Original Article
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Periacetabular Pelvic Osteotomy in Treatment of Patients with Developmental Dysplasia of the Hip

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Abstract

Background. Pelvic osteotomies are widely used for treatment of young active patients with developmental dysplasia of the hip (DDH) Type I according to the Crowe or type A according to Hartofilakidis classifications and the absence of severe degenerative cartilage lesions. Nowadays, Ganz periacetabular osteotomy (PAO) is the most common choice of surgeons around the world in treatment of such patients. ***The aim of the study*** was to evaluate the radiological and functional results of Ganz periacetabular osteotomy in patients with DDH. ***Material and Methods.*** A single-center retrospective analysis of 49 Ganz PAO was performed in 43 patients aged 36±9 years. The radiological evaluation criteria were Wiberg (AW), Lequesne (AL), Tonnis (AT) angles, and joint medialization. The results of treatment were evaluated using the Harris scale, iHOT-12, and VAS before treatment and 1 year after, the presence of complications was also monitored. ***Results.*** The average follow-up period was 35±15 months (from 1.0 to 6.9 years). Radiological parameters improved after surgery compared to preoperative ones: AW +19.9° (17.1° vs. 37.0°), AT -11.5° (19.9° vs. 8.4°), AL +14.1° (25.1° vs. 39.2°), joint medialization -5.5 mm (14.3 mm vs. 8.8 mm) ($p<0.001$). Functional results and quality of life of patients also improved: the Harris scale +35.6 points (47 vs 83 points), iHOT-12 +40.9 points (44 vs 85 points), pain level -2.8 points (5 vs 2 points) ($p<0.001$). Various complications developed in 20 out of 49 cases (40.8%). Neurological complications were resolved conservatively (22.4%). A direct correlation was evaluated between the surgical treatment of DDH in childhood and the development of neurological complications after PAO ($R = 0.76$; $p<0.001$). In 9 cases out of 49 (18.4%), revision surgery was required: in 3 — total hip replacement, in 2 — reorientation of the acetabulum, in 4 — arthroscopic fixation of the anterior articular lip. In 93.9% of cases native hip joint surfaces were preserved. ***Conclusion.*** Ganz PAO has good reconstructive capabilities and sufficient efficiency. The operation allows to restore the coverage of the femoral head with the acetabulum, delays total hip replacement and provides improved functional results.

Keywords: periacetabular osteotomy, development dysplasia of the hip, organ-preserving surgery.

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Introduction

Developmental dysplasia of the hip (DDH) is a developmental disorder accompanied by the acetabulum insufficient coverage of the femoral head, which leads to increased risk of secondary degenerative changes in the joint and ultimately to coxarthrosis [1, 2]. In the absence of severe signs of degenerative changes in the joint, pelvic osteotomies are increasingly becoming the treatment method for dysplasia in young patients [3, 4]. Pelvic osteotomies are designed to restore normal anatomy and biomechanics: increase the contact area of the femoral head, reduce contact stress, normalize the weight of bearing forces, and, as a result, prevent degenerative changes in the hip joint [2]. In recent decades, it is the periacetabular osteotomy (PAO) according to Ganz is the most popular worldwide treatment choice of dysplasia and is currently recognized as the "gold standard" in adult patients [3, 5]. PAO allows to achieve the reorientation of the acetabulum, which contributes to a balanced distribution of loads on the femoral head, better coverage of the femoral head with the acetabulum, maintaining contact of the hyaline cartilage of the acetabulum and the femoral head [6]. The experience of using PAO in Russia is not as great as abroad, such operations are performed only in a few medical institutions in the country. We started performing PAO in 2014.

The aim of the study was to analyze the X-ray and functional results of the treatment patients with DDH who underwent PAO according to Ganz.

Materials and methods

Design of the study

Type of study: single-center retrospective continuous.

Inclusion criteria: DDH type I according to the Crowe classification or type A according to Hartofilakidis, absence of severe degenerative cartilage lesions, age from 18 years.

Criteria for exclusion: the presence of contraindications to surgical treatment, the patient's disagreement with the proposed method of treatment, the inability to conduct control examinations after discharge from the hospital.

Patients

From January 2014 to October 2019, 59 pelvic PAO according to Ganz were performed in 52 patients by the surgical team of the Adult Orthopaedic Department under the guidance of one surgeon. 43 patients were available for follow-up (9 patients were unavailable for control examinations), 8 (18.6%) of them were men and 35 (81.4%) were women. The average age of the patients was 36±9 years (from 19 to 53 years; Me 38 [31; 44]), the average body mass index value is 24.5±3.2 kg/m2 (from 19.0 to 32.0 kg/m2; Me 24.4 [23.0; 26.0]). Thus, a total of 49 cases of PAO were analyzed (in six patients, the operation was performed on both sides).

Indications for PAO according to Ganz were: the presence of DDH type I dysplasia according to the classification Crowe or Type A by Hartofilakidis, accompanied by pain syndrome; intraarticular space more than 3 mm, hip flexion >110°, internal hip rotation <15°; severe degenerative cartilage lesions; age from 18 to 55 years. X-ray examinations of pelvis and hip joints were performed in three projections: anterior-posterior, lateral and external oblique projections with a pelvic rotation of 65° (false profile). The radiological criteria for assessing hip joint before and after PAO were the Wiberg angle (AW), the Lequesne angle (AL, anterior central marginal angle), the Tonnis angle (AT, acetabular index or angle of the acetabular roof inclination), the joint medialization, and the value of the hip joint intraarticular space[7].

Evaluation of results

The clinical evaluation of PAO results was performed using the Harris Hip Score, assessment of the patient`s life quality ac-

cording to the iHOT-12 questionnaire (international Hip Outcome Tool-international health assessment hip joint questionnaire), assessment of the pain syndrome intensity — using a 10-point visual analog scale (VAS). Patients were interviewed before the surgery and 12 months after it. The presence of complications (hip lateral cutaneous nerve neuropathy, sciatic nerve paresis, femoral nerve neuropathy and some other neurological complications, pain syndrome, aggravation of femoroacetabular impingement (FAI) symptoms, progression of degenerative cartilage lesions and, consequently, the need for total hip replacement) was also monitored throughout the entire follow-up period.

Surgical technique

The patient is placed on the radiolucent table in a supine position. From Smith–Petersen approach performed a sequential approach to the pubic, iliac, and sciatic bones with visualization of the lateral femoral cutaneous nerve. The standard cut can be changed to a more aesthetic "bikini" cut. An incomplete osteotomy of the sciatic bone is performed with a depth about 2.5 cm, preserving the integrity of the posterior column. It is important to perform an osteotomy of the thicker medial cortical layer, while the thinner lateral cortical layer will undergo a controlled fracture later during the final stage of osteotomy and acetabulum mobilization. Due to the risk of damage to the sciatic nerve during lateral osteotomy, the latter should be as relaxed as possible. To do this, the lower limb is fixed in abducted position, the knee is slightly flexed. Next, a complete osteotomy of the pubic ramus is performed at a distance of 1 cm from the iliac crest in the medial direction. It is important to conduct an adequate release of the periosteum around the pubic ramus, especially in young patients with a thick periosteum — this is necessary to ensure the mobility of the osteotomized fragment during repositioning of the acetabulum. To protect the obturator nerve, retractors with a blunt square tip are placed on the posterior-lower and posterior-upper sides of the pubic ramus. The use of a curved blunt Hohmann retractor allows to move the m. iliopsoas and the femoral neurovascular bundle, while maintaining a safe distance from the hip joint. Then a biplanar osteotomy of the ilium is performed by the osteotome bent at an angle of 45°. Osteotomy of the ilium begins with a medial cortical layer incision, then, holding the leg abducted, an incision of the lateral cortical layer is performed. The level of iliac osteotomy should be at a sufficient distance from the acetabulum to reduce the risk of damage to the superficial branch of the superior gluteal artery and the vessels supplying the acetabulum. In addition, a larger bone bridge will make it easier to position the Schanz pin during the graft reduction. Then a controlled fracture of the sciatic bone is performed. After the mobilization of the osteotomized acetabulum fragment, the Schanz pin is placed in the ilium wing to perform the reduction maneuver.

Next, the graft is shifted inwards, rotated forward and laterally to set the calculated angle of anteversion, then the osteotomized fragment is fixed to the ilium with two or three screws. The wound is sutured in layers. A more detailed surgical technique of PAO according to Ganz is described in the available literature [8, 9]. Figure 1 shows the left pelvic bone model with osteotomy lines and acetabular reduction after PAO.

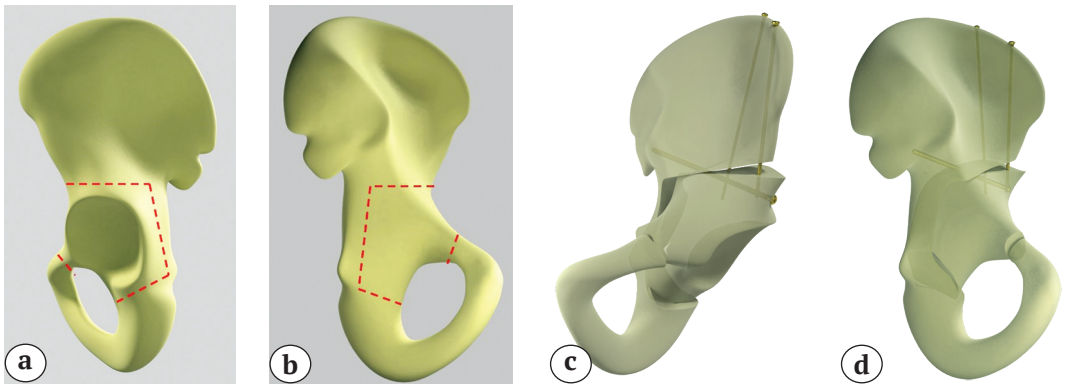

Figure 1. Model of the left pelvic bone with osteotomy lines and acetabular reduction after PAO:
a — side view (red dotted line show osteotomy lines);
b — medial view (red dotted line show osteotomy lines);
c — front view (shows acetabular reduction and screws fixation);
d — medial view (shows reduction of the acetabulum and screws fixation)

Statistical analysis

Statistical data analysis was carried out using the Statistica software package 12.0. The normality of the data distribution was checked using the Shapiro-Wilk test. For descriptive statistics, the data is presented in the form of M±SD, where M is the mean value of the sign, SD is the standard deviation; the minimum and maximum values are shown; Me [Q1; Q3], where Me is the median, Q1 is the first quartile, Q3 is the third quartile; for some values, a 95% confidence interval (CI) is indicated. To assess the differences, we used the sign criterion: we compared the results of the questionnaire survey obtained during the last examination of the patient with the indicators preceding the operation. The differences between the compared groups were considered statistically significant at a significance level of $p<0.05$. The degree of changes consistency in the studied parameters was estimated by the results of correlation analysis with the calculation of the Spearman coefficient (R).

Results

The analysis of 49 PAO performed in 43 patients was carried out: 26 PAO were performed on the left side (53.1%), 23 — on the right side (46.9%). The mean follow-up period was 35±15 months (from 1 year to 6.9 years; Me 32.9 [24.0; 45.5]). Fifteen (34.9%) patients received treatment in childhood: 6-conservative (plaster cast, Pavlik stirrups), 9-operative (triple pelvic osteotomy-3, Salter osteotomy — 2, Chiari osteotomy -1, femoral varization osteotomy-3). In four (9.3%) patients, the opposite hip joint was replaced for a year or more before PAO. The average surgery duration was 134±30 minutes (from 100 to 270 minutes; Me 125 [115; 140]). The volume of blood loss varied from 250 to 1500 ml, averaging 678±332 ml (Me 560 [500; 800]). The need for blood transfusions occurred in 12 cases out of 49, which resulted in blood loss during surgery, which was 24.5%. The average volume of intraoperative blood loss in surgeries performed during the first three years after the introduction of PAO was higher and amounted to 782±379 ml, and the same indicator in PAO performed in subsequent years decreased and amounted to 593±266 ml. As the surgeon gained experience, the average duration of the operation decreased by 10 minutes (139±39 minutes versus 129±20 minutes respectively). In the first three years

after the introduction of PAO, blood transfusion was performed in 40.9% of cases (9 out of 22), in subsequent years-in 11.1%(3 out of 27). The results of X-ray measurements are presented in Table 1.

Functional indicators and quality of patient`s life, according to the questionnaire survey, after PAO also significantly improved 1 year after surgery compared to the indicators before treatment. The average value on the Harris Hip Score increased from 47±9 points (from 31 to 64) before surgery to 83±8 points (from 65 to 100) 1 year after (p<0.001). The increase in values was +35.6 points (95% CI 32.6-38.6 points).

The average value of the iHOT-12 questionnaire before the operation corresponded to 44±12 points (from 20 to 70), 1 year after PAO according to Ganz-85±9 points (from 70 to 100) (p<0.001). The increase in values was +40.9 points (95% CI 36.4-45.4 points). The level of pain before PAO corresponded to 5±1 points (from 2 to 8), after treatment it decreased to 2±1 points (from 0 to 3) (p<0.001). On average, the decrease in values was -2.8 points (95% CI -3.2...-2.4 points) (Fig. 2).

Table 1

Results of X-ray measurements and functional parameters of patients before and after PAO

Parameter	Before surgery	After surgery	Difference in values	95% CI
AW, °	17,1±1,7 (от 12 до 20; Me 17 [16; 18])	37,0±6,2 (от 24 до 45; Me 38 [32; 42])*	19,9	18,0–21,7
AL, °	25,1±2,8 (от 20 до 31; Me 25 [23; 27])	39,2±2,8 (от 34 до 45; Me 39 [37; 41])*	14,1	12,9–15,2
AT, °	19,9±2,3 (от 16 до 25; Me 20 [18; 21])	8,4±1,5 (от 6 до 11; Me 9 [7; 9])*	-11,5	-12,3...-10,8
Medialization, mm	14,3±2,5 (от 9 до 20; Me 14 [13; 16])	8,8±2,0 (от 5 до 13; Me 9 [7; 10])*	-5,5	-6,2...-4,7
Intraarticular space, mm	5,5±1,1 (от 4 до 8; Me 5 [5; 6])	4,4±0,6 (от 4 до 6; Me 4 [4; 5])*	-1,1	-1,4...-0,8
The Harris Hip Score, points	47±9 (от 31 до 64; Me 48 [39; 55])	83±8 (от 65 до 100; Me 84 [78; 88])*	35,6	32,6–38,6
iHOT-12, points	44±12 (от 20 до 70; Me 45 [35; 55])	85±9 (от 70 до 100; Me 85 [80; 90])*	40,9	36,4–45,4
VAS, points	5±1 (от 2 до 8; Me 5 [4; 5])	2±1 (от 0 до 3; Me 2 [1; 3])*	-2,8	-3,2...-2,4

— $p<0.001$ when comparing values before and after surgery; AW — Wiberg angle; AL — Lequesne angle; AT — Tonnis angle (acetabular index).

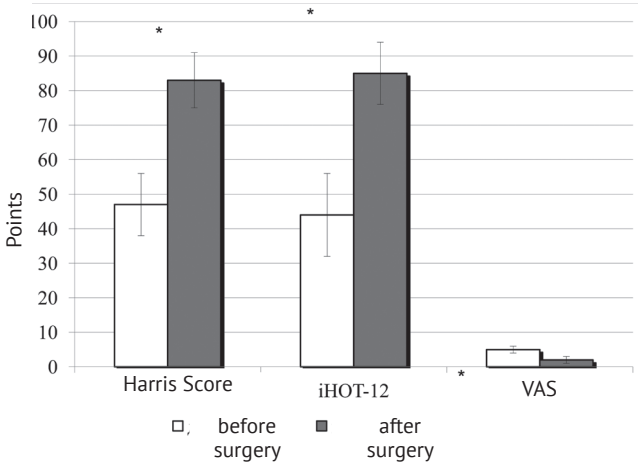

Figure 2. Functional indicators of patients, according to the questionnaire survey, before Ganz PAO and 1 year after it
* — p<0.001 comparing the values before and after the operation

Complications

Various complications developed in 20 out of 49 cases, which was 40.8%. We divided all complications into minor ones that did not require repeated intervention on hip joint, and significant ones that required rexision surgery. All minor complications were neurological and were resolved by medication and rehabilitation measures up to 1 year after surgery (11 cases out of 49-22.4%): lateral femoral cutaneous nerve neuropathy in 8 cases (16.4%), femoral nerve neuropathy in one case (2.0%), sciatic nerve paresis in one case (2.0%), reflex sympathetic dystrophy (algodystrophy) in one case (2.0%). A direct correlation was established between the presence of a history of surgical interventions for dysplasia of the affected hip joint in childhood and the development of neurological complications after PAO according to Ganz (R = 0.76; p<0.001). In 9 cases out of 49 (18.4%), revision surgery was required: in three cases (6.1%) — total hip replacement, in two cases (4.1%) - reorientation of the acetabulum (after reorientation in both patients there was surgical site infection, which was successfully treated by vacuum therapy), in four (8.2%) — arthroscopic fixation of the hip labrum. Thus, no significant complications were associated with nerves and blood vessels. It should also be noted that all revision surgeries for arthroscopic fixation of the hip labrum were performed during the first three years after the introduction of the PAO in the Adult Orthopaedic Department. In 93.9% of cases, they managed to save their own joint. Total hip replacement was performed on average after 2.3±0.7 years (from 1.8 to 3.0 years; Me 2.1 [1.9; 2.6]). In one case out of three, a 33-year-old patient developed aseptic necrosis of the femoral head. It should also be noted that a year before PAO, the woman underwent mini-lumbotomy, discectomy and anterior vertebral fusion with cage with allogenic bonegrafting, percutaneous transpedicular fixation of the L5-S1 segment due to herniated intervertebral discs. In two other patients (34-year-old male and 44-year-old female) it was not possible to stop the progression of the disease and the destruction of the hip joint cartilage, accompanied by a persistent pain syndrome, which led to the need for total hip replacement. Figure 3 shows the pelvic radiographs of the DDH patient, which was performed PAO.

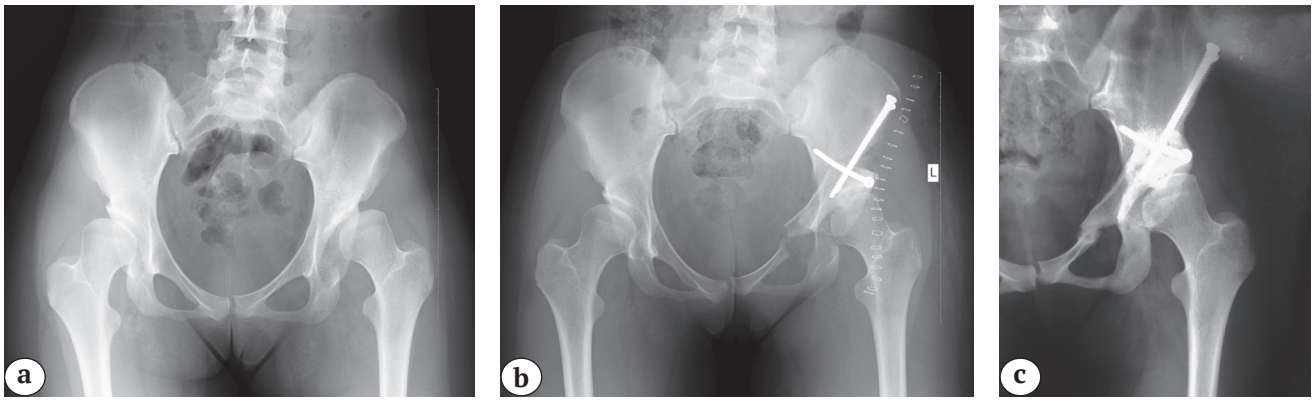

Figure 3. X-rays of the 19-year-old patient:
a — before the PAO: left hip DDH;
b — directly after the PAO; c — 3 years after the PAO: osteotomy zone consolidation

Discussion

In 1980, R. Ganz and his co-authors first described PAO technique. It was developed to achieve the following goals: to improve the mobility of the osteotomized pelvic fragment, which allowed for a greater amount of adjustment in all directions, including medialization; to increase the pelvis stability by preserving the posterior column; to ensure optimal blood supply to the bone graft by preserving the lower gluteal artery; preservation of the pelvic ring shape, which is a very important aspect, since the majority of candidates for PAO are reproductive age women[4, 10, 11]. PAO helped to delay or prevent, despite the high efficiency of endoprosthesis in middle-aged and elderly patients, total hip replacement in young patients is undesirable [12, 13]. Since then, PAO has been shown to provide significant pain relief and improvement in hip joint function in more than 90% of patients with DDH several decades after surgery [9, 14].

In the original technique PAO according to Ganz was performed using the Smith-Petersen approach. Partial osteotomy of the sciatic bone with preservation of the posterior column integrity, complete osteotomy of the pubic ramus, and biplanar osteotomy of the ilium were performed [8, 15, 16]. For the first time, the results of treatment using this method were published by R. Ganz and co-authors in 1988 [8]. The study described a group of 63 patients (75 PAO) aged 12 to 56 years. There was a significant reduction in pain and excellent coverage of the femoral head after surgical treatment. A group of patients led by S. D. Steppacher studied patients operated on by R. Ganz and found that an excellent result was maintained in 87.6% of cases up to 10 years; in 77.3% - up to 15 years and in 60.5% - up to 20 years [5]. T. Matheney and co-authors, having studied 135 cases of PAO, reported a 76% survival rate of hip joints for 9 years after surgery [11].

Many researchers make modifications of the original PAO surgical technique proposed by R. Ganz and thereby obtain higher functional results of treatment or reduce the number of complications. For example, the authors use mini-invasive approaches to hip joint [17, 18, 19], ilioinguinal approach [20], modified iliac spine wafer osteotomy, which avoids the use of fixing screws [21], and some other modifications. In the present we prefer the classical PAO method, modifying only the incision. We use the "bikini" cut, which does not change the essence of Smith-Petersen approach, however, is more advantageous from an aesthetic point of view. It is necessary to take into account that the "bikini" cut is more transverse and, unlike the classic one, it cannot be expanded. Probably,

in near future, we will also make some improvements to the PAO technique, relying on our own experience, however, in our opinion, the classical surgical technique of PAO shows stable good results.

A group of authors led by L. Ramirez-Nunez studied the results of treatment of 131 patients with DDH, who underwent PAO using the mini-invasive technique described by A. Troelsen, with an average follow-up period of 7.7±2.8 years [3]. The average age of patients was 32.3±9.5 years, 77.9% of patients were women. The authors noted an improvement in the radiological pelvic parameters, including the Wiberg, Tonnis, and Lequesne angles, after the PAO towards the values of relatively healthy people, as well as a statistically significant improvement of functional results according to the Non-Arthritic Hip Scale questionnaire from 60.7 points before surgery to 92.0 points after. The most common postoperative complication was transient dysesthesia of the lateral cutaneous nerve of the femur, which developed in 10 (7%) cases. J. C. Clohisy and co-authors reported the results of PAO in the treatment of patients with DDH with a minimum two-year follow-up period. Prospectively, the authors analyzed a large multicenter cohort, including 391 PAO cases. 79% of the patients were women, the average age was 25.4 years; the average follow — up time after PAO was 2.6 years. The authors conducted an in-depth statistical study of the preoperative characteristics of patients to identify risk factors for clinical outcomes of surgery. Thus, it was found that an increase in the patient's age correlated with an improvement in the HOOS questionnaire after surgery, in particular, the section related to pain. Increased BMI (25 to 30 kg / m2) was also correlated with reduced pain, daily activity, and improved quality of life after surgery. Male gender was negatively correlated with the ability to perform everyday tasks after surgery. Interesting is that patients with more severe dysplasia had a more significant improvement in functional outcomes and quality of life, according to the questionnaires, compared with patients with mild dysplasia. The data obtained by the authors reflect patients ' expectations for PAO [22]. So, it is quite possible that the elderly patients, for example, people with overweight, severe dysplasia make fewer demands on their hip joint and have lower functional expectations from surgery. FAI is a consequence of DDH. Instability of the joint can lead to the separation of the articular labrum, which causes the progression of pain after PAO. Failure to remove the FAI during PAO or before surgery leads to the fact that the reorientation of the acetabulum to a new position provokes a greater contact between the femoral head and the acetabulum elements in the FAI area. Several studies by various authors have shown that men have a higher risk of FAI progression after PAO, which can negatively affect activity in everyday life [23, 24]. It should be noted that in our study, among 4 patients with FAI and articular labrum detachment, who underwent PAO there was a progression of pain syndrome, there were 3 women and 1 man, which is not consistent with the results of colleagues. It is likely that this may be due to a relatively small group of patients to identify similar patterns in our study, as well as to the lack of experience of the surgeon at that time and hypercorrection, since all revision surgeries of arthroscopic fixation of the articular labrum were performed during the first three years after the introduction of the PAO in the Adult Orthopaedic Department. Patients with mild DDH present difficulties in diagnosing the disease and making surgical decisions. Symptomatic mild dysplasia may be associated with other factors that affect treatment outcomes, such as excessive torsion of the femur or failure of the soft tissues surrounding the hip joint. In addition, in mild dysplasia cases there is more likely to produce hypercorrection, which will lead to FAI and a decrease in functional results. The presented results of J. C. Clohisy on the risk

factors for PAO outcomes contradict the data of T. Matheney and co-authors, who attributed the age over 35 years, as well as insufficient congruence of the articular surfaces to the predictors of the ineffectiveness of the operation, leading to total hip replacement or a high level of pain after PAO [11]. Disputes concerning the age after which the performance of PAO is ineffective continue at the present time. Each patient with DDH needs an individual approach, and PAO should not be rejected as a treatment option for dysplasia just because the patient is older than 40 or 45 years, but they should be warned about the increased risk of possible insufficient effectiveness of the operation. In our study, there are patients older than 50 years (50, 51 and 53 years) with congruent articular surfaces, who did not develop any significant postoperative complications requiring repeated surgical intervention, completely satisfied with the results of PAO. It should be noted that obesity (BMI above 30 kg / m2) is a risk factor for the development of significant complications after PAO. In the study involving 280 PAO cases with an average follow-up period of 48 months, it was found that the average probability of developing significant complications after PAO in obese patients was 22% versus 3% in non-obese patients [25]. In our study, a high direct correlation was established between the presence in the anamnesis of surgical treatment of dysplasia of the affected hip joint in childhood and the development of neurological complications after PAO ($R = 0.76$; $p<0.001$). In 9 out of 10 cases where any neurological complications developed after PAO, the patient underwent a triple pelvic osteotomy or other variants of pelvic or hip osteotomies in childhood. An increased likelihood of developing neurological complications after PAO in the presence of a history of pelvic surgery is associated with the presence of scarring in the soft tissues surrounding the hip joint. Among the patients presented in this study was a woman, who underwent delivery by caesarean section a few years before PAO. After the operation, she developed femoral nerve neuropathy, due to the scar tissue pressure on the nerve after the operation. It is likely that not only operations associated with the treatment of dysplasia in childhood increase the risk of neurological complications after PAO, but also any other interventions near the pelvic osteotomy area.

We found that the average volume of blood loss after PAO in the general sample was 678±332 ml, and the need for blood transfusion occurred in 24.5% of cases. J. Shang and co-authors in their study reported that intraoperative blood loss was 791±312 ml, and the frequency of blood transfusions was 86.5% [26], which exceeds the data obtained by us. The authors proposed a multimodal protocol for managing blood loss, including intraoperative autohemotransfusion, the use of tranexamic acid (20 mg/kg intravenously and 0.5 g topically, immediately before closing the incision), the absence of drainage in the postoperative period, and a special technique for laying ice. With use of the described protocol, it was possible to reduce the volume of intraoperative blood loss by more than 2 times — up to 382±144 ml, which made it possible not to use blood transfusion in any of the cases of PAO [26]. We believe that the local use of tranexamic acid in PAO is interesting and may be a promising direction in the large joints surgery. In the study of J. C. Clohisy and co-authors, which included 391 PAO, 7% of cases developed significant postoperative complications, including various neurological problems (2%), pulmonary embolism (0,5%), deep vein thrombosis (0.3%) and deep infection, demanding surgical treatment (0,5%), fractures (1,5%), the heterotopic ossification requiring resection (1%), isolated cases of dislocation of the femoral head and loss of fixation osteocartilaginous fragment of the pelvis due to the patient falling. In 3% of cases, repeated surgical intervention was required (most often — hip joint arthroscopy), in 0.8% of cases, patients un-

derwent total hip replacement. According to the questionnaire survey data (HOOS, mHHS, UCLA, SF-12), in 93% of cases, patients were satisfied with the results of treatment [22].

In an earlier systematic review by a group of authors led by J. C. Clohisy, the authors tracked the results of 626 PAO for an average of 5 years after surgery [27]. In 79% of cases, patients showed excellent and good clinical results of treatment, in 7.3% of cases after surgery total hip replacement was required, the frequency of significant postoperative complications ranged from 6% to 37%, the authors called coxarthrosis of moderate and high severity as a predictor of an unfavorable outcome. Current patient selection criteria changed and now coxarthrosis is a contraindication to PAO, but the level of complications after PAO continues to be high. As a result of our study, it was found that various postoperative complications developed in 40.8% of cases: minor — in 22.4%, significant-in 18.4%. The data obtained are consistent with the results of the majority of colleagues who use PAO for treatment of patients with DDH [20, 27, 28]. Neurological complications remain among the most common after PAO. In our study, neuropathy of the lateral femoral cutaneous nerve developed in 16.4%. In a systematic review, J. C. Clohisy and co-authors reported a frequency of dysesthesia of the lateral femoral cutaneous nerve, reaching 14% of cases, almost an each third of them required neurolysis [27]. I. Swarup and co-authors demonstrated that the frequency of damage to the lateral femoral cutaneous nerve reached 14.8% [28]. Currently, the PAO proposed by R.Ganz et al., is the most preferred treatment for patients with DDH. However, this procedure has a steep learning curve and requires sufficient experience from the surgeon [5, 20, 29]. The most common mistake when performing PAO is a violation of the pelvic ring integrity. Hypercorrection can lead to the occurrence of FAI, separation of the articular labrum, pain syndrome and a decrease in the range of motions [22]. Hypocorrection may be ineffective, which will not lead to a reduction in pain and reduce the patient's discomfort. Postoperative complications include the following: risk of damage to nerve structures (lateral femoral cutaneous nerve, femoral nerve, sciatic nerve), heterotopic ossification, instability of the osteotomized fragment fixation, stress fracture [27, 28, 30, 31]. However, in properly selected patients and in the hands of experienced surgeons, PAO should be considered as a safe and effective operation as total hip replacement [12, 13].

Conclusion

PAO for DDH type I according to Crowe is a reproducible technique, has good reconstructive capabilities and allows to restore the coverage of the femoral head with the acetabulum. The functional status and quality of life improved after treatment, the intensity of pain decreased — most patients are satisfied with the surgery results. PAO, performed according to the indications, has sufficient effectiveness, allows to delay the total hip replacement. However, the surgical technique complexity and the high frequency of possible postoperative complications require considerable surgeon experience and significantly delay the popularization of PAO in the Russian Federation.

Ethical approval

The study was approved at a meeting of the local ethics committee and fully complies with the ethical principles of The Helsinki Declaration as revised in 2013.

Informed consent

Informed voluntary consent to participate in the study was obtained from all patients.

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