	subgroup 1	subgroup 2		
M. gluteus medius, μV	195.29 ± 47.11 191 [178–226]	119.72 ± 22.24 116 [99–133]	260 ± 66.47 273 [202–307]	352.6 ± 60.3 370 [298–401]
M. rectus femoris, μV	243.50 ± 46.92 239 [197–290]	174.39 ± 37.44 176 [142–200]	301 ± 78.61 308 [228–365]	387.3 ± 54.7 395 [316–434]
M. adductor longus, μV	183 ± 46.24 200 [139–214]	119.61 ± 17.51 118 [105–133]	221.83 ± 61.59 202 [178–286]	253 ± 51.6 261 [218–319]

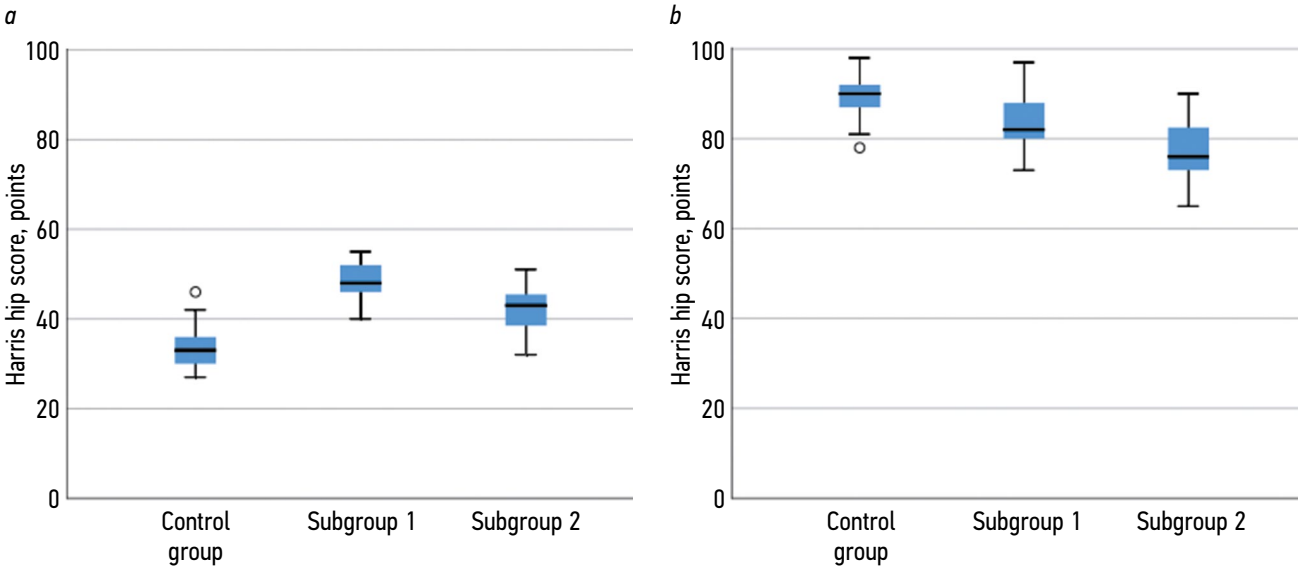

Fig. 1. Dynamics of indicator changes in the Harris hip score before (*a*) and after (*b*) surgery in patients of the main and control groups.

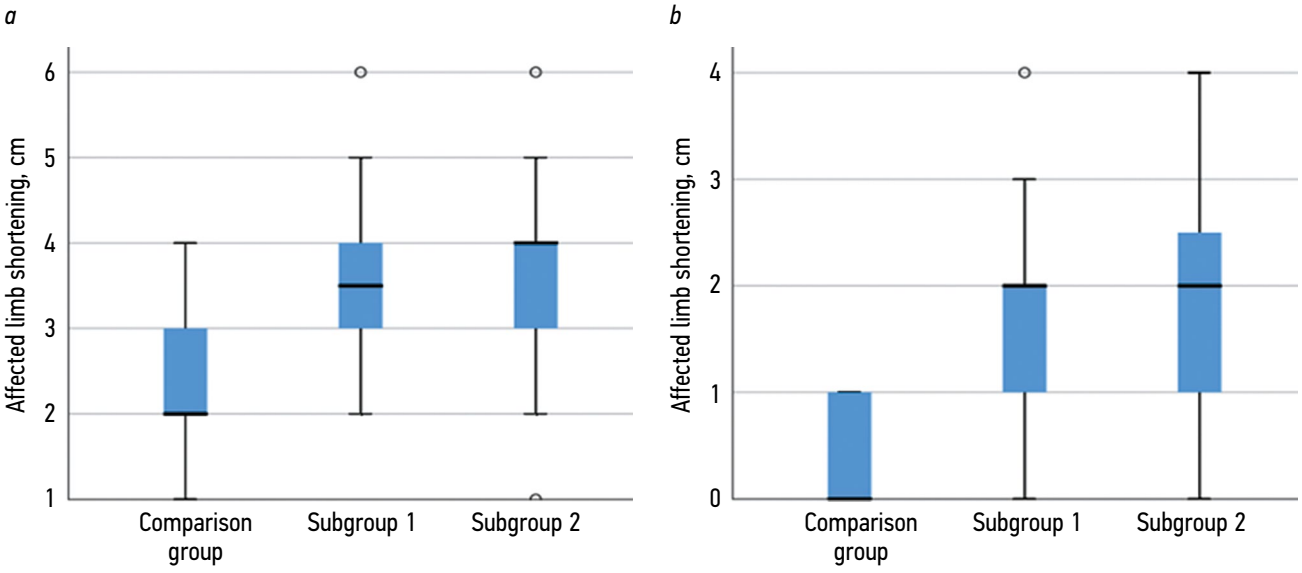

Fig. 2. Dynamic of changes in the magnitude of affected limb shortening before (*a*) and after (*b*) surgery in patients of the main and control groups

muscle conditions. The correct gait stereotype was completely restored in patients in the comparison group, and the mean residual shortening was no >1 cm. The difference in the circumference of the thigh on the affected and healthy sides decreased from 50% to 35%–40% in the main group, and muscle hypotrophy decreased compared to the preoperative value. Residual muscle hypotrophy of the thigh of the operated limb was noted in 5 patients, amounting to 7% compared to the healthy lower limb in the control group.

Goniometric data in patients of both groups are presented in Table 3.

Based on Table 3, the amplitude of movement in patients of both subgroups of the main group and comparison group significantly changed compared to the preoperative indicators ($p < 0.05$) toward its increase.

Changes indicate a significant improvement in the hip joint function. Concurrently, the intergroup analysis revealed the presence of significant differences ($p < 0.05$) in goniometric indicators. Thus, movements in the hip joint approached the physiological values in patients of the comparison group. In addition, significant differences ($p < 0.05$) were found in the parameters of flexion and abduction in the hip joint in patients of the main group according to intragroup analysis data. Flexion and abduction limitation persisted in a number of patients of the main subgroup 2, which was associated with the presence of cicatricial changes in the soft tissues of the hip joint after repeated surgical interventions. In 90% of patients of the main group with fibrous ankylosis and various contractures in the hip joint after surgery, these indicators were completely eliminated, and in 10% of cases, decreased to 15° ± 2.93°. These changes were eliminated in all patients of the control group.

Radiation examination showed the stability of results achieved during the surgery in all patients of both groups, namely the mean tilt of the acetabular component in the frontal plane was 47.06° ± 2.43° in patients of the main group, and the leg anteversion was 14.73° ± 2.93°. In patients in the comparison group, similar indicators were 42.73° ± 1.58° and 17.13° ± 1.96°, respectively. The offset value was close to that on the contralateral healthy lower limb. During the follow-up period from 2 to 10 years (on average, 5 years), no patient underwent revision surgery.

A significant change ($p < 0.05$) of their electrogenesis was revealed compared with the preoperative indicators according to the electrophysiological state analysis of the main periarticular muscles (Table 4).

In addition, electrogenesis of the *musculus gluteus medius* increased by 37% and 35%, adductor muscles increased by 37 and 33%, and *musculus rectus femoris* increased by 26 and 22%, in patients of the main subgroups 1 and 2, respectively. Moreover, obtained values of the average amplitude of electrogenesis were significantly better in patients of the subgroup 1 compared to that of the subgroup 2, which

Table 3. Data and dynamics of changes in the amplitude of movement in the affected hip joint

Movement nature (from the middle position — 0°)	Main group						Control group		
	subgroup 1			subgroup 2					
	before surgery	after surgery	dynamics, %	before surgery	after surgery	dynamics, %	before surgery	after surgery	dynamics, %
Flexion, deg.	36.41 ± 10.17 40 [25–44]	107 ± 8.67 110 [100–115]	76	21.48 ± 11.09 20 [14–30]	96.74 ± 5.76 100 [90–100]	68	31.43 ± 11.61 30 [20–41]	112 ± 8.16 115 [107–120]	97
Extension, deg.	7.47 ± 4.4110 [5–11]	12.35 ± 2.93 12 [10–15]	71.42	1.87 ± 2.39 0 [0–5]	9.35 ± 2.82 10 [7–10]	400	3.33 ± 4.04 0 [0–6]	14.53 ± 3.76 15 [11–17]	336
Abduction, deg.	4.59 ± 7.0 4 [0–5]	43.47 ± 4.91 45 [40–47]	89.5	7 ± 5.25 8 [0–10]	36.52 ± 5.04 35 [35–40]	92.8	3.60 ± 4.59 2 [0–5]	47.43 ± 7.06 50 [43–55]	92.3
Internal rotation, deg.	9.53 ± 6.18 8 [5–15]	32.35 ± 6.15 35 [30–35]	78.4	6.43 ± 5.2 6 [0–10]	28.65 ± 5.04 30 [5–30]	82.7	6.80 ± 5.78 5 [0–10]	36.13 ± 4.88 35 [32–40]	85.6
External rotation, deg.	11.94 ± 7.24 15 [5–15]	43.94 ± 8.25 45 [40–50]	63	1.83 ± 3.65 0 [0–1]	37 ± 6.77 40 [35–40]	93.7	9.37 ± 7.10 10 [5–12]	47.47 ± 7.06 49 [42–55]	73.9

Table 4. Data and dynamics of changes in the amplitude of electrogenesis of the main muscles of the hip joint in patients of both groups

Muscles under study	Main group						Контрольная группа		
	subgroup 1			subgroup 2					
	before surgery	after surgery	dynamics, %	before surgery	after surgery	dynamics, %	before surgery	after surgery	dynamics, %
M. gluteus medius, µV	195.29 ± 47.11 191 [178–226]	269 ± 27.60 275 [251–299]	37.94	119.72 ± 22.24 116 [99–133]	161.89 ± 20.19 165 [147–177]	35.22	260 ± 66.47 273 [202–307]	282.09 ± 60.87 300 [234–320]	8.46
M. rectus femoris, µV	243.50 ± 46.92 239 [197–290]	308.69 ± 45.49 312 [279–342]	26.77	174.39 ± 37.44 176 [142–200]	213 ± 32.06 209 [188–232]	22.41	301 ± 78.61 308 [228–365]	328.39 ± 62.93 324 [278–380]	8.97
M. adductor longus, µV	183 ± 46.24 200 [139–214]	233 ± 30.56 233 [204–262]	37.32	119.61 ± 17.51 118 [105–133]	159.94 ± 25.65 165 [143–187]	33.71	221.83 ± 61.59 202 [178–286]	259.70 ± 57.52 265 [204–294]	17.07

was associated with pronounced cicatricial changes in soft tissues due to both infection history and repeated iatrogenic effects on them. Similar indicators of the studied muscles almost reached the healthy lower limb values after treatment in patients of the comparison group.

DISCUSSION

The efficiency of total hip arthroplasty and its long-term results were studied well in adult patients [19–22]. Possibilities of using total arthroplasty in adolescents are being actively analyzed, but still largely undetermined [12, 23, 24].

The choice of approach for orthopedic and surgical treatment of adolescents with coxarthrosis that developed after acute hematogenous osteomyelitis depends on the severity of secondary anatomical changes in the hip joint components and is largely determined by age-related decrease in the possibilities for mutual remodeling of the articular surfaces of the acetabulum and femoral head. Until recently, hip joint arthroplasty with demineralized osteochondral allocaps was performed in the clinic to restore the supporting and motor functions of the affected lower limb in patients with this pathology; however, this intervention implies a long rehabilitation period and does not fully restore the lost joint function and often leads to fibrous ankylosis formation in a physiologically disadvantageous position. Low efficiency of arthroplasty with demineralized osteochondral allocaps in adolescents is discussed [12], which also emphasizes the negative impact of this surgery on the forthcoming arthroplasty. Currently, in the clinic of the H. Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery, arthroplasty almost completely replaced arthroplasty with demineralized osteochondral allocaps for the treatment of adolescents with coxarthrosis terminal stages.

Indications for endoprosthetics in patients of both main and control groups were persistent pain syndrome and gross dysfunctions of the hip joint. However, the pain syndrome in the affected joint was less pronounced and was mainly localized in the lumbosacral spine in patients of the main group. This was due to long-term compensatory torsion of the pelvis and lumbar spine caused by either pathological hip dislocation (subgroup 1) and/or the vicious lower limb position in combination with its shortening (subgroup 2).

Vast majority of patients (75%) of the main group had previously undergone various reconstructive interventions. Iatrogenic effects on the bone and soft tissue components of the affected joint negatively influenced its functional state and arthroplasty results.

Obtained analysis data revealed that endoprosthetics results in patients of the control group were close to the physiological norm. However, results were worse in patients

of the main group due to gross anatomical and functional changes. Nevertheless, postoperative period indicators completed the restoration of the supporting and motor functions of the affected joint.

Long-term results and survival rate of prosthesis components in adolescents are insufficiently covered in literature; however, M. Torchia et al. published in their study the results of cement total arthroplasty performed in 50 patients with a follow-up period of at least 10 years. The age of patients was 11–19 years (average age was 17 years). The average follow-up period was 12.6 years (1.6–18.6 years). Most of the poor results were due to acetabular component loosening. X-ray manifestations of the acetabular component loosening after 15 years were detected in 60% of cases, and these of the femoral component were noted in 20%. Radiographic manifestations of polyethylene liner wear were associated with incorrect acetabular component positioning. Authors noted patient satisfaction with results, probably because the functional impairment was severe and the patient's expectations were limited. Before surgery, most patients realistically considered arthroplasty as a lifesaving procedure, appreciating the benefits, without excluding the possibility of failure.

Indications for total arthroplasty in adolescents with contraindications to alternative surgeries or if they are unacceptable should be carefully analyzed. In addition, the use of cement fixation of the acetabular and femoral components is not recommended [25]. In all cases, cementless components were implanted. The implant was selected, taking into account the size of the joint, presence of deformities, and repeated endoprosthetics necessity. A wide choice of constructions, as well as a variety of sizes and organ-preserving technologies for implantation of cementless components enabled the avoidance of cemented arthroplasty. It should be noted that positive reviews are reported about the usage of cementless components for patients under the age of 20 years (on average 17 years) according to the conclusion of a group of scientists from Philadelphia. They studied the efficacy of cementless total arthroplasty in patients under 20 years of age in a short term, and revealed that cementless total arthroplasty successfully restores the function and eliminates pain syndrome in adolescents. All patients were able to independently move and perform daily activities, including attending school. With short term follow-up period, no complications, failures, or repeated surgeries were noted [26]. Russian scientists made a great contribution to the study of the total hip arthroplasty aspects, but not all nosologies leading to stage III coxarthrosis have been studied, and the proportion of post-infectious coxarthrosis among them is small.

According to the mid-term results of our study, revision interventions were not performed in patients of both groups. Difference in indicators after arthroplasty in our study indicated a negative effect of treatment results on the number of surgeries performed. According to our study, multiple previous interventions on the hip joint negatively affect arthroplasty outcome. Nevertheless, arthroplasty enabled the reduction of hypotrophy degree and improved electrical activity of muscles in the affected joint area, even with their initial severe damage. The choice between arthrodesis and hip arthroplasty in patients of this age group is being discussed. In our opinion, arthrodesis performed even in the correct physiological position of the affected limb cannot provide an optimal quality of life for the patient and adversely affects the state of adjacent joints. Progressive cicatricial changes and fatty degeneration of the hip joint muscles can make arthroplasty simply impossible in the future. Dependence of fatty degeneration on the duration of ankylosis was studied [28]. Authors presented unsatisfactory functional results of endoprosthetics, and low rates of postoperative quality of life were registered with late endoprosthetics, in the presence of long-term ankylosis and irreversible muscle changes. The choice of total hip arthroplasty as a treatment method for terminal stage coxarthrosis is due to early patient activation, which contributes to the regression of cicatricial changes and muscle fatty degeneration.

CONCLUSION

Results after hip arthroplasty in adolescents with coxarthrosis, which developed as an acute hematogenous osteomyelitis complication and characterized by gross anatomical and functional disorders in the hip joint and surrounding soft tissues, are as close as possible to the results of patients in the control group, who did not have gross anatomical and functional changes in the hip joint and surrounding soft tissues.

Taking into account the restoration of the musculoskeletal function of the affected lower limb and absence of complications of the early and late postoperative period, total cementless hip arthroplasty in adolescents with the sequellae of acute hematogenous osteomyelitis is believed to be an effective surgical treatment method, since it restores the lower limb function within a short time and for a long period of time, which was lost as a result of acute hematogenous osteomyelitis, which in turn improves the quality of life and social adaptation of the adolescent.

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Patients (with their representatives) gave their consent to the processing and publication of personal data.

Author contributions. *Kh.D. Imomov* obtained and analyzed patient data, compiled the literature review, and wrote the article text. *V.E. Baskov* developed the study design and edited the article text. *V.A. Neverov* and *P.I. Bortulev* performed staged editing of the article text.

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