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Femoral Head Reduction Osteotomy for the Treatment of Severe Femoral Head Deformities and Articular Incongruity in Children with Perthes Disease

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Abstract

Background. Lack of adequate treatment for children with Perthes disease leads to the formation of severe femoral head deformity with articular surfaces incongruity, followed by the development of femoroacetabular impingement and early hip osteoarthritis. To date, femoral head reduction osteotomy is the most effective treatment option for such patients. However, the results of its performance have been discussed in only a few case-control studies with small sample sizes in both international and domestic literature.

The aim of the study was to evaluate the effectiveness and safety of femoral head reduction osteotomy and to analyze the further development of the hip joint in children operated for severe femoral head deformity due to Perthes disease.

Methods. We have analyzed preoperative and postoperative results of clinical and radiological examination of 20 patients (20 hip joints) aged 8 to 12 years with deformed Perthes femoral head and articular surfaces incongruity. Femoral head reduction osteotomy was performed in all patients.

Results. A radical proximal femoral reconstruction has led to significant improvement in the shape of the proximal femur with improved head sphericity and restoration of articular congruence. However, at the 6- to 12-month follow-up, some patients, primarily those with progressive lateral acetabular rim deformity, exhibited a decrease in the intraoperatively achieved Wiberg angle, an increase in the percentage of femoral head extrusion from the acetabulum, and varying degrees of Shenton line disruption.

Conclusions. Performing femoral head reduction osteotomy with correct surgical technique is an effective reconstructive technique for the treatment of children with a severe saddle-shaped deformity of the femoral head and articular surfaces incongruity. In patients with Tönnis and Sharp angles exceeding the upper limit of the physiological norm, due to the formation of secondary subluxation, it is advisable to simultaneously perform femoral head reduction osteotomy and triple/periacetabular pelvic osteotomy. This treatment option should be chosen only after a critical analysis of potential risks.

Keywords: children, Legg-Calve-Perthes disease, saddle-shaped deformity, incongruity, femoral head reduction osteotomy, hip subluxation.

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Сегментарная резекция головки бедренной кости при грубой деформации эпифиза и дисконгруэнтности суставных поверхностей у детей с болезнью Пертеса

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Реферат

Актуальность. Отсутствие адекватного лечения детей с болезнью Пертеса приводит к формированию грубой деформации головки с дисконгруэнтностью суставных поверхностей с последующим развитием фемоно-ацетабулярного импинджмента и раннего коксартроза. В настоящее время у данной категории пациентов наибольшей эффективностью обладает сегментарная резекция головки бедренной кости. Однако результаты ее выполнения в мировой и отечественной литературе освещены в единичных публикациях с дизайном «случай — контроль» и небольшим количеством пациентов.

Цель исследования — оценить эффективность и безопасность выполнения сегментарной резекции головки бедренной кости, а также динамику дальнейшего развития тазобедренного сустава на основании анализа результатов хирургического лечения детей с грубой деформацией головки бедренной кости при болезни Пертеса.

Материал и методы. Проведен анализ результатов клинического и лучевого методов исследования 20 пациентов (20 тазобедренных сустава) в возрасте от 8 до 12 лет с грубой деформацией головки бедренной кости и дисконгруэнтностью суставных поверхностей при болезни Пертеса до и после оперативного лечения. Всем пациентам выполнялась сегментарная резекция головки бедренной кости.

Результаты. Радикальная реконструкция проксимального отдела бедренной кости привела к значительному улучшению его формы, улучшению сферичности головки и восстановлению конгруэнтности. Вместе с тем на сроке наблюдения от 6 до 12 мес. у пациентов с имеющейся исходно хоть и не выраженной, но прогрессирующей деформацией латерального края вертлужной впадины, отмечалось уменьшение достигнутых интраоперационно значений угла Wiberg, увеличение процента экструзии головки бедренной кости из вертлужной впадины, а также нарушение непрерывности линии Shenton различной выраженности.

Заключение. Выполнение сегментарной резекции головки бедренной кости с соблюдением корректной хирургической техники является безопасной и эффективной реконструктивной методикой лечения детей с грубой «седловидной» деформацией головки бедра и дисконгруэнтностью суставных поверхностей. У пациентов со значениями углов Tönnis и Sharp, превышающими верхнюю границу среднефизиологической нормы, ввиду формирования вторичного подвывиха целесообразно симультанно выполнять сегментарную резекцию головки бедренной кости и тройную/периацетабулярную остеотомию таза после проведения критического анализа возможных рисков.

Ключевые слова: дети, болезнь Легга–Кальве–Пертеса, седловидная деформация, дисконгруэнтность, сегментарная резекция головки бедренной кости, подвывих бедра.

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INTRODUCTION

Perthes disease, historically considered an osteochondropathy, is now classified as an idiopathic avascular necrosis of the femoral head in children [1]. Although the etiology of the disease has been extensively studied, it remains not fully clear. Though the primary hypothesis suggests a multifactorial origin, several theories have been proposed, including mechanical, genetic, and systemic risk factors [2, 3, 4, 5]. According to various authors, the incidence ranges from 0.4 to 29.0 per 100,000 children per year [6, 7, 8]. The disease typically manifests between the ages of 3 and 12 years, most commonly between 5 and 7 years. Boys are affected up to five times more frequently than girls, and in 76-90% of cases, the disease is unilateral [9, 10]. The disruption of blood supply to the femoral epiphysis is the underlying cause of the disease, while genetic and other factors may predispose to its development [11]. Currently, the gold standard for treating children with Perthes disease is containment therapy, aimed at preventing femoral head deformity. This can be achieved either conservatively (using plaster casts or orthopedic braces depending on the child's age) or through reconstructive surgery [12, 13, 14, 15, 16].

Without appropriate treatment, children with extensive necrotic focus inevitably develop severe femoral head deformity and articular surface incongruity, leading to adduction contracture, gait disturbances, pain, and ultimately femoroacetabular impingement and early hip osteoarthritis [17, 18, 19, 20, 21].

Surgical treatment in such cases remains challenging, with the optimal correction technique still debated. Its choice largely depends on the severity of the femoral head deformity. The main goals of reconstructive surgery are to eliminate the pathomechanical conflict between the femoral head and acetabular rim, improve the shape of the proximal femoral epiphysis, and restore congruence in the hip joint.

For children with the severe loss of femoral head sphericity (saddle-shaped deformity) and joint surface incongruity, where periarticular osteotomies aimed at primary surgical containment are contraindicated, the most appropriate surgical method is femoral head reduction osteotomy. This technique was first described by M. Leunig and R. Ganz [22] and later detailed in a comprehensive surgical technique report by K.A. Siebenrock et al. [23]. Despite its high effectiveness, femoral head reduction osteotomy has been discussed in only a few case-control studies with small sample sizes in both international and domestic literature. Additionally, some studies suggest that most patients who undergo femoral head reduction osteotomy subsequently require triple pelvic osteotomy due to secondary hip subluxation [23, 24].

The aim of the study was to evaluate the effectiveness and safety of femoral head reduction osteotomy and to analyze the further development of the hip joint in children operated for severe femoral head deformity due to Perthes disease.

METHODS

Study design: a single-center open-label prospective cohort study.

Inclusion criteria: age from 8 to 12 years, severe saddle-shaped femoral head deformity with articular incongruity, no prior hip operations, no neurological or hereditary diseases, voluntary informed consent from legal guardians for participation in the study.

Exclusion criteria: age below 8 or above 12 years, preservation of femoral head sphericity, possibility of achieving primary surgical containment through extra-articular procedures, confirmed neurological or hereditary diseases.

The study included 20 patients (20 hip joints) aged 8-12 years (mean age 10.2±1.1) with severe femoral head deformity and articular incongruity due to Perthes disease.

Clinical examination was held according to standard orthopedic protocols for hip pathology assessment. Comprehensive preoperative evaluation included hip X-ray imaging in AP and axial views, as well as in the abducted position of the lower limbs (to verify the absence of femoral head centration within the acetabulum, indicating articular incongruity), along with computed tomography (CT) and magnetic resonance imaging (MRI) of the hip joints. All images were used to assess the true extent of the femoral head deformity, the condition of the hyaline cartilage, and the positioning of the acetabular rim.

Radiographic parameters assessed included Sharp angle, Tönnis angle, femoral neck-shaft angle (NSA), articulo-trochanteric distance (ATD), index of sphericity of acetabulum (ISA), index of sphericity of femoral head (ISH), index of congruence of articular surface (ICAS), femoral head extrusion index (FHEI), Wiberg angle, and Shenton line continuity.

CT was used for the further assessment of the proximal femoral epiphyseal deformity and signs of postoperative avascular necrosis.

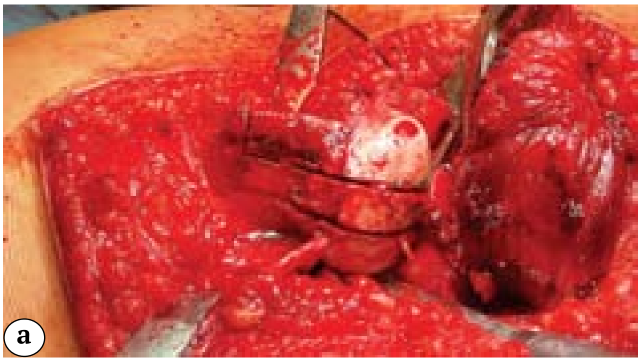
Surgical technique

Reconstructive operation was performed under combined anesthesia with multimodal analgesia for 48 hours postoperatively. We strictly adhered to the methodology of safe surgical hip dislocation and femoral head reduction osteotomy [22, 23]. With a patient in decubitus position on the healthy side, a skin incision was made, followed by subcutaneous tissue and fascia dissection. After exposing the external hip rotators, a trochanteric slide osteotomy was performed for improved joint capsule visualization. The capsule was then incised in a Z-shaped manner. After transecting the ligamentum teres, the femoral head was dislocated, and a periosteal-capsular-muscular flap containing the main vascular supply (medial femoral circumflex artery branches) was mobilized. Segmental femoral head reduction osteotomy was then performed (Figure 1).

After reducing the femoral head into the acetabulum, radiography of the hip joint was performed in AP and axial views using a C-arm, along with the visual assessment of the range of motion and the evaluation of the position of the acetabular rim. The next stage involved tight closure of the joint capsule, distalization of the greater trochanter to relatively lengthen the femoral neck and achieve satisfactory tension of the gluteus medius muscle, followed by osteosynthesis using two 4.5 mm screws with washers for adequate compression. The wound was sutured in layers, leaving a drain tube at the anterior surface of the hip joint capsule.

Statistical analysis

Statistical analysis was conducted using Excel 2010 and SPSS Statistics v.26. Descriptive statistics included means (M), standard deviations (SD), and median (Me) with the 25th and 75th percentiles (Q_1-Q_3). The Mann-Whitney U test and Wilcoxon test were used for comparisons. Spearmen's rank correlation coefficient (Rs) was used to determine relationship strength ($0.01 \leq r \leq 0.29$ – weak; $0.30 \leq r \leq 0.69$ – moderate; $0.70 \leq r \leq 1.00$ – strong). The value of the coefficient described the direction (positive or negative) of correlation. To assess the degree and type of influence of one variable on another, regression analysis was performed using both linear and quadratic regression models. The proportion of variance explained was evaluated using the coefficient of multiple determination (R^2).



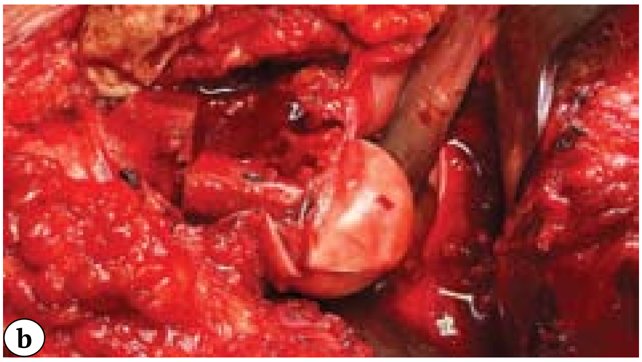


Figure 1. The stages of performing femoral head reduction osteotomy:
a — marking and osteotomy of the preoperatively planned central part of the head and neck; b — fragment adaptation and osteosynthesis with two 3.5 mm screws after removal of the central part of the head and neck

Table 1

Patients' hip goniometry results before surgical reconstruction, deg.

Motion	Range of motion of the affected joint, M±SD, Me [Q_1-Q_3]	Range of motion of the healthy joint, M±SD, Me [Q_1-Q_3]
Flexion	104.3±5.3 105 [100-105]	117±4.6 120 [115-120]
Abduction	5±3.1 5 [5-5]	38±3.4 40 [35-40]
Internal rotation	0.9±2.0 0 [0-0]	22,6±4.0 25 [20-25]
External rotation	48.0±6.4 50 [45-50]	33.0±4.8 35 [30-35]

RESULTS

Upon admission for inpatient treatment, the primary complaint of the patients was limited range of motion in the hip, characterized by an externally rotated position of the affected lower limb with a pronounced limitation of abduction and internal rotation. The results of the conducted goniometry are presented in Table 1.

Statistical analysis of the data presented in Table 1 revealed significant differences ($p<0.05$) in the range of motion between the healthy and affected joints.

The results of the hip joint radiometric assessment are reflected in Table 2.

Table 2

Values of the indices characterizing the radiographic anatomical structure of the femoral and pelvic components of the hip joint, as well as its stability, in children with a deformed Perthes femoral head in comparison with reference values based on the literature

Parameter	Affected side, M±SD, Me [Q_1-Q_3]	Healthy side, M±SD, Me [Q_1-Q_3]	Reference values in children without hip joint pathology [25, 26, 27]
Sharp angle, deg.	50.8±3.2 52 [48.3-53.0]	43.6±2.1 43 [42.3-45.0]	35-50
Tönnis angle, deg.	11.9±2.7 12.5 [9.0-14.8]	7.5±1.0 7 [7-8]	0-10
NSA, deg.	128±3 128.5 [126.3-130.8]	135.5±5.3 136 [135.0-140.0]	125-145
ATD, mm	14±0.9 14 [13.5-14.8]	9.4±9 7.7 [6.2-8.7]	–
ISA	1.0±0.1 1 [0.95-1.10]	0.9±0.1 1 [0.9-1]	0.8-1.2
ISH	1.3±0.1 1.3 [1.2-1.3]	0.8±0.1 0.8 [0.7-0.9]	0.6-1.0
ICAS	0.8±0.1 0.8 [0.7-0.8]	1.3±0.1 1.3 [1.2-1.4]	1.1-1.4
Wiberg angle, deg.	13.4±2 13 [12-15]	28.2±2.1 28 [26.3-30.0]	25-40
FHEI, %	39.9±7.8 40.5 [32.3-45.0]	14.6±2.7 14 [13.0-15.6]	No more than 25%
Shenton line	Disruption no more than 5 mm – 13 patients (65%) Undisrupted – 7 patients (35%)	Undisrupted	Undisrupted

In some patients, a moderately pronounced exceedance of the reference values of Sharp and Tönnis angles was noted, which, in our opinion, is due to prolonged localized pathological pressure of the femoral head on the superolateral section of the acetabulum (Figure 2).

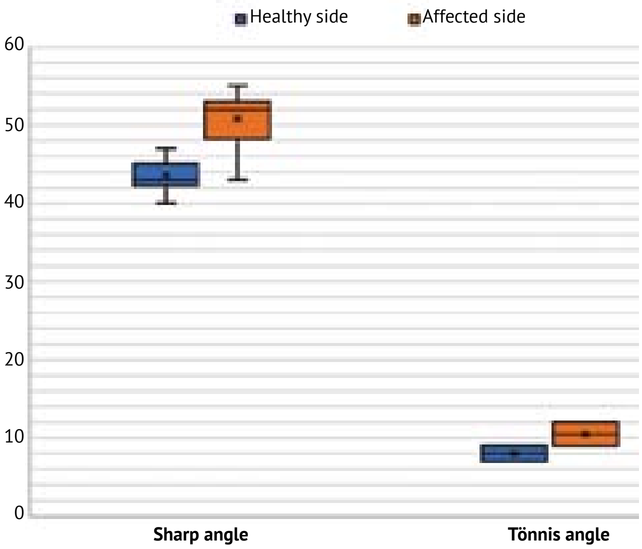


Figure 2. Distribution of Sharp and Tönnis angles values in patients before surgery.
Hereinafter — the medians (a horizontal line inside the shaded area), average values (the"x" symbol inside the shaded area), interquartile range (the shaded area), maximum and minimum values (horizontal lines at the end of the whiskers) are marked

NSA values on the affected side, although lower than those on the healthy side, did not demonstrate statistically significant differences ($p>0.05$). In contrast, ATD values on the affected side were significantly lower ($p<0.05$) compared to those of the contralateral proximal femur. This confirms the severe course of the disease in this patient category, leading to shortening and thickening of the femoral neck with the formation of a high greater trochanter position. In our opinion, these processes are associated with the suppression of the epiphyseal growth plate function and the normal growth function of the greater trochanter. The femoral head sphericity index on the affected side was significantly higher than the corresponding values on the intact side ($p<0.05$), whereas the acetabular sphericity index showed no significant differences ($p>0.05$). At the same time, the formation of severe femoral head deformity leads to the impaired congruence of the articular surfaces, as indicated by ICAS values, which significantly differed ($p<0.05$) from those of the healthy joint. A pronounced decrease in Wiberg angle, combined with an increase in femoral head extrusion from the acetabulum, expressed as a percentage, compared to the corresponding values in the healthy joint ($p<0.05$), can be interpreted as a developed hip subluxation.

In more than half of the patients, a disruption of Shenton line was diagnosed on the affected side. Most authors interpret this as an indication of altered hip joint congruence, manifesting as subluxation or dislocation, which is particularly evident in cases of the hip dysplasia of grades II-IV [28, 29, 30]. At the same time, it should be noted that all patients had X-rays of the hip joints in AP view with the affected limb positioned in external rotation due to the essentially absent range of internal rotation. In this clinical scenario, the disruption of Shenton line is inevitable and, in our opinion, cannot be considered a reliable diagnostic criterion for assessing articular congruence in this patient category.

The conducted correlation analysis revealed strong positive relationships between the values of Tönnis and Sharp angles and the femoral head extrusion index, with correlation coefficients of $\rho = 0.87$ and $\rho = 0.82$, respectively.

The performed regression analysis showed that the coefficient of determination (R^2) for the relationship between the parameters characterizing the anatomical structure of the acetabulum and the femoral head extrusion index exceeded 0.7. There were no significant differences between the linear and quadratic models, which brought the studied parameters closer to linear regression. The approximation is considered good, as more than 70% of the sample can be explained by the regression formula (Figure 3).

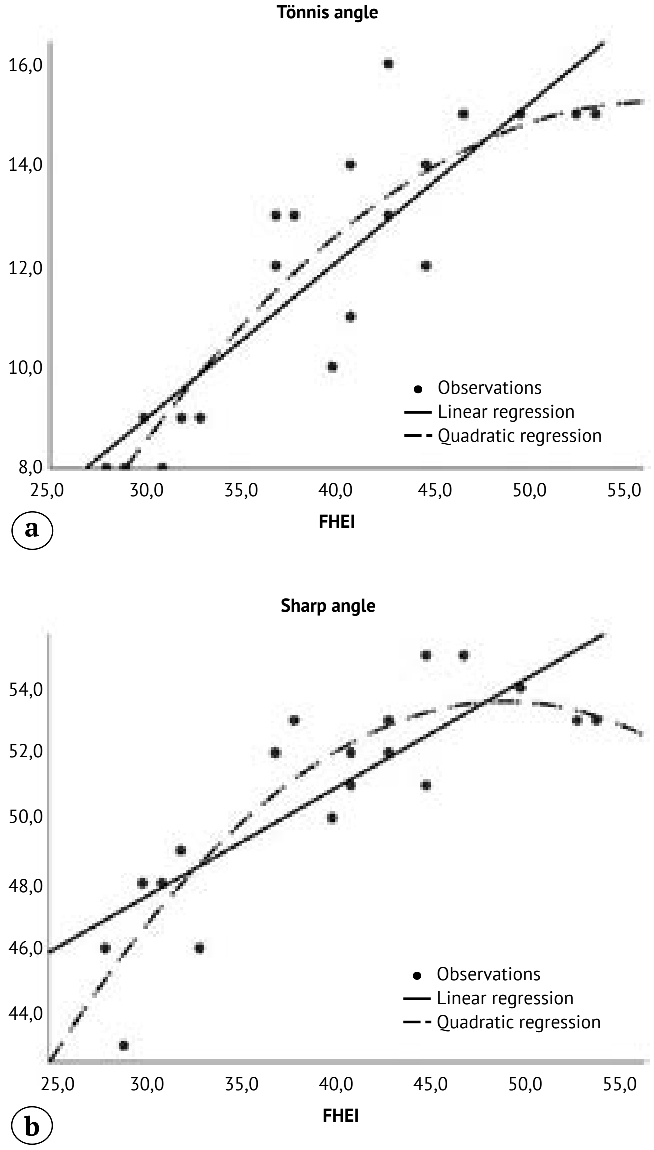


Figure 3. Regression analysis results reflecting the relationship between the indicators that characterize the anatomical structure of the acetabulum and the femoral head extrusion index:
a — between Tönnis angle and FHEI;
b — between Sharp angle and FHEI

Based on the results of the MRI, in addition to confirming the deformation of the cartilage model of the femoral head, we found that in patients with Sharp and Tönnis angle values within the range of normal physiological variation, the acetabular rim was positioned horizontally. In contrast, in patients with Sharp and Tönnis angle values exceeding the upper limit of normal physiological variation, a reverse vertical position of the acetabular rim was observed (Figure 4).

After the surgical reconstruction of the hip joint, all patients underwent comprehensive rehabilitation according to a protocol developed in the clinic [31].

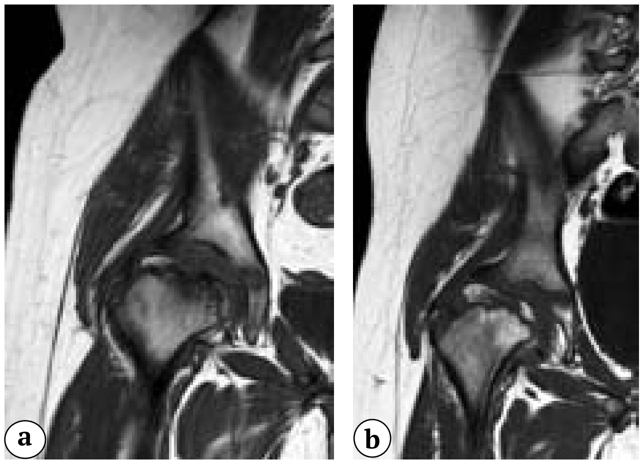


Figure 4. MR image of the acetabular rim position (marked with an arrow) in patients:
a — values of Sharp and Tönnis angles are within the average physiological variation (a horizontal position);
b — values of Sharp and Tönnis angles exceed the upper limit of the average physiological variation (a reverse vertical position)

The outcomes of the surgical reconstruction were evaluated within a follow-up period of 6 to 12 months.

Clinical examination revealed limb shortening on the operated side in all patients, with an average length discrepancy of 1.5±0.3 cm. Goniometric data presented in Table 3 indicate an improvement in the function of the affected hip joint, with a significant increase in abduction and internal rotation range of motion compared to preoperative values ($p<0.05$).

A comparative analysis of the radiological examination results is presented in Table 4. In some patients, Sharp and Tönnis angle values showed negative dynamics, with a more pronounced exceedance of the upper limit of reference values compared to the preoperative measurements (Figure 5).

Table 3

Patients' hip goniometry results after surgical reconstruction, deg.

Motion	Range of motion of the affected joint, M±SD, Me [Q_1-Q_3]	Range of motion of the healthy joint, M±SD, Me [Q_1-Q_3]
Flexion	109.0±4.0 110 [105-115]	117.0±4.6 120 [115-120]
Abduction	26.0±4.4 25 [22.5-30.0]	38.0±3.4 40 [35-40]
Internal rotation	14.8±4.0 15 [10-15]	22.6±4.0 25 [20-25]
External rotation	38.0±4.0 40 [35-40]	33.0±4.8 35 [30-35]

Table 4

Dynamics of changes in the indices characterizing the radiographic anatomical structure of the femoral and pelvic components of the hip joint, as well as its stability, in children after hip reconstruction surgery

Parameter	Time	
	Immediately after surgery, M±SD, Me [Q_1-Q_3]	6-12 moths after surgery, M±SD, Me [Q_1-Q_3]
Sharp angle, deg.	50.8±3.2 52 [48.3-53.0]	52.0±5.2 53 [46.0-56.5]
Tönnis angle, deg.	11.9±2.7 12.5 [9.0-14.8]	14.1±5 14.5 [9-18.6]
NSA, deg.	130.8±2.5 131 [129-132]	131.0±2.4 131 [130-132]
ATD, mm	14±0.9 14 [13.5-14.8]	15.6±2.4 15 [14.0-17.4]
ISA	1.0±0.1 1 [0.95-1.1]	1.00±0.15 1 [0.95-1.10]
ISH	0.74±0.10 0.75 [0.7-0.8]	0.76±0.1 0.76 [0.70-0.83]
ICAS	1.24±0.10 1.3 [1.1-1.4]	1.3±0.1 1.3 [1.1-1.4]
Wiberg angle, deg.	29.2±1.8 29.5 [28-31]	24.4±5.3 25.5 [20.3-28.8]
FHEI, %	21.8±4.2 23 [19.3-25.0]	32±6 31.5 [26.5-36.5]
Shenton line	Undisrupted	Undisrupted – 5 patients (25%) Disruption no more than 5 mm – 4 patients (20%) Disruption more than 5 mm – 11 patients (55%)

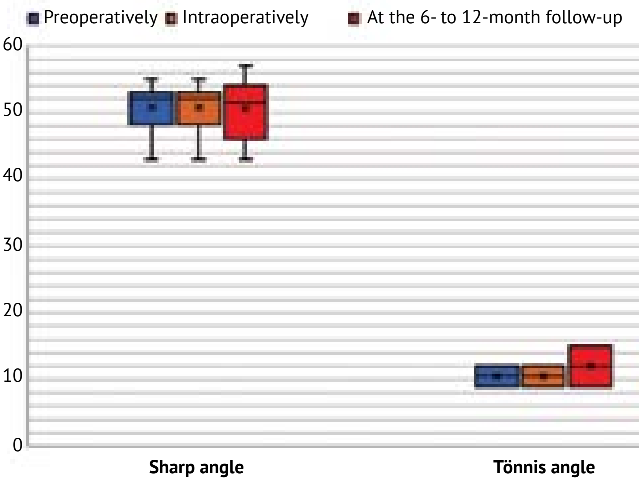


Figure 5. Distribution of Sharp and Tönnis angles values in patients over time

Radical surgical reconstruction led to a slight increase in NSA value compared to preoperative ones (p>0.05), which was not the case for other parameters. There was a significant increase in ATD index (p<0.05) due to the distalization of the greater trochanter. Despite the observed progression of the lateral acetabular rim deformity in some patients, the acetabular sphericity index remained within normal limits throughout the follow-up period. The values of femoral head sphericity index changed significantly after surgery in all patients, falling within the range of physiological variation. This contributed to the restoration of not only the congruence of the femoral head and acetabular articular surfaces but also the overall stability of the hip joint, as evidenced by ICAS, FHEI, Wiberg angle, and the continuity of Shenton line immediately after surgical reconstruction. However, at the 6- to 12-month follow-up, some patients, primarily those with progressive lateral acetabular rim deformity, exhibited a decrease in the intraoperatively achieved Wiberg angle, an increase in the percentage of femoral head extrusion from the acetabulum, and varying degrees of Shenton line disruption. In our view, these findings indicate the development of secondary hip subluxation, which may necessitate surgical stabilization of the hip joint through a triple pelvic osteotomy (Figure 6).

It should be noted that this radiographic anatomical condition was observed in the vast majority of cases in patients who initially had a reverse vertical position of the acetabular rim.

According to CT scans at 6 to 12 months after radical reconstructive surgery on the proximal femur, no cases of postoperative avascular necrosis of the femoral head were identified. This indicates the safety of such surgical interventions when performed with meticulous adherence to proper technique.

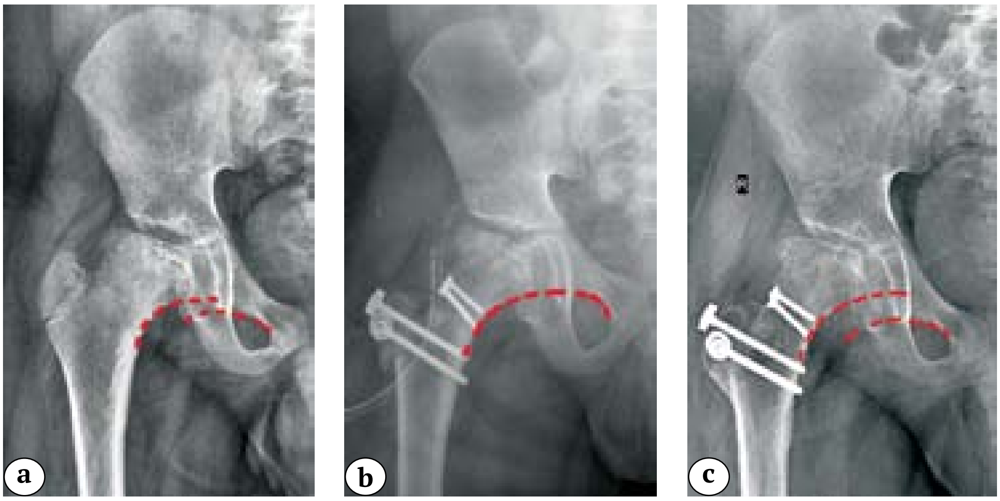


Figure 6. Right hip X-rays (the red dashed line marks the condition of Shenton line):
a — before surgery, incongruent articular surfaces of the femoral head and acetabulum, a moderate deformity of the lateral acetabular rim, and Shenton line disruption of a maximum of 5 mm are observed;
b — immediately after femoral head reduction osteotomy, articular surfaces congruence and hip joint stability are restored;
c — 8 months after surgery, the formation of hip subluxation (progressive lateral acetabular rim deformity, Shenton line disruption more than 5 mm) is observed

DISCUSSION

The outcome of Perthes disease directly depends on the volume and localization of necrotic focus in the femoral head [32]. In cases where the disease outcome corresponds to classes IV and V according to the S.D. Stulberg classification, severe deformation of the femoral head develops, accompanied by articular incongruity and joint subluxation. According to global literature data, without adequate surgical treatment, this condition leads to femoroacetabular impingement and early hip osteoarthritis [33, 34, 35, 36, 37, 38, 39]. Currently, for children with disease outcomes corresponding to class III in the S.D. Stulberg classification, both the arthroscopic correction of femoral head sphericity abnormalities and the technique of safe surgical hip dislocation are successfully used [40, 41, 42, 43, 44, 45].

Approaches to the surgical correction of severe deformities of the proximal femoral epiphysis and articular incongruity in the hip joint (Stulberg classes IV and V) remained highly debatable until the first description of the technique and feasibility of femoral head reduction osteotomy. There is no doubt that this technique has significantly expanded the capabilities of orthopedic surgeons in providing medical care to this severely affected patient group. Several researchers, including the author of the paper, have convincingly demonstrated its safety and high potential for correcting severe femoral head deformities while restoring the articular congruence [23, 24, 46, 47, 48, 49]. At the same time, the complexity of the surgical technique, requiring a high level of knowledge in topographic anatomy of the vessels supplying the femoral head, along with a prolonged learning curve, somewhat limits its widespread application. A search in available scientific databases identified no more than 12 publications on this topic, most of which are case-control studies with small patient cohorts. The treatment outcomes of all patients included in our study, assessed by the intraoperative correction of femoral head shape, restoration of articular congruence and overall hip joint stability, as well as the absence of postoperative aseptic necrosis, fully correspond to the data reported in world literature. However, the development of secondary hip subluxation in some patients after surgical treatment, in our opinion, requires further investigation of its causes. Some authors describe supplementing femoral head reduction osteotomy with triple or periacetabular pelvic osteotomy, justified by persistent or newly developed hip subluxation, verified either during intraoperative radiographic control or in the early postoperative period. The main indication for periarticular intervention is disruption of Shenton line [23, 50, 51].

To date, only two studies have been dedicated to the simultaneous performance of femoral head reduction osteotomy in combination with periacetabular pelvic osteotomy in children with severe femoral head deformity and articular incongruity [52, 53]. Despite a relatively long follow-up period (ranging from 23 to 56 months postoperatively), both studies included a very limited number of patients. The study by J.C. Clohisy et al. involved 6 patients, while that by K. Gharanizadeh et al. included 4 patients. It is also noteworthy that, despite the preoperative radiometric assessment of key hip joint structural and stability parameters, the necessity for periacetabular osteotomy was determined intraoperatively based on fluoroscopic imaging of the affected joint in various views.

Based on the findings of our study, as well as on the analysis of global literature data, we believe that the primary predictors of secondary hip subluxation following femoral head reduction osteotomy are the deformation of the lateral acetabular rim (exceeding the upper limit of the normal physiological range of Tönnis and Sharp angles) and its reversed vertical orientation.

Study limitations

This study is limited by a short follow-up period, a relatively small number of patients, and the current lack of mid-term outcomes following subsequent stabilizing interventions on the hip joint. Further research is planned to develop an algorithm for selecting the optimal surgical treatment approach for this patient category.

CONCLUSIONS

The femoral head reduction osteotomy, when performed with proper surgical technique, is a safe procedure in terms of the risk of postoperative aseptic necrosis and serves as an effective reconstructive method for treating children with severe saddle-shaped deformity of the femoral head and articular incongruity. This approach allows for the restoration of the radiographic anatomical structure of the affected proximal femur to parameters comparable to those of a healthy side, as well as for the reestablishment of the congruence and stability of the hip joint.

In patients with a reverse vertical orientation of the acetabular rim and Tönnis and Sharp angle values exceeding the upper limit of the physiological norm, the femoral head reduction osteotomy most often results in secondary subluxation, necessitating subsequent surgical stabilization through triple or periacetabular pelvic osteotomy. Given this consideration, we believe that for patients with such radiographic anatomical features, it is advisable to evaluate the feasibility of performing reconstructive surgery on both the femoral and pelvic components of the joint in a single surgical intervention after a critical analysis of potential risks. In our opinion, these surgical treatment methods for children should be performed under strict indications in specialized departments of federal-level institutions, where specialists have undergone extensive training and prolonged learning curve.

DISCLAIMERS

Author contribution

Bortulev P.I. — study concept and design, data acquisition, analysis and interpretation; drafting the manuscript.

Baskaeva T.V. — data acquisition, analysis and interpretation; editing the manuscript.

Poznovich M.S. — data acquisition, analysis and interpretation.

Barsukov D.B. — editing the manuscript.

Pozdnikin I.Y. — editing the manuscript.

Rustamov A.N. — data acquisition, analysis and interpretation.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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