

REHABILITATION OF ADOLESCENTS AFTER SURGICAL TREATMENT OF DYSPLASTIC COXARTHROSIS

© *O.V. Bortuleva, V.E. Baskov, P.I. Bortulev, D.B. Barsukov, I.Y. Pozdnikin*

The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia

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Background. The prevalence and severity of stage II and III dysplastic coxarthrosis determine the medical and social importance of its prevention and treatment. For a practicing orthopedic surgeon, there are two established stages of orthopedic treatment: the surgical stage and the restorative stage. The domestic and foreign literature from the previous 25 years comprises few publications regarding the rehabilitation of young children after reconstructive hip joint surgeries. Thus, the issues regarding the rehabilitation of teenagers following extra-articular operations on the hip joint remain unexplored.

Aim. To evaluate the effectiveness of the developed program of rehabilitation for children after the surgical treatment of dysplastic coxarthrosis stages I and II.

Material and methods. We analyzed the results of the surgical and rehabilitative treatment of 40 children (100%) with dysplastic coxarthrosis stage I and II; the study population included 27 girls (67.5%) and 13 boys (32.5 per cent) aged 13–18 years (total 54 joints). The rehabilitation period was divided into the following 4 stages: I preoperative, II postoperative day 1–2, III postoperative day 3–21, IV outpatient treatment (after hospital discharge to 1 year postoperatively).

Results. By the time of discharge, the range of motion in the hip joint was as follows: bending $950^\circ \pm 40^\circ$, withdrawal $150^\circ \pm 50^\circ$, and extension $100^\circ \pm 30^\circ$. According to the results of the electromyography performed 3 months postoperatively, there was an increase in the amplitude of biopotentials for the gluteal muscle. The long-term result was evaluated after 1 year. The average modified Harris Hip Score and a scale developed in the The Turner Scientific and Research Institute for Children's Orthopedics, significantly ($p < 0.05$) differed from preoperative ones.

Conclusion. Early rehabilitation allows an increase in the strength and tone of muscles and restores the amplitude of movements in conditions of altered anatomical and biomechanical relationships in the hip. The verticalization of patients with the learning of proper load distribution on the parts of the foot enables effective recovery of the correct gait pattern. Comprehensive treatment of adolescents with dysplastic coxarthrosis according to the proposed method not only improves the condition of the affected hip joint and lower limb as a whole, but also improves the child's quality of life.

Keywords: children; rehabilitation; hip joint; dysplastic coxarthrosis; pelvic osteotomy.

РЕАБИЛИТАЦИЯ ПОДРОСТКОВ ПОСЛЕ ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ ДИСПЛАСТИЧЕСКОГО КОКСАРТРОЗА

© *О.В. Бортулёва, В.Е. Басков, П.И. Бортулёв, Д.Б. Барсуков, И.Ю. Поздникин*

ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург

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Актуальность. Распространенность патологии и тяжесть клинической картины при II и III стадиях диспластического коксартроза определяют высокую медико-социальную значимость его профилактики и лечения. Для практикующего хирурга-ортопеда является аксиомой то, что любое ортопедическое лечение состоит из двух нераздельных этапов: хирургического и восстановительного. В доступной отечественной и зарубежной литературе за последние 25 лет существуют единичные публикации о восстановительном лечении детей младшего возраста после реконструктивных операций на тазобедренном суставе. Вопросы реабилитации подростков после внесуставных операций на тазобедренном суставе остаются неизученными.

Цель исследования — оценить эффективность программы реабилитации детей после хирургического лечения диспластического коксартроза I–II стадий.

Материалы и методы. Проведен анализ результатов хирургического и восстановительного лечения 40 детей (100 %) с диспластическим коксартрозом I–II стадий: 27 девочек (67,5 %) и 13 мальчиков (32,5 %) в возрасте

от 13 до 18 лет (всего 54 сустава). Период реабилитации мы разделили на четыре этапа: I — предоперационный, II — 1–2-е сутки после хирургического лечения, III — 3–21-е сутки после хирургического лечения, IV — амбулаторный (с момента выписки из стационара до 1 года после хирургического лечения).

Результаты. К моменту выписки амплитуда движений в тазобедренном суставе составила: сгибание — $95 \pm 4^\circ$; отведение — $15 \pm 5^\circ$; разгибание — $10 \pm 3^\circ$. По данным электромиографии, выполненной через 3 месяца после операции, отмечалось увеличение амплитуды биопотенциалов для средней ягодичной мышцы. Отдаленный результат оценивался спустя 1 год. Средние показатели модифицированной шкалы Harris Hip Score и шкалы, разработанной в НИДОИ им. Г.И. Турнера, значимо ($p < 0,05$) отличались от дооперационных.

Выводы. Ранняя реабилитация позволяет увеличить силу и тонус мышц и восстановить амплитуду движений в условиях измененных анатомических и биомеханических соотношений в тазобедренном суставе. Вертикализация пациентов с обучением правильного распределения нагрузки на отделы стопы дает возможность эффективно восстановить корректный стереотип походки. Комплексное лечение подростков с диспластическим коксартрозом по предложенной методике не только улучшает состояние пораженного тазобедренного сустава и нижней конечности в целом, но и оказывает положительное влияние на качество жизни ребенка.

Ключевые слова: дети; тазобедренный сустав; реабилитация; диспластический коксартроз; остеотомия таза.

Introduction

Despite substantial advancements in medical technologies for the diagnosis and treatment of the musculoskeletal system pathology, decreasing the frequency of deforming arthrosis of the hip joint is challenging. Coxarthrosis of dysplastic genesis accounts for approximately 50% of large joints arthrosis. The prevalence of pathology and the severity of the clinical condition of dysplastic coxarthrosis (DKA) at stages II and III determine the high medical and social significance of its prevention and treatment. In addition, the congenital inferiority of hip joint tissues and the overburden of joint components due to the lack of coverage of the femoral head and the cotyloid cavity play a determining role in DKA pathogenesis [1–6]. In an actively growing individual, this condition is attributed to the imbalance between the growth rates of the cotyloid cavity and femoral components of the joint. The clinical and X-ray signs of DKA appear at 10–12 of age, or even earlier in acute cases. In contrast, after being symptomatic, there is no reverse development, and the disease progresses rapidly after the onset. During the development of degenerative and dystrophic diseases of the hip joint, the indicators of the patients' physical condition most significantly change as a result of biomechanics disorder of complete musculoskeletal system. Typically, the choice of the surgical intervention method depends on the specific clinical and radiological situation [7]. Thus, at stages I and II, the transposition of the acetabular joint component is the most effective in increasing the contact area of the articular surfaces of the femoral head and the

cotyloid cavity by altering the spatial orientation of the latter [8–11]. At stage II-b, the presence of fixed contractures, the severity of pain syndrome, and degenerative and dystrophic changes (DDC) in the pelvic and femoral joint components facilitate both organ-preserving and organ-replacing surgeries. At stage III of DKA, only surgical methods, such as total hip arthroplasty, can save patients from pain syndrome, enabling them to return to their age-specific, pre-disease lifestyle as soon as possible. In patients aged >18 years, the algorithm and treatment methods of DKA have been previously investigated and standardized [12]. However, in children, less attention has been paid to rehabilitation with regard to improving methods and techniques of surgical interventions. In the available Russian and foreign literature for over the past 25 years, only a few reports exist on the rehabilitation of children in the younger age group in the postimmobilization period after surgical treatment for hip joint instability of dysplastic genesis; there are no studies on restorative treatment after reconstructive surgeries of the hip joint in adolescents, especially in the early postoperative period.

Thus, this study **aims** to evaluate the efficacy of the developed program for the rehabilitation of adolescents after surgical treatment of DKA at stages I–II.

Materials and methods

Between 2015 and 2017, we reviewed the results of surgical and regenerative treatment of 40 children (100%) with DKA at different stages.

The patients comprised 27 girls (67.5%) and 13 boys (32.5%) aged 13–18 years (total 54 joints). Bilateral pathology was observed in 14 patients (35%). After a comprehensive examination, 15 patients (37.5%) were diagnosed with DKA stage I, 15 (37.5%) with stage IIa, and 10 (25%) with stage IIb. An informed consent was obtained from all patients to participate in the study, to process personal data, to examine and perform surgical intervention. All 40 patients (100%) underwent transposition of the cotyloid cavity after triple osteotomy of the pelvis, alone or in combination with femur osteotomy (Fig. 1). Of note, surgery was performed based on a technique developed in the Department of Hip Joint Pathology (Turner Scientific and Research Institute for Children's Orthopedics, Saint Petersburg, Russia) from the external-lateral access. In addition, clinical, radial, and electrophysiological research methods were used to assess the anatomical and functional state of the affected hip joint. The clinical examination comprised goniometry, limb length measurement, and gait evaluation. Radiation methods facilitated complex X-ray assessments based on the commonly used indicators (e.g., the angles of Wiberg and Sharp, front cover, inclination of the cavity in the sagittal plane and cervical–diaphyseal and that of the antetorsion, thickness of the cavity bottom, lateral and cranial displacement of the femoral head, and coefficient of the bone coverage) and assessed the severity and dynamics of DDC. In EMNG and EMG studies, the state of the nervous and muscular systems was determined before surgery, followed by evaluation and analysis of the data obtained. In the ENMG study of the femoral, tibial, and peroneal nerves, nerve

conductivity was assessed from both sides, including the state of myoneural apparatus of the lower extremities and the dependence of the severity of the deviation of neurophysiological indices of the normal ones. For a comprehensive assessment of the functional condition of the hip joint, all patients were asked to complete the questionnaire of the modified Harris Hip Score scale, signifying the functional condition of the hip joint, and that of the scale developed at the Turner Scientific and Research Institute for Children's Orthopedics, which characterizes the violations in the typical life of adolescents to a greater extent. The data obtained during this study were processed using the Statistica for Windows (version 6.0) program.

In this study, the rehabilitation period was divided into the following four stages:

I: preoperative;

II: 1–2 days after surgical treatment;

III: 3–21 days after surgical treatment;

IV: after patients were discharged to outpatient and polyclinic conditions in a primary care facility.

At stage I, the primary task was to develop a correct attitude in patients and their parents for the forthcoming surgical intervention, emphasizing the possibility of improving the adolescents' quality of life. Besides detailed information about the objectives of the forthcoming surgical intervention, unique aspects of anatomical changes, and biomechanics of the affected joint, all patients were trained in isometric contraction method of the muscles of the lower extremities, focusing on the gluteal muscles, the anterior surface of the femoral muscle, and the training of the correct walking stereotype. In addition, exercises were performed

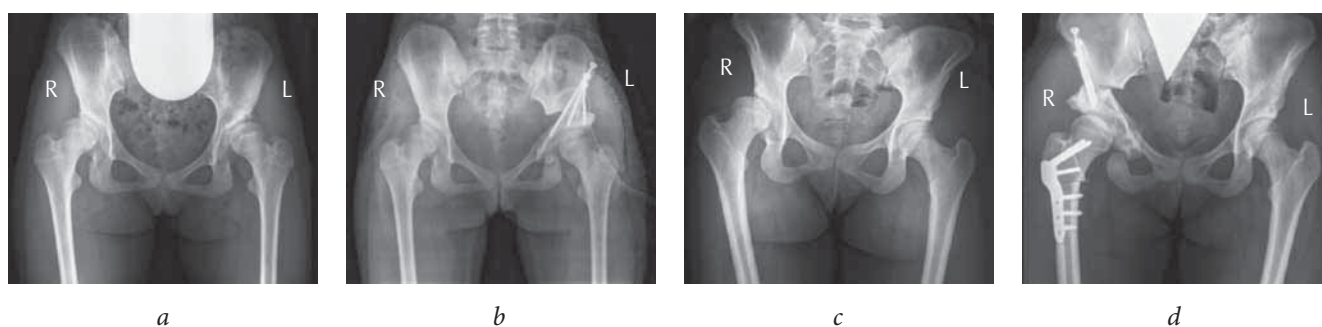


Fig. 1. Radiography of the hip joints in direct projection of patients in the treatment and control groups: *a* — Patient K., 14 years old, diagnosed with bilateral DKA of stage II, before surgery radiograph; *b* — Patient K., 14 years old, after transposition of the cotyloid cavity following triple osteotomy of the pelvis on the left. Osteosynthesis of fragments with malleolar screws is seen; *c* — Patient S., 17 years old, diagnosed with right-sided DKA stage IIa, before surgery; *d* — patient S., 17 years old, after transposition of the cotyloid cavity following triple osteotomy in combination with corrective osteotomy of the right femur. Osteosynthesis of pelvic fragments with malleolar screws and femur with a plate with angular stability (LCP pediatric hip plate) is seen

for 1 min (15 repetitions) for three to four times a day.

At stage II, the primary objective was to initiate recovery of the muscle tone and strength and amplitude of movements under conditions of altered anatomical relationships in the hip joint. In addition, the previously described exercises aimed at improving the “pump” function of the muscles. Based on our experience, one of the most effective exercises at this stage is flexion in the knee joint in the patient’s prone position. As several muscles of the hip joint region are diarticular, this exercise facilitates attaining their required stretching as quickly and painlessly as possible, which subsequently exerts a positive impact on restoring the amplitude of motion in the operated joint. From postoperative day 2, mechanotherapy was started on the “Artromot K1” apparatus by lying in extreme positions for up to 2 min, depending on the general state of the patients.

At stage III, mechanotherapy was continued with a gradual increase in the amplitude and speed of movements of the knee and hip joints. Under the guidance of an exercise physiologist, patients began performing active exercises focusing on flexion and retraction; these exercises must be static and dynamic, i.e., with a delay in the extreme positions in suspension, similar to the maximal involvement of the medial fibers in muscle work. Thus, the entire myogaster receives a uniform, maximum possible load. By day 5, we observed that the pain syndrome was almost completely arrested, and edema of the soft tissues of the postoperative wound area had considerably reduced. Further, to augment the muscle strength from this point to postoperative day 14, all active exercises were performed with “weight,” (gymnastic band), a fitball in the absence of muscle relaxation in extreme positions, and a gradual increase in “weight” because of a change in the density of rubber and the degree of air compression in the fitball. Notably, exercises were performed with repetitions for 10–15 times up to four times a day. On postoperative day 14 after the healing of the postoperative wound, we removed the sutures and performed control radiography, and all patients were verticalized. From day 15–21, all pediatric patients were taught walking with crutches in the absence of a load on the operated side with the obligatory performance of all step acts (stretching the limb forward, bending the hip and knee joints, and rolling from the heel to the toe). Besides continuing

physical therapy after the removal of stitches, all patients underwent electrostimulation of the gluteus muscles and the quadriceps muscle of the thigh in the syncope rhythm for 10–15 min (seven sessions).

At stage IV, after discharge, all patients were recommended to continue performing the above exercises of physical therapy and electric myostimulation of the muscles of the lower extremities with courses of 10–15 procedures once every 6 months. Furthermore, 12 weeks after surgery, the activities in pool and balneotherapy were recommended.

Results and discussion

The clinical examination facilitated in determining the magnitude of different sizes of the lower extremities. In this study, the limb shortening on the side of the lesion was 2.5 ± 1.1 cm. To estimate the amplitude of movements in the affected joint (flexion, $100^\circ \pm 5^\circ$; retraction, $30^\circ \pm 7^\circ$; extension, $15^\circ \pm 3^\circ$; rotational movements, $150^\circ \pm 5^\circ$) and determine the presence of decompensation of the function of the middle and minor gluteus muscles, a positive Duchenne–Trendelenburg symptom was diagnosed in 26 patients (86.7%). In addition, to perform manipulation specific for coxarthrosis and to determine the involvement of the joint surface of the femoral head and cotyloid cavity in the pathological process, positive FADIR and FABER test were performed in 39 patients (97.5%). The nearest results of the complex treatment were evaluated by the clinical method (goniometry) and radiographic method (X-ray) on postoperative days 18–20. The amplitude of movements in the hip joint at the time of discharge was as follows: flexion, $95^\circ \pm 4^\circ$; retraction, $15^\circ \pm 5^\circ$; and extension, $10^\circ \pm 3^\circ$. An equal limb length was attained in 31 patients (77.5%), whereas the residual shortening in nine patients (22.5%) did not exceed 1 cm. Moreover, the X-ray evaluation for the restoration of anatomical relationships after reconstructive interventions was performed along with electrophysiological examination after 3 months of the surgical treatment. We observed the highest differences (in 91% of cases) in pronounced shifts in the electromyography (EMG) pattern of the voluntary activity of the middle gluteus muscle. EMG revealed that the amplitude of the biopotentials was $<301 \pm 17.6$ mV for the middle gluteus muscle on the side of the

Таблица 1

Indices of the functional condition of the hip joint before and after the treatment

Average score by the Harris Hip Score		Average score on the scale developed at the Turner Scientific and Research Institute for Children's Orthopedics	
Before surgery	After 1 year	Before surgery	After 1 year
60.1 (95% CI: 57.5–62.8)	82.2 (95% CI: 73.8–90.6)	5.84 (95% CI: 5.23–6.45)	0.08 (95% CI: 0.04–0.12)

lesion before surgery and was $459 \pm 14.7 \mu\text{V}$ after 3 months on the same side after surgery.

We evaluated long-term results of the treatment after 1 year. The increase in the amplitude of movements in the operated joint was on average 15% ($14.5^\circ \pm 3.5^\circ$) of the available value at the time of discharge. In addition, the average values of the modified Harris Hip Score scale and the scale developed at the Turner Scientific and Research Institute for Children's Orthopedics differed significantly ($p < 0.05$) from the preoperative ones (Table 1), suggesting an improvement not only in the function of the lower extremities but also in the adolescents' quality of life as a whole.

For a practicing orthopedic surgeon, it is axiomatic that any orthopedic treatment comprises of two inseparable stages: surgical and restorative. To date, surgical treatment techniques for pediatric and adolescent patients with DKA have been comprehensively investigated and standardized [1, 2], which cannot be said regarding the rehabilitation following surgery for this category of patients. The limited studies on this topic primarily deal with the implementation of restorative treatment in children in the younger age group and are dated to the late 1970s and early 1980s [15]. The primary objective of such rehabilitation was to restore the amplitude of movements after prolonged gypsum immobilization. In addition, contemporary studies have also reported on the evaluation of the efficiency of restorative treatment of pediatric patients in the long-term postoperative period [16]. Nevertheless, the possibilities for starting early rehabilitation have not been investigated at all, which, in turn, emphasizes the urgency and necessity of creating such programs.

Conclusions

This study infers the following major findings. First, the early rehabilitation of adolescents after surgical treatment of DKA helps in increasing the

strength and tone of muscles and restoring the amplitude of movements in conditions of altered anatomical and biomechanical correlations in the hip joint after "aggressive" surgical intervention. Second, verticalization of patients with training to correctly distribute the load on foot in the early postoperative period facilitates efficient restoration of the correct gait stereotype with the observance of all acts of walking. Finally, complex treatment of adolescents with DKA, according to the proposed method, not only improves the condition of the affected hip joint and lower limb as a whole but also positively affects the quality of life of pediatric patients.

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Information about the authors

Oksana V. Bortuleva — MD, PhD Student of the Department of Hip Pathology. The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia.

Vladimir E. Baskov — MD, PhD, Head of the Department of Hip Pathology. The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia. E-mail: dr.baskov@mail.ru.

Pavel I. Bortulev — MD, Research Associate of the Department of Hip Pathology. The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia. E-mail: pavel.bortulev@yandex.ru.

Dmitry B. Barsukov — MD, PhD, Senior Research Associate of the Department of Hip Pathology. The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia. E-mail: dbbarsukov@gmail.com.

Ivan Y. Pozdnykin — MD, PhD, Research Associate of the Department of Hip Pathology. The Turner Scientific Research Institute for Children's Orthopedics, Saint Petersburg, Russia. E-mail: pozdnykin@gmail.com.

Оксана Вячеславовна Бортулёва — аспирант отделения патологии тазобедренного сустава ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург.

Владимир Евгеньевич Басков — канд. мед. наук, руководитель отделения патологии тазобедренного сустава ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург. E-mail: dr.baskov@mail.ru.

Павел Игоревич Бортулёв — научный сотрудник отделения патологии тазобедренного сустава ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург. E-mail: pavel.bortulev@yandex.ru.

Дмитрий Борисович Барсуков — канд. мед. наук, старший научный сотрудник отделения патологии тазобедренного сустава ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург. E-mail: dbbarsukov@gmail.com.

Иван Юрьевич Поздныкин — канд. мед. наук, научный сотрудник отделения патологии тазобедренного сустава ФГБУ «НИДОИ им. Г.И. Турнера» Минздрава России, Санкт-Петербург. E-mail: pozdnykin@gmail.com.