Original article
https://doi.org/10.18019/1028-4427-2024-30-1-18-27

Isometry as a predictor of osteosynthesis result in fractures of the posterior acetabulum

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Abstract

Introduction More than 80% of injuries to the acetabulum involve its posterior parts or injuries associated with their destruction. Most poor outcomes of surgical treatment of acetabular fractures manifest themselves in the first 24 months. Surgeons consider accurate anatomical reduction of fragments to be the main predictor of good results. A number of researchers showed good results of its surgical treatment, including those with inaccurate reduction. Poor results also occur in patients with no risk factors and ideal reduction. Thus, inaccurate reduction does not always lead to poor results; the reasons for positive results have not been discussed.

Purpose To evaluate the effect of maintaining hip joint isometry in surgical approach on the outcome of reconstructive operations in the treatment of traumatic destruction of the posterior parts of the acetabulum.

Materials and methods From 2005 to 2021, surgeons from the Moscow Regional Research and Clinical Institute performed 120 reconstructive operations on 120 patients with fractures of the posterior structures of the acetabulum. Of these, 84 patients followed the recommended monitoring regimen, completed the Harris Questionnaire, and had radiographs taken within the specified time frame. From the 84 patients, two groups of 42 patients each were formed that differed in the method of treating the external rotators.

Results During two years of follow-up after reconstructive surgery on the acetabulum, clinical indications for hip replacement were identified or hip replacement was performed in 5 patients in the first group and in 25 patients in the second (11.9 and 59.5%, respectively).

Discussion Accurate reduction of fragments is considered to be the main condition for good results after reconstructive operations for fractures of the posterior part of the acetabulum. Maintaining the isometry in the joint, namely, cutting off and then reinserting external rotators while preserving the attachment sites and length of the muscles, can have a significant impact on the outcome of reconstructive operations for traumatic injuries of the posterior parts of the acetabulum due to maintaining isometry of the hip joint. It seems that the preservation of force vectors centering the femoral head in the acetabulum causes the growth of ossification that forms secondary congruence.

Conclusions Maintaining hip joint isometry in surgical treatment of fractures of the posterior acetabulum by changing the method of treating the external rotators provides significantly better clinical outcomes.

Keywords: acetabulum fracture, osteosynthesis, joint arthroplasty, Kocher – Langenbeck approach, modification

For citation: Galkin AG, Shavyrin DA, Voloshin VP, et al. Isometry as a predictor of osteosynthesis result in fractures of the posterior acetabulum. *Genij Ortopedii*. 2024;30(1):18-27. doi: 10.18019/1028-4427-2024-30-1-18-27

INTRODUCTION

Treatment results of acetabular fractures still may result in dissatisfaction.

More than 80 % of injuries to the acetabulum occur in its posterior parts or injuries associated with their destruction [1, 2]. The most common causes of poor outcomes are the progression of post-traumatic coxarthrosis and avascular necrosis of the femoral head (ANFH) [1, 2].

Most poor outcomes of surgical treatment of acetabular fractures manifest themselves in the first 24 months. Thus, of the total outcomes in ANFH, more than 72 % of cases are diagnosed in the first two years [3]. Of the total number of patients with coxarthrosis that develops in the postoperative period, 87 % were diagnosed in the first 24 months [3]. According to a meta-analysis, osteoarthritis in stages 3 and 4 develops in more than 19 % of patients [1]. According to literature sources, of the total number of conversions to arthroplasty, 79 % happen within the first two years [4]. Thus, the analysis of poor outcomes in the first two years of the postoperative period is an objective way of assessing the results of surgical treatment.

The risk of conversion to arthroplasty after an acetabular fracture, depending on the type of fracture, is 27 % for transverse fractures of a posterior wall fracture, 23 % for T-shaped fractures, 15 % for posterior column and posterior wall fractures, and 12 % for isolated posterior wall fractures [4, 5, 6].

Most researchers assess the results of patients who were operated on in the first 10-14 days after injury [1, 5, 6, 7], as the results tend to worsen with increasing time the injury [2]. A growth in poor outcomes with age of patients has been noted [8]. Age over 46 years old leads to conversion to arthroplasty in 25.7 % of cases, while all patients in the reported study underwent surgical treatment within the first two weeks after injury [8]. Many authors note that the comminuted nature of the fracture results in poor outcomes more frequently [5, 7]. Thus, the analysis of the results of surgical treatment of acetabular fractures identified three main risk factors: the injury is more than three weeks old, the fracture is comminuted, and the patient's age is over 45 years.

Due to risk factors, the failure rate of reconstructive operations may exceed 50 % [9]. In their absence and precise reduction, negative outcomes are approximately 20 % [10]. Surgeons consider accurate anatomical reduction of fragments to be the main predictor of good results [11, 12]. In such cases, the progression of coxarthrosis was 13.2 % [1]. However, in mal-reduction, the probability of coxarthrosis was 43.5 % [1]. E Letournel analyzed the data of 1000 patients with fractures of the acetabulum and identified post-traumatic arthrosis in less than 5 % of cases when anatomical reduction was achieved, and in more than 60 % in cases with mal-reduction [2, 13, 14]. At the same time, an analysis of the results of treatment of 350 injured showed good outcomes of early surgical treatment in 83 % of patients. Thus, it was shown that surgical intervention in the early stages after injury significantly improves treatment results, provided there is good reduction and reliable fixation of bone fragments [1, 2]. Moreover, a number of researchers have shown good results of surgical treatment, including those with inaccurate reduvtion [1, 8, 15]. On the contrary, poor results are often found in patients with no risk factors and ideal reduction [15]. Thus, inaccurate reduction does not always lead to poor results, and the reasons for positive results have not been discussed.

The most common approach for surgical treatment of injuries to the posterior parts of the acetabulum is the Kocher – Langenbeck approach [1], which is also used in hip arthroplasty [16].

We analyzed data from the literature on the use of the Kocher – Langenbeck approach both for fractures of the posterior acetabulum and for hip replacement in order to identify possible common causes of failures.

The main disadvantage of the Kocher – Langenbeck approach for hip replacement is the increased risk of posterior dislocation of the endoprosthesis [17, 18]. This is due to the fact that the standard Kocher – Langenbeck approach involves the intersection of the external rotators (piriformis and triceps muscles) at the point of transition to the tendon part, followed by their end-to-end reinsertion [19, 20]. There are studies that show the low stability potential of this reinsertion method. The failure of rotators with this method of reinsertion, according to researchers, exceeded 70 % [20, 21, 22]. This was the reason for searching and using other methods of refixation of external rotators in arthroplasty.

Based on the literature data indicating a reduction in the risk of endoprosthesis dislocation by changing the method of treating external rotators in the Kocher – Langenbeck approach [16, 17, 18, 23], we made the assumption that the reasons for the increased risk of endoprosthesis dislocation during primary hip replacement using the posterior approach and poor results of reconstructive operations for fractures of the posterior structures of the acetabulum may be identical. That is, failure of the short rotator sutures and/or changes in the site of their reinsertion can lead to disorders in the centering of the femoral head in the acetabulum, thus creating areas of overload of the articular surfaces of the acetabulum and femoral head. This, in turn, may be a starting mechanism for rapid degeneration of cartilage or a cause of impaired blood supply to bone tissue in the overload zone.

The method of treating external rotators using the Kocher – Langenbeck approach with the subsequent failure of the rotator sutures may cause negative results due to changes in the hip joint isometry.

Purpose: to evaluate the effect of maintaining hip joint isometry in surgical approach on the outcome of reconstructive operations in the treatment of traumatic destruction of the posterior parts of the acetabulum.

MATERIALS AND METHODS

Between 2005 and 2021, the surgeon of the orththopaedic department at the Moscow Regional Research and Clinical Institute performed 120 reconstruction operations for fracrures of the posterior structures of the acetabulum. Among them, 84 patients followed the recommended regime of follow-up, filled in the Harris questionnaire and took radiographs at appointed time-points. The criteria for inclusion in the study were age from 18 to 80 years, radiological confirmation of injury to the posterior parts of the acetabulum, the ability to evaluate clinical and radiological results according to the examination schedule (after 3 months, one year and two years). Exclusion criteria were patient's absence or unwillingness to participate in the study, inability to complete the prescribed clinical and radiographic examinations.

In the preoperative period, the injured had radiographs of the pelvis in the direct projection; the injured hip joint was examined in the oblique obturator and iliac projections. A mandatory condition was an RCT examination to assess the nature of the fracture and bone tissue destruction.

In the postoperative period, radiographs in the direct projection were assessed three months, one year and two years after surgical treatment. After one year and two years after surgery, each patient completed the Harris Questionnaire, both if the outcome was good and if the patient had undergone hip replacement. The period for filling out the questionnaire after arthroplasty could exceed 2 years, which is associated with the need for rehabilitation after surgery.

A retrospective analysis of the results of reconstructive operations in the posterior parts of the acetabulum after their traumatic destruction in the first two years after surgery was performed.

Statistical analysis was performed in RStudio 2022.07.2 (RStudioPBC). Since the distribution of most quantitative variables was non-normal, non-parametric methods were used in the analysis. To describe quantitative variables, medians and quartiles (Me [LQ; UQ]) were calculated; to describe qualitative variables, absolute (n) and relative (%) frequencies were calculated. Comparisons of quantitative variables in independent samples were performed using the Mann – Whitney test; quantitative variables were compared using the Chi-square test or Fisher's exact test. A two-factor analysis of the influence of the type of approach (group) and duration of injury on the probability of arthroplasty was carried out using a logistic regression model. The level of error of the first type (α) was taken equal to 0.05. Null hypotheses were rejected at $p < 0.05$.

The groups were formed according to the principle of approach to the acetabulum.

Group 1 were patients who underwent a modified Kocher – Langenbeck approach with cutting off the rotators from the place of their attachment to the greater trochanter and reinserting them to the maternal bed through pre-formed canals in the greater trochanter in the area of their initial attachment ($n = 42$).

Group 2 were patients who underwent the Kocher – Langenbeck approach with standard end-to-end reinsertion of external rotators (n = 42).

In both groups, the majority of patients were under 45 years of age. The groups turned out to be absolutely identical in terms of gender composition. There were 20 patients with comminuted fractures in the first group and 22 in the second group (Table 1).

Table 1

Characteristics of patients included in the study

Parameter		Group 1 (n = 42)		Group 2 (n = 42)		p value
		abs. n	%	abs. n	%	
Age	Under 45 years	26	61.9	28	66.7	0.82[a]
	Over 45 years	16	38.1	14	33.3	
Type of injury	Posterior wall	19	45.2	18	42.9	1[b]
	Posterior column	1	2.4	1	2.4	
	Posterior wall + posterior column	7	16.7	7	16.7	
	Both columns	7	16.7	8	19	
	Both columns + posterior wall	8	19	8	19	
Gender	Male	40	95.2	35	83.3	0.156[b]
	Female	2	4.8	7	16.7	
Comminuted fracture	1-2 fragments	20	47.6	22	52.4	0.827[a]
	3+ fragments	22	52.4	20	47.6	
Injury duration	Less than 3 weeks	30	71.4	13	31	< 0.001[a]
	3 weeks and more	12	28.6	29	69	

[a] – Mann – Whitney test, [b] – Fisher's exact test

Both groups were similar in regard to injury patterns.

The main difference between the groups was the duration of the injury (Table 1). The difference in the number of patients in these groups is due to the fact that in the second group, the operation in the majority of cases (35 subjects) was performed in the conditions of the Moscow Regional Research and Clinical Institute, and the delay was associated with the transfer of the patient from a medical facility in the Moscow region. In the first group, the operations were performed on 32 subjects at a medical facility in the Moscow region by a visiting specialist from the Moscow Regional Research and Clinical Institute.

In both groups, no purulent complications were noted, with the exception of 3 cases of superficial inflammation, which was quickly arrested.

RESULTS

During a two-year follow-up after reconstruction surgery on the posterior acetabulum, hip arthroplasty due to clinical indications for arthroplasty was performed in 5 patients in group 1 and 25 patients in group 2, accounting for 11.9 and 59.5 %, respectively. However, there was a pronounced imbalance in the duration of injury in the groups, which required additional analysis of the results.

Table 2

Functional results of reconstructive operations in patients of groups 1 and 2

Parameter		Group 1 (n = 42)	Group 2 (n = 42)	p value
		Me [*LQ*; *UQ*], *min-max*		
Harris Hip Score at 1 year		83 [79; 87]. 51-91	60.5 [56; 84]. 45-91	0.002[a]
Harris Hip Score at 2 years		87 [85.2; 90]. 81-94	86 [83.2; 89.8]. 75-93	0.122[a]
Harris Hip Score dynamics 2-1 year		3.5 [2; 6.8]. -3-35	23.5 [5; 27.8]. -5-40	< 0.001[a]
THA	No THA, n (%)	37 (88.1)	17 (40.5)	< 0.001[b]
	THA, n (%)	5 (11.9)	25 (59.5)	

[a] – Mann – Whitney test, [b] – Chi-square test

Table 2 shows the obvious negative dynamics of the results of reconstructive operations during the first year in group 2 and the leveling of the results in both groups after hip replacement for negative outcomes of reconstructive operations. It should be noted that there is a significant difference in conversion to arthroplasty in the groups: 11.9 % in group 1 and 59.5 % in group 2 (Fig. 1).

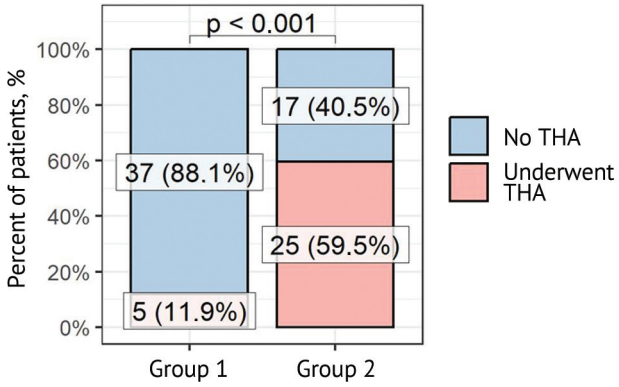

Fig. 1 Patients that needed THA in groups 1 and 2

Analysis of the dynamics of functional treatment results of patients in need of THA and patients satisfied with the results of reconstructive operations is shown in Tables 3, 4 and Figure 2.

Table 3

Functional results of reconstructive operations in patients that needed THA

Parameter	Group 1 (n = 5)	Group 2 (n = 25)	Value p[a]
	Me [*LQ*; *UQ*], *min-max*		
Harris Hip Score at 1 year	57 [53; 59], 51-61	57 [53; 59], 45-63	0.889
Harris Hip Score at 2 years	87 [86; 88], 86-90	84 [83; 86], 75-91	0.023
Harris Hip Score dynamics 2-1 year	29 [29; 34], 29-35	27 [24; 30], 19-40	0.111

[a] – Mann – Whitney test

Table 4

Functional results of reconstructive operations in patients that did not need conversion to THA

Parameter	Group 1 (n = 37)	Group 2 (n = 17)	Value p[a]
	Me [*LQ*; *UQ*], *min-max*		
Harris Hip Score at 1 year	84 [81; 88], 68-91	86 [84; 89], 78-91	0.176
Harris Hip Score at 2 years	87 [85; 91], 81-4	90 [88; 91], 76-93	0.127
Harris Hip Score dynamics 2-1 year	3 [2; 5], -3-17	4 [1; 5], -5-8	0.829

[a] – Mann – Whitney test

Fig. 2 Comparison of Harris Hip Scale in the patients of two groups that needed (a) and did not need (b) THA

The analysis of the characteristics of the groups included in the study revealed statistically significant differences in the duration of injury in patients of both groups (Table 5). Since this could theoretically have an impact on the rate of conversion to arthroplasty, it was decided to conduct

a two-factor analysis with the construction of a logistic regression model. After including the factor of injury duration, the type of approach retained a significant effect on the likelihood of arthroplasty, so we can assume that the type of approach is a predictor independent of how long the injury was.

Table 5

Results of a two-factor analysis of the influence of injury duration and group on the frequency of THA in patients

Parameter		Odds ratio (OR)	95 % CI	*p* value
Duration of injury	Less than 3 weeks	–	–	
	3 weeks and more	2.83	0.95; 8.73	0.064
Group 1		–	–	
Group 2		7.92	2.61; 27.7	< 0.001

Conversion to THA in the standard Kocher – Langenbeck approach happened in 20 out of 29 patients with an injury duration of more than three weeks, which was 69 %. In a modified approach, it was in 2 out of 12 cases, which corresponds to 16.7 %.

In group 1 of patients with a comminuted fracture, arthroplasty was performed in 18.2 % of cases, in group 2 – in 90 % (Fig. 3).

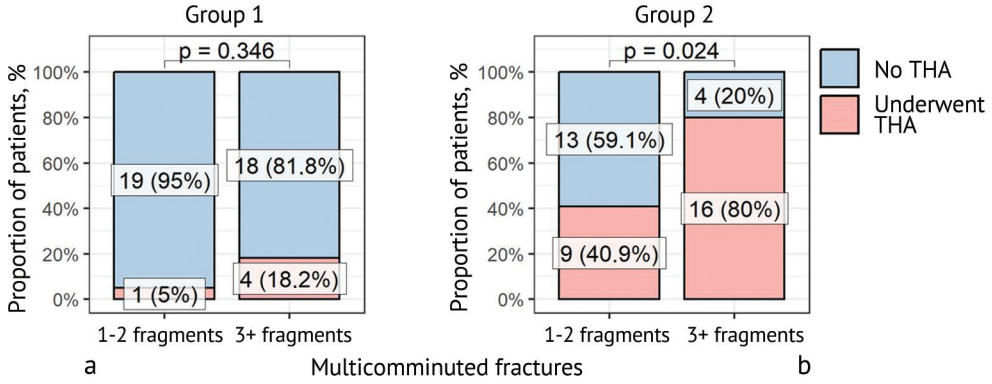

Fig. 3 Proportion of patients in need of THA in multi-comminuted and not multi-comminuted injury in group 1 (a) and group 2 (b)

The majority of patients in group 2 over 45 years of age (12 out of 14, accounting for 85.7 %) required hip replacement; in group 1, it was necessary in 18.75 %.

It should be noted that patients in group 2 were mostly over 45 years old and had comminuted fractures. It is important that the duration of injury in patients in group 2 in most cases exceeded 3 weeks.

The results of reconstructive operations in regard to the injury pattern differed significantly in groups 1 and 2. The largest number of poor outcomes in group 1 occurred in the injuries to the posterior wall, in 4 out of 19; one case out of eight with injury to the posterior wall and posterior column (Table 6). In group 2, the greatest number of failures was observed in patients with posterior wall injury, 13 out of 18 and in combined injuries to the posterior wall and posterior column; 2 out of 8 in posterior column injury, 5 out of 8 in injuries to both columns and the posterior wall (Table 6).

Table 6

Conversion to THA due to injury pattern

Type of injury	Number of operations			
	Group 1, conversion to THA		Group 2, conversion to THA	
	total (*n*)	failure (*n*)	total (*n*)	failure (*n*)
Posterior wall	19	4	18	13
Posterior column	1		1	
Posterior wall + posterior column	6		7	5
Both columns	8		8	2
Both columns + posterior wall	8	1	8	5

A clinical case of surgical treatment outcome in a patient with fractures of both columns and posterior wall of the acetabulum that were treated with a modified approach

Patient I, born in 1979, sustained trauma in a road accident and was operated in 2014.

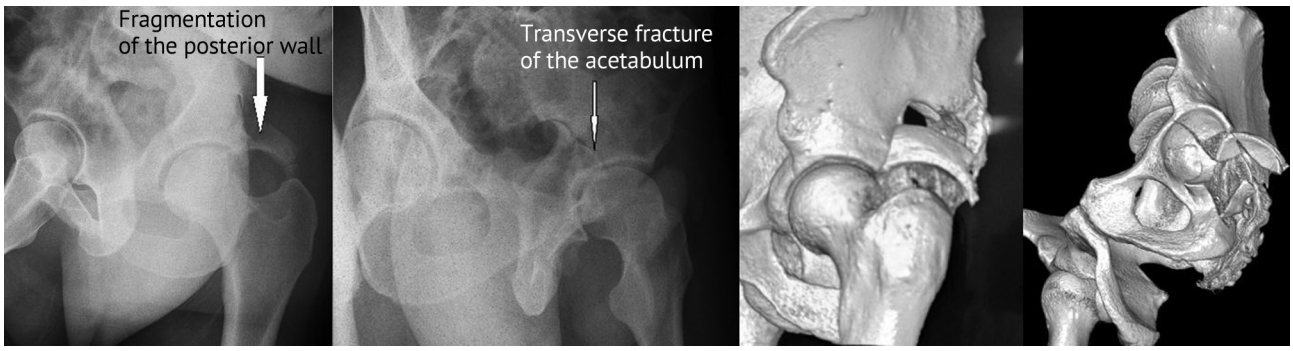

Fig. 4 Transverse fracture of the acetabulum and a comminuted fracture of the posterior wall

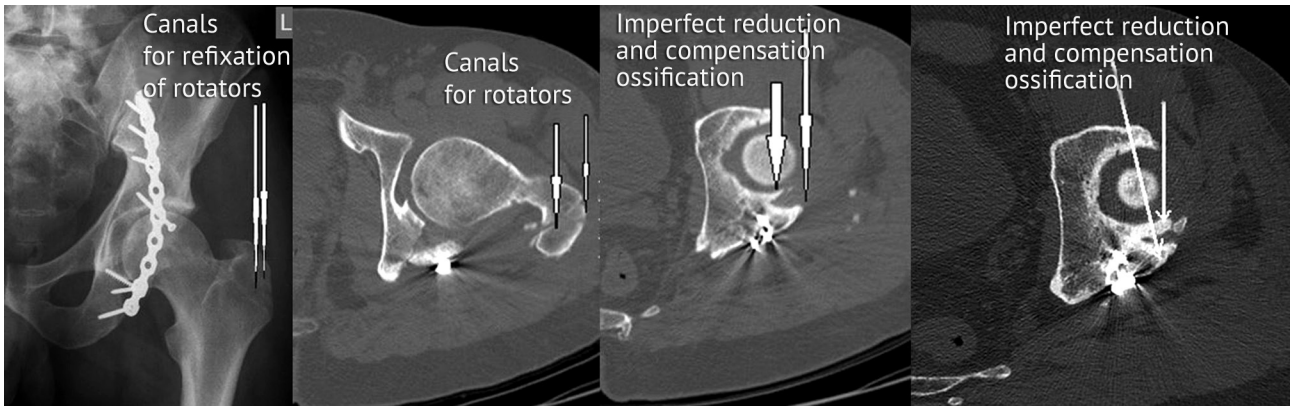

Fig. 5 Canals in the greater trochanter for refixation of short rotators. Ossifications resulting from imperfect reduction, compensating for the articular surface

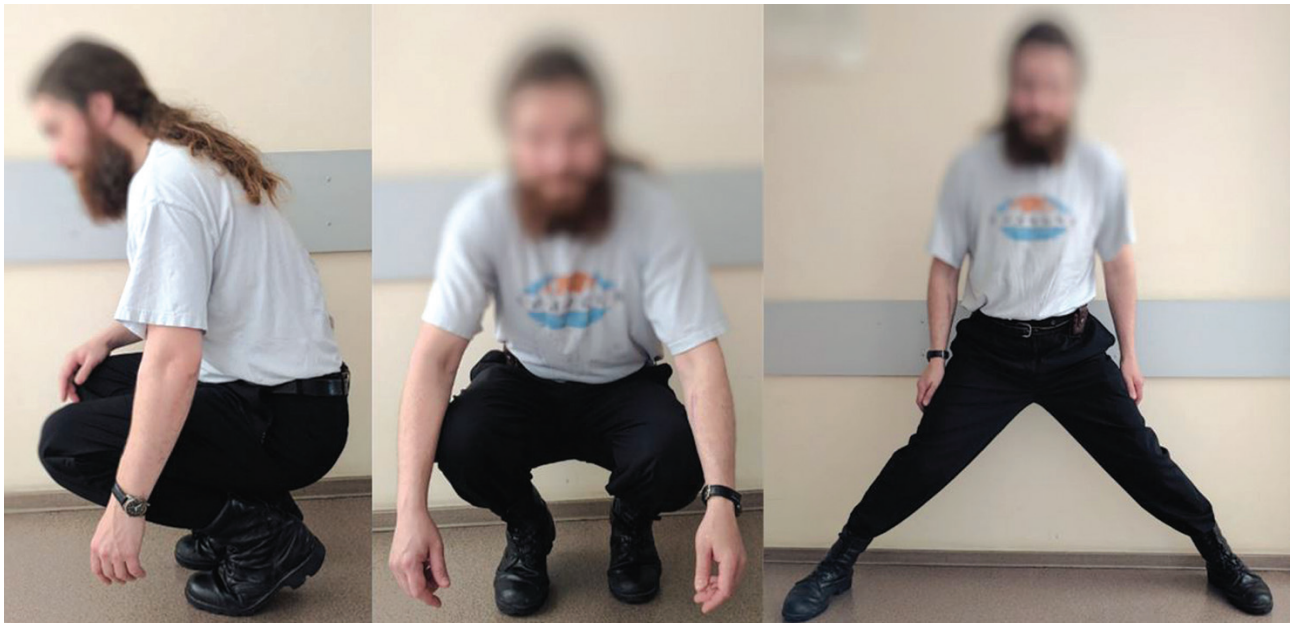

Fig. 6 Patient's photo 2 years after the operation; functional outcome

The patient is in contact and is satisfied with the result.

DISCUSSION

It is known that the main condition for a good result in intra-articular fractures is accurate reduction of fragments [11, 12]. However, it has been shown that a residual displacement of even 6 mm between the fragments results in a good surgical treatment outcome in an intra-articular fracture, provided that this is a displacement in width, that is, a fissure-like displacement between the fragments [24]. A step-like displacement leads to the development of arthrosis [24]. There is no change in the area of the articulating surface if bone is translated in width; in a step-like displacement, the load is concentrated on a smaller surface area.

A number of authors point to the relationship of the magnitude of contact stress between articular surfaces with the development of arthrosis in post-traumatic defects of the articular surface [25, 26]. It has been proven that an increase in contact stress leads to cartilage degeneration [26], that is, the concentration of load on a limited area leads to the progression of post-traumatic arthrosis. The role of the location of the load axis on the formation of excess stress and, as a consequence, cartilage degeneration has also been confirmed [24].

In the standard Kocher – Langenbeck approach, the probability of rotator suture failure exceeds 70 % [20]. The incompetence of the posterior rotators causes a violation of isometry in the hip joint due to inability to antagonize the anterior rotators. As a result, the centering of the femoral head in the acetabulum is violated. This phenomenon can lead to concentration of the contact stress between the articular surfaces even under the conditions of anatomical reduction.

Most studies [1, 2, 11, 12] show that the main reason for failure is an inaccurate reduction of fragments. Almost all authors indicate that residual displacement leads to an increased risk of post-traumatic coxarthrosis. However, the researchers do not explain a phenomenon of a good result in residual displacement of fragments.

We believe that maintaining isometry in the joint, namely, cutting off and reinserting the external rotators while preserving the attachment sites and the length of the muscles, may significantly influence the outcome of reconstructive operations in the treatment of traumatic injuries of the posterior structures of the acetabulum due to maintaining isometry of the hip joint. It is likely that the preservation of force vectors centering the femoral head in the acetabulum causes the growth of ossifications that form secondary congruity.

CONCLUSION

The results obtained show that surgical treatment of acetabular fractures using a modified approach allows for significantly better clinical results in both patients with and without risk factors.

Conflict of interest *Not declared*

Funding *Not declared.*

Ethical expertise *Not required.*

Informed consent *Signed during hospitalization in a hospital within the framework of compulsory medical insurance.*

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The article was submitted 28.03.2023; approved after reviewing 05.06.2023; accepted for publication 01.12.2023.

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