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COMPREHENSIVE TREATMENT OF LEGG-CALVE-PERTHES DISEASE IN CHILDREN

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Abstract

Introduction. Legg–Calvé–Perthes disease (LCPD) is one of the most common pediatric osteochondropathies and is characterized by aseptic necrosis of the femoral head epiphysis followed by stage-dependent remodeling. The disease results in impaired hip joint congruency, development of range-of-motion limitations, pain syndrome, and an abnormal gait pattern.

Materials and Methods A prospective non-randomized controlled clinical trial. At this stage, 36 patients diagnosed with Legg–Calvé–Perthes disease were included and allocated according to the treatment method: the main group comprised 15 children, and the control group comprised 21 children. Primary data were obtained from inpatient medical records (Form No. 003/u).

Results. Both groups demonstrated a positive trend in hip joint functional status; however, improvement was more pronounced in the main group, with progression to the level of full compensation. Intergroup differences were statistically significant ($p < 0.001$).

Conclusions. Comprehensive treatment of Legg–Calvé–Perthes disease in children provided a statistically significant improvement in hip joint functional status in the long-term follow-up period. In the main group, outcomes assessed by the mHHS and Tsykunov scales were significantly higher than those in the control group.

Key words: Legg-Calve-Perthes disease, Modified Harris Hip score, Stulberg classification.

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Резюме

КОМПЛЕКСНОЕ ЛЕЧЕНИЕ БОЛЕЗНИ ЛЕГГ-КАЛЬВЕ-ПЕРТЕСА У ДЕТЕЙ

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Введение. Болезнь Легга–Кальве–Пертеса (БЛКП) относится к наиболее распространённым остеохондропатиям детского возраста и характеризуется асептическим некрозом эпифиза головки бедренной кости с последующим стадийным ремоделированием. Заболевание приводит к нарушению конгруэнтности тазобедренного сустава, формированию ограничений движений, болевого синдрома и патологического стереотипа ходьбы.

Материалы и методы. Проспективное нерандомизированное контролируемое клиническое исследование. На данном этапе в исследование включено 36 пациентов с диагнозом болезни Легга–Кальве–Пертеса, распределение которых осуществлялось в зависимости от применённого метода лечения: основная группа — 15 детей, контрольная — 21 ребёнок. Источником первичной информации являлись медицинские карты стационарных больных (форма №003/у).

Результаты. В обеих группах отмечена положительная динамика функционального состояния тазобедренного сустава, однако у пациентов основной группы улучшение было более выраженным, с переходом к уровню полной компенсации. Различия между группами были статистически значимыми ($p < 0,001$).

Выводы. Комплексное лечение болезни Легга–Кальве–Пертеса у детей обеспечило статистически значимое улучшение функционального состояния тазобедренного сустава в отдаленном периоде наблюдения, при этом в основной группе результаты по шкалам mHNS и Цыкунова были достоверно выше по сравнению с контрольной.

Ключевые слова: болезнь Легг–Кальве–Пертеса, Modified Harris Hip score, классификация по Stulberg.

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Түйіндеме

БАЛАЛАРДАҒЫ ЛЕГГ-КАЛЬВЕ-ПЕРТЕС АУРУЫН КЕШЕНДІ ЕМДЕУ

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Кіріспе. Легг–Кальве–Пертес ауруы (ЛКПА) балалар жасындағы ең жиі кездесетін остеохондропатиялардың бірі болып табылады және сан сүйегі басының эпифизінде асептикалық некроздың дамуы, кейіннен кезеңдік ремоделденуімен сипатталады. Ауру жамбас-сан буынының конгруэнттілігінің бұзылуына, қозғалыс көлемінің шектелуіне, ауырсыну синдромының пайда болуына және жүріс стереотипінің патологиялық өзгеруіне алып келеді.

Материалдар мен әдістер. Зерттеу дизайны бойынша жұмыс проспективті, рандомизацияланбаған, бақыланатын клиникалық зерттеу ретінде жүргізілді. Осы кезеңде Легг–Кальве–Пертес ауруы диагнозы қойылған 36 пациент зерттеуге енгізілді, олар қолданылған емдеу әдісіне байланысты бөлінді: негізгі топқа 15 бала, бақылау тобына 21 бала енгізілді. Бастапқы ақпарат көзі ретінде стационарлық науқастардың медициналық карталары (№003/у нысаны) пайдаланылды.

Нәтижелер. Екі топта да жамбас-сан буынының функционалдық жағдайының оң динамикасы байқалды, алайда негізгі топтағы пациенттерде жақсарудың айқындылығы жоғары болып, толық компенсация деңгейіне өтуімен сипатталды. Топтар арасындағы айырмашылықтар статистикалық тұрғыдан мәнді болды ($p < 0,001$).

Қорытындылар. Балалардағы Легг–Кальве–Пертес ауруын кешенді емдеу ұзақ мерзімді бақылау кезеңінде жамбас-сан буынының функционалдық жағдайының статистикалық тұрғыдан мәнді жақсаруын қамтамасыз етті. Негізгі топта mHNS және Цыкунов шкалалары бойынша нәтижелер бақылау тобымен салыстырғанда сенімді түрде жоғары болды.

Түйінді сөздер: Легг–Кальве–Пертес ауруы, Modified Harris Hip score, Stulberg классификациясы.

Дәйексөз үшін:

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Introduction

Legg–Calvé–Perthes disease (LCPD) is an idiopathic avascular necrosis of the femoral head epiphysis in children. It belongs to the group of pediatric osteochondropathies and is characterized by impaired blood supply followed by stage-dependent bone remodeling [1–3]. The disease leads to loss of hip joint congruency, reduced range of motion, pain syndrome, and abnormal gait patterns in affected children [4–6]. In a proportion of cases, residual femoral head deformity develops, which markedly increases the likelihood of early degenerative changes of the hip joint in adulthood [7–10].

To date, the etiology of LCPD remains multifactorial; disturbances of femoral head perfusion and bone trophic support are considered among the most important

pathogenetic mechanisms [11–13]. The condition most commonly occurs in children aged 4–8 years, and boys are affected substantially more often than girls [2,6].

Despite extensive clinical experience accumulated over decades, the optimal treatment strategy for pediatric LCPD continues to be debated [14–17]. Treatment success depends not only on the selected intervention, but also on timely unloading of the affected joint, the ability to restore hip biomechanics, and the quality of the rehabilitation program [15, 17–18].

Current concepts increasingly support combined approaches that integrate surgical techniques aimed at correcting intra- and periarticular abnormalities and improving conditions for femoral head repair, together with structured early rehabilitation programs designed to restore

limb function and reduce the risk of secondary complications [9,11,17].

The aim of the study. To evaluate clinical and functional results of comprehensive management of Legg–Calvé–Perthes disease in children.

Materials and Methods. A prospective, non-randomized, controlled clinical study. The study was conducted at the Department of Orthopedics and Rehabilitation of the Municipal State Enterprise “Multidisciplinary City Children’s Hospital No. 2” (Astana), at the Center for Diagnosis and Treatment of Rare Bone Pathology of the “Multidisciplinary Clinic Alanda” LLP (Astana), and at the Department of Orthopedics No. 2 of the Corporate Fund “University Medical Center” (Astana) during the period from 2018 to 2024.

Approval for the study was obtained from the Local Ethics Committee of the Non-Commercial Joint-Stock Company “Semey Medical University” (Protocol No. 2 dated October 25, 2018). At the current stage, 36 patients diagnosed with Legg–Calvé–Perthes disease were included. Group allocation was determined by the treatment method: the main group comprised 15 children, while the control group included 21 children. Primary data were obtained from inpatient medical records (Form No. 003/u). The allocation of patients into study groups was carried out on the basis of informed consent obtained from their legal representatives. Parents (or legal guardians) were provided with detailed information regarding the available treatment options, including an explanation of the treatment objectives, potential risks, expected outcomes, and possible complications associated with each method. Following this, a decision on the treatment approach was made, and patients were assigned to either the main (intervention) group or the control group accordingly. *The inclusion criteria:* patient age 7 to 17 years 11 months, stage II–III disease, and provision of informed consent for the use of the developed surgical approach (main group). Exclusion criteria were: age below 7 years, stages I, IV, and V of Legg–Calvé–Perthes disease, and incomplete diagnostic evaluation.

In the main group, surgical treatment was performed using an external fixation device with a distraction system. In the control group, a conventional surgical technique was applied, consisting of tunneling of the femoral head and neck with subsequent insertion of autologous cancellous bone graft [19]. The age at the time of surgery (both the developed and traditional methods) ranged from 7 to 11 years.

Treatment effectiveness was assessed starting from hospital discharge, with follow-up evaluations at 3, 6, and 12 months. Outcome analysis was performed for all included patients based on comprehensive clinical examination data and assessment of lower-limb functional status.

A comprehensive clinical and functional evaluation of the hip joint was conducted using the method proposed by Professor M.B. Tsykunov [20], which provides a quantitative assessment of pain severity, range of motion, gait characteristics, weight-bearing capacity, muscle atrophy, and limb length discrepancy.

Given the disabling nature of Legg–Calvé–Perthes disease in children, quality-of-life assessment was

incorporated into the study protocol. For evaluation of quality of life and functional hip status, the Modified Harris Hip Score (mHHS) questionnaire was used.

Development of an early rehabilitation algorithm after the use of an external fixation distraction system

An early rehabilitation protocol was developed to enhance functional recovery of the hip joint in children after surgical treatment of Legg–Calvé–Perthes disease, as well as to prevent muscle hypotrophy and reduce the risk of persistent contractures. The program was implemented both during limb fixation in the external fixator and after device removal, ensuring continuity of rehabilitation interventions throughout all stages of treatment [20–22].

The rehabilitation program was initiated on the first postoperative day. Patients were prescribed breathing exercises and were instructed in basic self-care activities and safe ambulation with crutches (standing up and moving within the ward), with mandatory supervision of proper load distribution and correct positioning/support of the operated limb. Isometric exercises were typically started on postoperative day 4, after reduction of the acute postoperative pain syndrome.

The exercise program included the following components:

Exercise 1. Isometric contraction of the hip abductors. A 5–8 cm support block was used. The patient placed the unaffected limb on the block and additionally supported the body with the hands, performing an isometric contraction of the abductor muscles of the operated limb without active movement. Each contraction was held for 3–5 seconds, followed by relaxation for 5–7 seconds. The exercise was performed for 8–10 repetitions in 2–3 sets.

Exercise 2. Isometric contraction of hip extensors (gluteal muscles). In the supine position (or prone position depending on the fixator configuration), the patient performed isometric gluteal activation without motion at the hip joint. The regimen included 3–5 seconds of contraction, 5–7 seconds of relaxation, 8–10 repetitions, and 2–3 sets.

Exercise 3. Isometric contraction of the hip adductors. In the supine position, a soft roll was placed between the knees, which the patient compressed without movement in the hip joints. The protocol was similar: 8–10 repetitions and 2–3 sets.

Neuromuscular electrical stimulation was initiated on postoperative days 4–5 in the absence of inflammatory complications and provided stable fixation within the external fixator. Isometric exercises represented the core component of early rehabilitation and were performed daily throughout the period of restricted active motion, which averaged 3–4 weeks. Subsequently, a gradual transition to active and dynamic therapeutic exercises was carried out.

Active exercises and dynamic physiotherapy were introduced after removal of the external fixation distraction system and restoration of stability of the osteoarticular structures. During the first two weeks, continuous passive motion (CPM) therapy of the hip joint was used as a mechanotherapy modality. Regular sessions facilitated early improvement in range of motion, reduction of swelling, enhancement of blood supply, and alleviation of pain. CPM therapy was generally well tolerated and was typically associated with minimal or no pain.

Therapeutic exercises were predominantly performed in the supine position. All movements were carried out smoothly and at a slow pace, avoiding abrupt actions and excessive muscle strain. An important element of training was instruction in proper breathing: inhalation was mainly synchronized with the contraction phase, whereas exhalation corresponded to relaxation. Exercises were performed in 8–10 repetitions for 2–3 sets (Figures 1–4).



Figure 1. Starting position for the exercise.

Exercise No. 6. This calf muscle exercise was initiated immediately after recovery from anesthesia following removal of the external fixation distraction system. The patient performed gentle ankle movements by pulling the foot toward the body (dorsiflexion) and pushing it away (plantar flexion) with mild muscle tension.

Exercise No. 7. Hip abduction of the operated limb was performed within a range of up to 15° without lifting the leg from the bed surface. The pelvic reference points remained unchanged during the movement, indicating the absence of pelvic shift while performing the exercise (Figure 2).



Figure 2. Demonstration of Exercise No. 7.

Exercise No. 8. With the knee flexed and the heel used as a support point, the patient performed a circular movement to slightly lift the “hip point” on the unaffected side. The operated lower limb remained immobile. Subsequently, the lower limb was rotated inward up to the “knee point,” directing the movement toward the healthy side (Figure 3a, b).

Exercise No. 9. Simultaneous maximal inward movement of both “knee points and feet,” followed by returning the limbs back to the initial position. The exercise was limited to the reverse movement only (Figure 4).

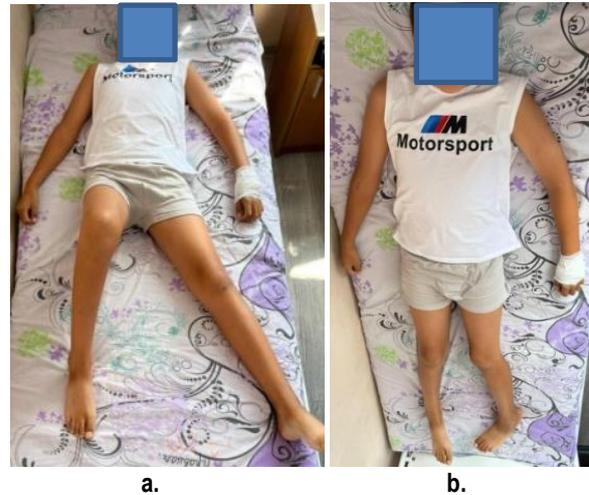


Figure 3 (a,b). Illustration of Exercise No. 8.



Figure 4. Illustration of Exercise No. 9.

Exercise No. 10. This exercise was performed under the supervision of a physiotherapy instructor. The patient was asked to carefully lift the operated limb with the knee flexed, gradually increasing the elevation to an individually tolerated level.

Exercise No. 11. With the operated limb placed on a support block and the patient bearing weight on the hands, an isometric contraction of the hip adductor muscles was performed, holding the contraction for 1–3 seconds.

Exercise No. 12. The patient supported the body with the hands while the operated limb, flexed at the hip joint, was positioned on a support block. Isometric contraction of the hip flexor muscles was then performed. The protocol included 5–10 repetitions performed 5–10 times per day. The height of the support block was increased gradually as functional capacity improved.

This exercise set was aimed at strengthening the flexor and extensor muscle groups of the lower limbs, improving

coordination, and restoring physiological movement patterns.

Exercise No.13. Sit-to-stand transfer. To perform the exercise, the patient leaned the trunk forward, initiated a partial rise, and then fully extended to the standing position. Crutch length was individually adjusted according to the patient's height to ensure correct posture while standing. The feet were positioned parallel, and weight bearing was distributed on both limbs with gradual involvement of the affected side.

Exercise No.14. Stair ascent and descent without using handrails. Initially, the unaffected limb was placed on the step while the operated limb was slightly lifted. The crutches were then moved, followed by placement of the operated limb onto the next step.

Starting from day 15 after removal of the distraction system, patients were allowed to perform water-based exercises aimed at gentle muscle activation without axial overload. After 6–8 weeks, stationary cycling without resistance was prescribed for 3–10 minutes, 1–2 times per day, under specialist supervision.

The active rehabilitation phase lasted from 6 to 12 months or longer. During this period, a gradual increase in active load on the lower extremities was implemented. After radiological confirmation of completion of reparative processes (reconvalescence stage), patients were allowed to walk without crutches.

Results

The results of hip joint functional assessment using the Tsykunov scale in both groups before treatment and at long-term follow-up are presented in Table 1.

Table 1.

Distribution of patients according to the Tsykunov scale in the two groups.

Group	Before treatment	After 12 months	p (W test, within the group)
Main group (n=15), Me [Q1-Q3]	2,8 [2,7; 3,0]	4,5 [4,2; 4,6]	p = 0,001
Control group (n=21), Me [Q1-Q3]	2,8 [2,7; 3,0]	3,3 [3,1; 3,8]	p < 0,001

According to Table 1, before treatment the integral score on the M.B. Tsykunov scale was comparable in the main and control groups and corresponded to a decompensated level of hip joint function: Me 2.8 [2.7; 3.0] in both groups.

In the main group, a pronounced improvement in hip joint function was observed, reaching values consistent with complete functional compensation: Me 4.5 [4.2; 4.6]. The within-group change was statistically significant (Wilcoxon signed-rank test, p = 0.001).

In the control group, a significant increase in the Tsykunov integral score was also identified: Me 3.3 [3.1; 3.8], which corresponds to a subcompensated functional level. Differences compared with baseline were statistically significant (Wilcoxon signed-rank test, p < 0.001).

Thus, both groups demonstrated positive functional dynamics of the hip joint; however, improvement was more substantial in the main group, with progression to complete functional compensation.

Between-group differences became distinct and statistically significant. In the main group, the proportion of patients with good and excellent outcomes reached 100%, whereas in the control group similar results were observed only in 38.1% of children (p < 0.001) (Table 2).

Functional assessment using the mHHS at 12 months showed that the median value in the main group reached 89 [88–90] points, corresponding to a good-to-excellent level of recovery. In the control group, the median was 77 [70–81] points, reflecting predominantly satisfactory functional outcomes. The differences between the groups were statistically significant (p < 0.001).

Table 2.

Pain score dynamics in children with Legg–Calvé–Perthes disease according to the mHHS scale at 12 months of treatment in the compared groups.

Grades	Main group (%), n-15	Control group (%), n-21	Statistical test
Excellent	6 (40,0)	2 (9,5)	F, p =0,001
Good	9 (60,0)	6 (28,6)	
Satisfactory	0 (0)	10 (47,6)	
Unsatisfactory	0 (0)	3 (14,3)	

The mHHS assesses hip joint function from the patient's perspective and reflects a subjective evaluation of pain severity and limitations in daily activities, whereas the M.B. Tsykunov scale is a clinician-based tool designed for an objective characterization of the orthopedic status. The combined use of these instruments provided a comprehensive and multidimensional assessment of the effectiveness of the applied treatment.

Discussion

The findings of this prospective study demonstrate that comprehensive management of Legg–Calvé–Perthes disease in children leads to a pronounced improvement in

hip joint function over a 12-month follow-up period. However, the extent of recovery was strongly influenced by the treatment strategy applied. The most substantial differences between the compared groups were observed at 12 months, suggesting a cumulative effect of treatment and rehabilitation interventions, which is consistent with the stage-dependent course of the disease and the prolonged nature of femoral head reparative remodeling.

Functional assessment using the mHHS at 12 months revealed a statistically significant advantage in the main group: the median score was 89 [88–90] points compared with 77 [70–81] points in the control group (p < 0.001).

These values indicate that patients in the main group achieved outcomes within the “good-to-excellent” range, whereas functional results in the control group were predominantly “satisfactory.” A similar trend was found when analyzing outcome categories: 100% of children in the main group had good or excellent results, while this proportion reached only 38.1% in the control group ($p < 0.001$). Therefore, the observed differences were not only statistically significant but also clinically meaningful, reflecting tangible improvements in daily activity performance, walking tolerance, and pain reduction.

Additional evidence supporting the effectiveness of the comprehensive approach was provided by the dynamics of the integral score on the M.B. Tsykunov scale. This clinician-based assessment tool enables quantitative characterization of the orthopedic status. At baseline, both groups had comparable values (Me 2.8 [2.7; 3.0]), indicating severe functional impairment and hip decompensation prior to treatment. At 12 months, the main group reached 4.5 [4.2; 4.6], corresponding to complete functional compensation, whereas the control group improved to 3.3 [3.1; 3.8], which reflects a subcompensated functional level. In both groups, within-group improvement was statistically significant ($p = 0.001$ and $p < 0.001$, respectively). Thus, positive functional changes were observed in all patients; nevertheless, recovery in the main group was more pronounced and was accompanied by progression to a more favorable functional status.

Importantly, the present study evaluated treatment outcomes using two complementary instruments with different clinical orientations. The mHHS reflects patient perception of pain and functional limitations, representing a patient-reported outcome measure. In contrast, the Tsykunov scale is based on objective clinical criteria and characterizes joint status from the physician’s perspective. The combined use of subjective and objective assessments reduces the risk of one-sided interpretation, which is particularly relevant in pediatric orthopedics, where functional improvement may either precede or lag behind clinical signs of compensation.

The results suggest that the superior outcomes observed in the main group were likely driven by two interrelated factors: the selected surgical strategy and the structured early rehabilitation program. In Legg–Calvé–Perthes disease, a key therapeutic goal is to create optimal conditions for femoral head remodeling while preserving sphericity and articular congruency. Failure to achieve these conditions may result in residual deformity, which determines long-term prognosis and increases the risk of early hip osteoarthritis. Techniques aimed at unloading the joint and optimizing biomechanics may reduce intra-articular compression and promote a more physiological course of reparative processes. In this context, rehabilitation becomes critically important, as it supports muscle balance, prevents contracture formation, and contributes to restoration of range of motion.

In the present study, early rehabilitation was organized in a stepwise manner and started from the first postoperative day. During the initial stage, emphasis was placed on residual pain reduction, alleviation of muscle spasm, training in safe mobility, and prevention of muscle atrophy. The use of isometric exercises under conditions of

restricted active motion is physiologically justified, as it maintains neuromuscular activation without imposing excessive load on the hip joint. The early addition of neuromuscular electrical stimulation (in the absence of inflammatory complications) may have further supported tissue trophic maintenance and improved muscle contractile capacity. It should be emphasized that preservation of strength in the hip abductors, flexors, and extensors is a key determinant of gait recovery and reduction of limping, which is directly reflected in mHHS outcomes.

A notable finding was that between-group differences became most evident at the 12-month time point. This highlights the importance of long-term follow-up in children with Legg–Calvé–Perthes disease. Early follow-up periods (3–6 months) may primarily reflect pain reduction and partial gait improvement, whereas final functional assessment requires sufficient time for completion of major reparative remodeling processes. From a practical standpoint, evaluation of treatment effectiveness in LCPD should therefore include at least one year of follow-up, and preferably longer when feasible.

Overall, the results of this study support the clinical rationale for a comprehensive approach to pediatric Legg–Calvé–Perthes disease, combining surgical intervention with a structured early rehabilitation program. The significant improvement in hip function according to mHHS and the transition to complete compensation on the Tsykunov scale in the main group indicate the clinical effectiveness of the proposed strategy. These findings suggest that comprehensive treatment may represent a promising approach to improving quality of life and functional outcomes in children with LCPD during the first year of follow-up.

Conclusions. Comprehensive treatment of Legg–Calvé–Perthes disease in children resulted in a statistically significant improvement in hip joint function at long-term follow-up. Moreover, functional outcomes assessed by the mHHS and Tsykunov scales were significantly higher in the main group compared with the control group.

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