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Results of intra-articular and combined interventions in patients with ischemic deformity of the femoral head

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Abstract

Introduction Extra-articular operations for correction of ischemic deformities of the femoral head are not effective enough. Currently, intra-articular correction methods are used, among which one of the most effective methods is considered to be reduction osteotomy of the femoral head.

Purpose The aim of the work is to evaluate the results of intra-articular and combined interventions in patients with ischemic deformity of the femoral head.

Materials and methods The study included patients with ischemic deformity of the head and proximal femur (n = 15), divided into two groups. In the first group (n = 7), the patients underwent reduction osteotomy of the head using only the Ganz technique. Patients of the second group (n = 8) additionally underwent surgery on one or both joint components: corrective intertrochanteric osteotomy of the femur, pelvic osteotomy, or combined intervention. The joint was fixed with the Ilizarov apparatus.

Results The average D'Aubigne-Postel score in the first group was (14.7 ± 0.3) points, in the second group — (15.0 ± 0.2) points. When analyzing the radiometric data after treatment, a reliable improvement in the parameters characterizing the sphericity and the degree of head centralization was recoreded in patients of both groups. Radiographic results of patients in the first group: good result — 3 joints (43 %), fair — 3 joints (43 %), poor — 1 joint (14 %); the second group: good result — 3 joints (38 %), fair — 4 joints (50 %), poor result — 1 joint (12 %).

Discussion Simultaneously with the reduction osteotomy of the head, it is allowed to perform additional surgical interventions aimed at eliminating instability of the hip joint. Conducting a reducing osteotomy of the head in the conditions of a functioning growth plate is considered debatable.

Conclusion Intra-articular interventions that change the shape and improve the congruence of articular surfaces may be an alternative to early arthroplasty in adolescents and young adults in certain clinical situations.

Keywords: ischemic deformity of the femoral head, acetabular dysplasia, femoral head, reduction osteotomy

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INTRODUCTION

Deformity of the femoral head is one of the unfavorable outcomes of ischemic lesions in the proximal femur of various origins [1, 2]. The most common causes of this condition in the treatment of congenital hip dysplasia are Legg-Calvé-Perthes disease and aseptic necrosis of the femoral head [1, 2, 3]. The main morphological signs of the pathology are asphericity and an increase in the size of the femoral head [3]. These changes contribute to the decentration of the head, the formation of femoroacetabular impingement, which is accompanied by dysfunction of the joint and pain [4]. Such a disorder of the joint biomechanics results in an increase in intra-articular pressure and is considered one of the leading causes of early development and rapid progression of coxarthrosis [5]. Extra-articular corrective operations on the proximal femur can improve the centering of the head and partially compensate for intracapsular deformities. However, their effectiveness for correction of the deformity of the femoral head is insufficient [1, 6]. Surgical dislocation with osteochondroplasty can be used for correction of deformed head mainly in the sagittal plane [7]. However, asphericity in the frontal plane cannot be eliminated by resection due to the risk of damage to the feeding retinacular vessels of the femoral head. The optimal option in this case is reduction osteotomy of the femoral head [8, 9].

Purpose of the work is to evaluate the results of intra-articular and combined interventions in patients with ischemic deformity of the femoral head.

MATERIALS AND METHODS

The work is based on a retrospective study of clinical and radiometric characteristics and analysis of the results of surgical treatment of patients with ischemic deformities of the femoral head, operated on in the period from 2014 to 2022. The mean follow-up period was (4.6 ± 0.3) years (from 2 to 10 years).

Inclusion criteria: ischemic deformities of the femoral head developed due to degenerative lesions of the hip joint of various origins, causing disruption of joint relationships and the formation of femoroacetabular impingement; reduction osteotomy of the femoral head in the medical records and the follow-up period of more than two years.

Exclusion criteria: other intra-articular interventions; exclusively extra-articular interventions; follow-up term of less than two years.

Patients with unilateral joint damage at the time of surgery (n = 15) were divided into two groups based on the volume of surgical interventions performed: Group 1 — 7 patients (14.0 ± 0.2) years old; Group 2 — 8 patients (16.1 ± 0.4) years old. Patients in the first group underwent only reduction osteotomy of the femoral head, while patients in the second group additionally underwent an extra-articular intervention on one or both articular components. The distribution of patients by gender and etiologic factor is presented in Table 1.

Femoral head reduction osteotomy (HRO) was performed using the Ganz technique in all cases [9, 12]. First, osteotomy of the greater trochanter was performed; next a co-tissue flap was formed to preserve the blood supply to the head. After producing surgical dislocation of the hip, two osteotomies of the head were performed in the sagittal direction. The intermediate fragment was removed, and the remaining bone fragments of the head were aligned and fixed with screws. Next, the head was reduced into the acetabulum. The joint was fixed with the Ilizarov apparatus for 30 days. This operation only was performed in seven cases (group 1).

Table 1

Patient's etiology of the disease and gender

Gender, etiology	Group 1 (n = 7)		Group 1 (n = 8)	
	No	%	No	%
Boys	5	33.3	5	33.3
Girls	2	13.3	3	20.1
Perthes disease	3	20.1	3	20.1
Septic coxitis	1	6.6	1	6.6
Aseptic necrosis due to hip dysplasia management			2	13,3
Aseptic necrosis following treatment of slipped capital femoral epiphysis	1	6.6		
Posttraumatic aseptic necrosis			1	6.6
Idiopathic aseptic necrosis	2	13.	1	6.6

Three cases of the second group additionally underwent corrective intertrochanteric osteotomy of the femur. The indication for its implementation was an increased neck-to-shaft angle (two joints) and retroversion of the epiphysis (one joint). Intertrochanteric osteotomy was performed simultaneously with the intervention on the femoral head. The period of fixation with the apparatus in these cases was increased to 45 days. In three cases, pelvic osteotomy was additionally performed in the patients of the second group. The indication for its implementation was acetabular dysplasia (WBS angle ⩾ 15°). Surgery on the pelvic bone was performed two weeks after the surgery on the femoral head. The period of fixation with the apparatus on was 50–55 days. Two cases of the second group underwent additional surgeries on both joint components.

This study presents only radiographic results. The radiographic study was performed using certified equipment (FS #2006/527). Radiographic data are presented without patients' information. Hip joint radiographs were taken in the anteroposterior view before treatment and at the last follow-up. The following radiographic parameters were determined and analyzed: hip extrusion index (EI), hip sphericity index (HSI) [2], ATD (articular-trochanteric distance), lateral displacement index (SL), lateral displacement angle (LDA-angle formed by a vertical line drawn through the teardrop figure and a line tangent to the inferomedial edge of the neck, normally 20–25°) [10], and the inclination angle of the supporting surface of the cavity (WBS).

The radiographic parameters were assessed according to Kruczynski [10] and the method of the Ilizarov National Medical Research Center of Traumatology and Orthopaedics [11] (Table 2). Kruczynski's evaluation considered the discontinuity of the Shenton line, the angle of lateral displacement, and the shape and centering of the head. The functional outcomes were assessed according to D'Aubigne – Postel.

Table 2

Evaluation of radiographic results according to the Ilizarov Center technique

Parameters	3 points	2 points	1 point
Condition of the femoral head	Structure and shape did not change or improved	Shape of the head impaired	Both shape and structure of the femoral head impaired
ATD, mm	> 10	0–10	< 0
EI	1.0–0.85	0.84–0.65	< 0.65
HSI	1.0–1.4	> 1,4	< 1.0
LDA°	< 20	20–25	> 25
SL, cm	< 0.5	0.5–1.0	> 1.0
Arthrosis severity	Did not change	Worsened by 1 stage	Worsened by more than 1 stage

The study was conducted at the Ilizarov National Medical Research Center of Traumatology and Orthopaedics in accordance with the ethical standards of the Helsinki Declaration of the World Medical Association. All patients gave informed consent for conducting the study without their identification.

Statistical analysis of the study results was performed using Microsoft Excel 2007 software. Unweighted variation rows were compiled from the quantitative data. Averages, their error and reliability were determined. The obtained data were processed using nonparametric statistics methods using Wilcoxon and Mann-Whitney U-criteria.

RESULTS

In the first group of patients, the duration of the rehabilitation period was (8.6 ± 0.4) months, and in the second one (10.2 ± 0.3) months.

Evaluation of functional results after treatment revealed gait improvement in both groups (Table 3). In the first group, two patients showed complete restoration of the lower limb weight-bearing and normalization of walking. Hip joint function assessment showed that mobility indices improved in both groups, with the average index being higher in the second group than in the first. Limitation of joint mobility in the horizontal plane remained in all the cases. In the first group, the range of motion in the sagittal plane of more than 80° was recorded in four observations. One patient in the second group showed complete restoration of mobility in the sagittal and frontal planes. Extension contracture persisted in a patient of the first group. The absence of pain or insignificant pain was noted in all cases in the patients of the second group and in six cases of the first group.

Functional results of the first group according to the D'Aubigne – Postel criteria were good (15–18 points) in 3 cases (42.86 %), fair (12–14 points) in 3 cases (42.86 %), and poor (11 points) in 1 case (14.28 %); in the second group: a good result (15–18 points) was recorded in 4 cases (50 %), a fair one (12–14 points) in 4 cases (50 %).

Table 3

Dynamics of functional parameters before and after treatment

Functional parameter	Before treatment		After treatment	
	Group 1 (*n* = 7)	Group 2 (*n* = 8)	Group 1 (n*n* = 7)	Group 2 (*n* = 8)
Mean D'Aubigne-Postel score, points	10.6 ± 0.2	10.3 ± 0.2	14.7 ± 0.3	15 ± 0.2
Pain, points	3.2 ± 0.1	3.4 ± 0.1	5 ± 0.3	5.5 ± 0.1
Mean joint mobility, points	3.4 ± 0.3	3.4 ± 0.1	4.8 ± 0.3	5 ± 0.2
Motion activity, points	3.8 ± 0.2	3.6 ± 0.2	5 ± 0.2	5.2 ± 0.2

The analysis of radiometric data after treatment showed a reliable improvement in the indices characterizing the sphericity and the degree of head centralization in both groups (Table 4). The average sphericity index was higher in the first group; the differences between the groups were statistically insignificant. The shape of the head became oval in most cases. The degree of extrusion decreased in almost all cases: the average EI value in the first group was 0.1 (0–0.15), in the second group it was 0.09 (0–0.12).

The proximal displacement index improved significantly in both groups and in 10 patients corresponded to the norm (0 mm). The lateral displacement index improved significantly only in the second group. In the first group, no statistically significant changes in this parameter were recorded after treatment.

The analysis of the condition of the proximal femur in both groups established a reliable improvement in the relationship between the femoral head and the apex of the greater trochanter was noted.

However, the normal value of the articulotrochanteric distance was found only in two patients of the second group. The average ATD value in the first group was 10.2 mm (5–13) and 10.8 mm (7–16) in the second group.

Table 4

Dynamics of roentgenometric parameters

Parameter	Group 1 (n = 7)		Group 2 (n = 8)	
	Time point of study			
	Before surgery	Follow-up	Before surgery	Follow-up
HSI	0.57 ± 0.06	0.79 ± 0.02*	0.55 ± 0.03	0.74 ± 0.02*
EI	0.31 ± 0.02	0.1 ± 0.03*	0.37 ± 0.03	0.09 ± 0.02*
SLI (mm)	8 ± 1.3	3 ± 1.2*	16.2 ± 1.6	4.4 ± 1.2*
LDA(°)	24.3 ± 1.9	21.5 ± 1	28.7 ± 3.8	22 ± 0.9*
WBS (°)	7.8 ± 1.2	7.6 ± 1.1	19.8 ± 1.5	9.3 ± 1.2*
ATD (mm)	3 ± 1.1	10.2 ± 1.3*	3.6 ± 1.8	10.8 ± 0.9*

Note: * — significant difference with the initial value $P < 0.01$

The evaluation of radiological results of the first and second groups was carried out according to the Kruczynski classification and according to the criteria of the Ilizarov National Medical Research Center of Traumatology and Orthopedics (Table 5)

Table 5

Evaluation of radiographic results in the studied groups

Criteria	Group 1 (n = 7)		Group 2 (n = 8)	
	No	%	No	%
Kruczynski				
Good	4	57.1	4	50.0
Fair	3	42.9	4	50.0
Ilizarov Center				
Good	3	42.9	3	37.5
Fair	3	42.9	4	50
Poor	1	14.2	1	12.5

Complications

A 23-year-old patient from the first group sustained a femoral neck fracture during osteotomy of the femoral head. The bone fragments were fixed with screws. This complication did not affect the duration of hardware treatment or the outcome.

A 14-year-old patient from the second group had radiographic signs of aseptic necrosis.

Four years after surgery, the first group patient showed signs of arthrosis progression such as subchondral sclerosis and narrowing of the joint space. Severe pain was an indication for hip arthroplasty.

Case reports

The 11-year old patient of the first group with ischemic deformity of the head of the right femur resulting from Perthes disease in stage IIIb (Fig. 1). Reduction osteotomy of the head of the right femur according to the Ganz method and fixation of the right hip joint with the Ilizarov apparatus for one month were performed.

Initial functional parameters were: pain — 4 points, mobility index — 2 points, motor activity index — 3 points. Radiological examination revealed a deformed flattened head, sphericity index was 0.5, extrusion index was 0.3, articulotrochanteric distance was 5 mm, cranial displacement index was 7mm.

Nine years later, the patient had no pain at all (6 points), his gait improved (5 points), the joint mobility index increased to 5 points, the sphericity of the head improved (sphericity index is 0.8), the distance from the apex of the greater trochanter to the center of the head increased (9 mm), the extrusion index (0.1) and cranial displacement (3 mm) decreased. The centering of the head in the acetabulum did not change significantly: the angle of inclination of the supporting surface of the acetabum (7° before and after surgery) and the angle of lateral displacement (from 22° to 20°).

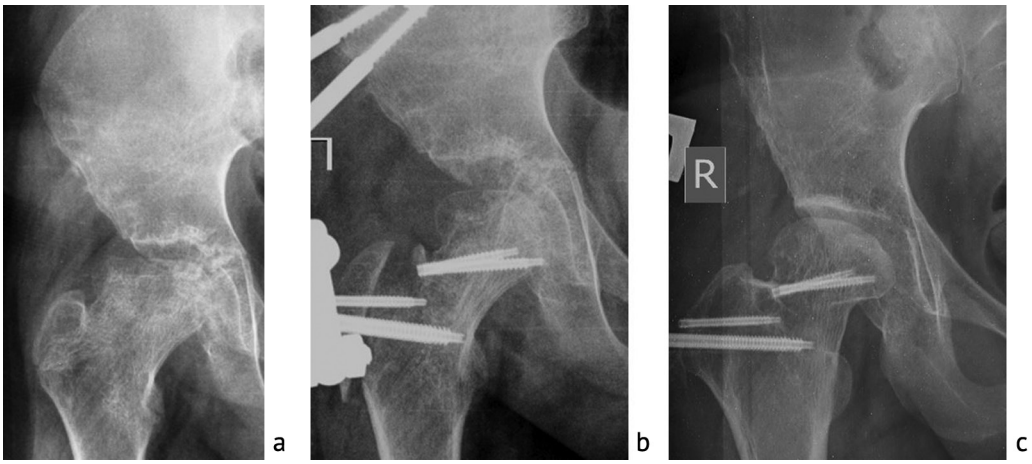

Fig. 1 Patient's radiographs: (a) before treatment; (b) reduction osteotomy of the femoral head; (c) 9-year follow-up

A 13-year old patient of the second group with ischemic deformity of the head of the right femur due to aseptic necrosis of the head in stage IV (Fig. 2). Reduction osteotomy of the head of the right femur according to Ganz was performed; after 14 days an additional osteotomy of the pelvis on the right was performed and the hip joint was fixed with the Ilizarov apparatus for 50 days.

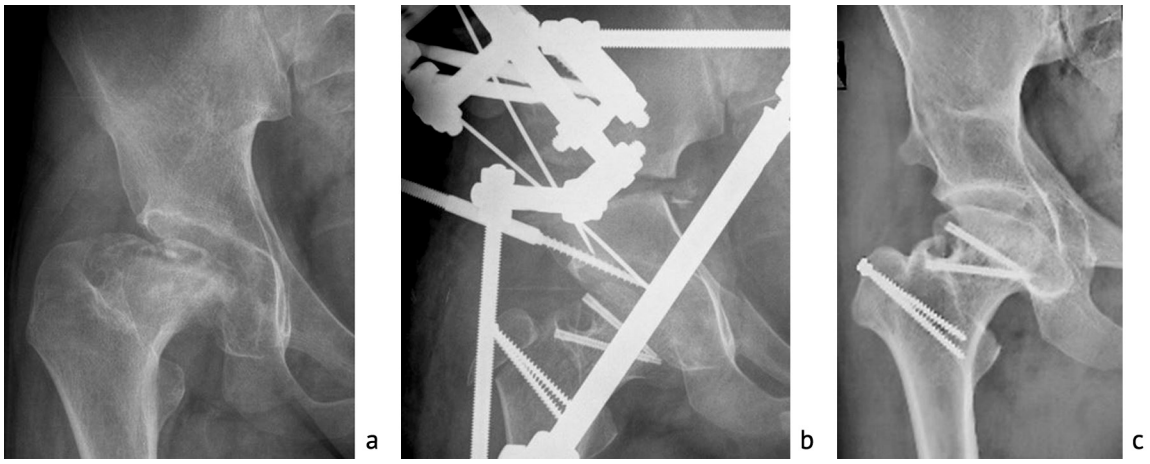

Fig. 2 Patient's radiographs: (a) before treatment; (b) reduction osteotomy of the femoral head, osteotomy; (c) 10-year pelvic old outcome

Initial functional parameters were: pain syndrome — 3 points, mobility index — 2 points, motor activity index — 3 points. Radiological examination revealed a deformed flattened head, high position of the apex of the greater trochanter, discontinuity of the Shenton line. Sphericity index was 0.4, extrusion index was 0.3, articulo-trochanteric distance was 3 mm, cranial displacement index was 15 mm.

At 10-year follow-up, the patient still had minor pain (5 points), her gait improved (6 points), joint mobility increased to 4 points, sphericity index increased to 0.7, articulo-trochanteric distance increased (11 mm), extrusion index (0.08) and lateral (cranial) displacement index (4 mm) decreased.

After pelvic osteotomy, the angle of inclination of the supporting surface of the acetabulum (from 19° to 8°) and the angle of lateral displacement (from 28° to 21°) changed significantly.

DISCUSSION

Ischemic deformity of the femoral head that changes its sphericity and size, causes disorders in joint relationships, is recognized as an important reason of early development and rapid progression of arthrosis in young people [1, 5, 14]. The possibilities of extra-articular reconstructive interventions are significantly limited [1, 6, 15, 16]. Therefore, intra-articular corrective interventions aimed at changing the shape of the head are of great importance. These include osteochondroplasty, cheilectomy, reduction osteotomy of the femoral head [16, 17]. This paper presents the medium-term results of HRO.

The limitations of this study are a small sample of patients and a short follow-up period. Also, the radiometric parameters analyzed were measured only on anteroposterior pelvic radiographs. It was associated with the fact that the main component of the head deformity that was targeted for correction by surgery was in the frontal plane.

The comparison of functional results with the data of other authors revealed that the proportion of good results among our patients was lower (47 %) [1, 9, 18, 19, 20, 21]. The rate of poor outcomes (6 %) did not differ significantly [1, 9, 18]. Siebenrock et al. analyzed the treatment results of 11 patients and noted the absence of reliable differences in the initial and postoperative functional state [1]. In our groups, the preoperative average D'Aubigne – Postel score was significantly lower and statistically differed from the functional result achieved. This may be due to the fact that the main cause of the deformity, according to the literature, was Perthes disease [3, 9, 12, 19, 21]. The incidence of this pathology among the etiological factors in our patients was only 40 %. The rest of the cases were consequences of aseptic necrosis of a different etiology, which are characterized by more pronounced functional and anatomical disorders.

According to the literature, changes in the shape and size of the head do not always ensure subsequent stability of the joint [1, 3, 9, 18]. According to D. Paley, it is possible to use an external fixator in this situation [16, 18]. Most specialists recommend using extra-articular surgeries on the articular components to correct joint instability [1, 3, 14, 17]. A number of authors accept their implementation in the late period during the formation of hip subluxation [9, 18]. According to others, a more common point of view, interventions on the articular components should be performed simultaneously with osteotomy of the head [1, 3, 20, 21]. In the analyzed group, the Ilizarov apparatus was used in all cases. The purpose of its use was not to compensate for remaining instability, but to ensure decompression of the hip joint and create conditions for limb weight-bearing in the postoperative period. The decision on the need to perform additional surgeries on the articular components was made during the preoperative planning. Separate (with an interval of 2 weeks) performance of pelvic osteotomy was due to the specifics of the technology of this intervention. It should be noted that among the patients of the first group, who did not undergo additional extra-articular operations, there were no signs of joint instability. We did not find statistically significant differences in the functional and anatomical results when performing only HRO (Group 1) and using combined interventions (Group 2).

One of the debatable issues remains the possibility of performing the reduction osteotomy of the head in the conditions of a functioning growth zone of the head [1]. According to D. Paley, this condition is a relative contraindication for the use of this operation [16, 18]. According to the opposite point of view, the growth zone does not have a significant effect on the outcome of treatment [3, 20].

The small sample size in our study does not allow for an objective conclusion. However, it should be noted that all four patients with a functioning growth zone of the head achieved a good anatomical and functional result.

Despite the aggressiveness of the intervention, many authors note a low risk of aseptic necrosis [1, 3, 9, 12, 19]. In the analyzed group of patients, this complication was noted in one case. It may have been caused by technical errors in performing the intra-articular intervention.

Heterotopic ossification is considered one of the possible adverse effects of the reduction osteotomy of the head [1, 3]. In the analyzed group, this complication was not observed. One intra-operative fracture of the femoral neck was diagnosed in a 23-year-old patient. According to the literature, this complication may result in early arthroplasty [18]. In the conditions of transosseous osteosynthesis, the violation of the integrity of the femoral neck did not have any effect on the course of the postoperative period and the outcome of treatment.

In one case four years after the operation, joint arthroplasty was performed due to severe functional impairment (pain syndrome). Similar data on conversion to arthroplasty are provided by D. Paley [16, 18].

It should be noted that most reports on the use of HRO have small size of patients' sample and short follow-up periods [1, 3, 20, 21]. Therefore, the impact of this intervention on the course of the degenerative process in the joint requires further study.

The preliminary results we obtained are necessary for planning further research with a larger number of subjects and a longer follow-up period.

CONCLUSION

The preliminary results obtained in this study and literature data suggest that intra-articular interventions that reshape and improve the congruence of articular surfaces may be an alternative to early hip replacement in adolescents and young adults in certain clinical situations.

Conflict of interests *None.*

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Ethical standards *The study was conducted in accordance with the ethical standards of the Helsinki Declaration of the World Medical Association.*

Informed consent *Patients' parents gave informed consent for the study.*

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