



## Pelvic Osteotomies for Treatment of Young Patients With Hip Osteoarthritis Secondary to Developmental Dysplasia

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**Background.** The value of joint-sparing reconstructive procedures in patients with osteoarthritis in a dysplastic hip is controversial.

**The study aimed** to evaluate the immediate and mid-term results of reconstructive interventions performed in patients with this pathology.

**Methods.** The treatment results of 30 patients aged 14–40 years with osteoarthritis in the dysplastic hip were analyzed. The mean follow-up time was  $6.8 \pm 1.5$  years in group 1 and  $4.1 \pm 0.7$  years in group 2. The clinical condition and treatment results were assessed by D'Aubigne-Postel, Severin, Tonnis criteria, and the Ilizarov Center system. In all cases, extra-articular reconstructive procedures were performed on both articular components.

**Results.** The patients were divided into two groups by age. In group 1 (14–18 years), the functional result was  $16.0 \pm 0.5$  points. According to the Severin criteria, the joints were distributed as follows: Ia, 7; IIa, 7; IIb, 2; and III, 3. The degree of hip osteoarthritis did not change in 13 joints. Osteoarthritis progressed in one joint, and arthritic changes regressed in four joints. The treatment results according to the criteria of the RSC VTO were good in 14 joints, satisfactory in 5, and unsatisfactory in 1. In group 2 (>18 years,  $n = 11$ ), the functional result was  $15.0 \pm 0.4$  points. The distribution of joints according to the Severin criteria was as follows: Ia, 3; IIa, 6, and III, 2. The degree of osteoarthritis did not change in 10 joints. Osteoarthritis progressed in one joint. The treatment results according to the criteria of the Ilizarov Center were good in seven joints, satisfactory in three, and unsatisfactory in one.

**Conclusions.** The differentiated use of joint-sparing reconstructive procedures makes it possible to slow down the progression of the pathological process in the joint even in patients with developed osteoarthritis and, in some cases, to use them as a temporary alternative to endoprosthesis in adolescents and young adults.

**Keywords:** dysplastic hip, hip osteoarthritis, joint-sparing reconstruction.

 **Cite as:** Teplenky M.P., Oleinikov E.V., Bunov V.S., Fozilov D.T. [Pelvic Osteotomies for Treatment of Young Patients With Hip Osteoarthritis Secondary to Developmental Dysplasia]. *Travmatologiya i ortopediya Rossii* [Traumatology and Orthopedics of Russia]. 2022;28(1):19-27. (In Russian). <https://doi.org/10.17816/2311-2905-1678>.

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Submitted: 14.10.2021. Accepted: 23.12.2021. Published Online: 08.02.2022.



## Реконструкция тазобедренного сустава у молодых пациентов с диспластическим коксартрозом

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**Актуальность.** Значение суставосберегающих реконструктивных вмешательств у пациентов с развившимся диспластическим коксартрозом остается дискуссионным. **Цель исследования** — оценка ближайших и среднесрочных результатов реконструктивных вмешательств, выполненных у пациентов с диспластическим коксартрозом.

**Материал и методы.** Проанализированы результаты лечения 30 пациентов с диспластическим коксартрозом в возрасте от 14 до 40 лет. Пациенты были разделены на две группы. В первую группу вошли 19 пациентов в возрасте 14–18 лет, во вторую — 11 пациентов в возрасте 19–40 лет. В первой группе средний срок наблюдения составил  $6,8 \pm 1,5$  лет, во второй группе —  $4,1 \pm 0,7$  года. Клиническое состояние и результаты лечения оценивали по критериям D'Aubigne–Postel, Severin, Tönnis и по системе оценки, разработанной в НМИЦ ТО им. акад. Г.А. Илизарова. У всех пациентов выполняли внесуставные суставосберегающие реконструктивные вмешательства, показания к которым устанавливали с учетом типа суставных поверхностей и величины индекса конгруэнтности суставных поверхностей.

**Результаты.** В первой группе средний функциональный результат составил  $16,0 \pm 0,5$  балла. Распределение суставов по классификации Severin: Ia — 7, IIa — 7, IIb — 2, III — 3. Степень артроза не изменилась в 13 суставах. Прогрессирование артроза отмечено в одном суставе, регресс артрозных изменений — в четырех суставах. Результаты лечения по критериям НМИЦ ТО им. Г.А. Илизарова: хороший — 14 суставов, удовлетворительный — 4 сустава, неудовлетворительный — 1 сустав. Во второй группе функциональный результат составил  $15,0 \pm 0,4$  балла. Распределение суставов по критериям Severin: Ia — 3, IIa — 6, III — 2. Степень артроза не изменилась в 10 суставах, прогрессирование артроза произошло в одном суставе. Результаты лечения по критериям НМИЦ ТО им. Г.А. Илизарова: хороший — 7 суставов, удовлетворительный — 3, неудовлетворительный — 1.

**Заключение.** Дифференцированное применение суставосберегающих реконструктивных вмешательств дает возможность замедлить прогрессирование патологического процесса в суставе даже в условиях развившегося артроза и позволяет в ряде случаев использовать их в качестве временной альтернативы эндопротезированию у подростков и пациентов молодого возраста.

**Ключевые слова:** тазобедренный сустав, диспластический коксартроз, реконструкция, суставосберегающие операции.

Тёпленький М.П., Олейников Е.В., Бунов В.С., Фозилов Д.Т. Реконструкция тазобедренного сустава у молодых пациентов с диспластическим коксартрозом. *Травматология и ортопедия России*. 2022;28(1):19-27. <https://doi.org/10.17816/2311-2905-1678>.

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Рукопись получена: 14.10.2021. Рукопись одобрена: 23.12.2021. Статья опубликована онлайн: 08.02.2022.

## Background

Excessive pressure between the articular surfaces can lead to the development of degenerative and dystrophic changes in the cartilage in dysplastic coxarthrosis because of the decrease in the area of their contact [1, 2] and is possibly associated with an impairment of the spatial position, shape, and ratio of the articular components [3, 4]. Studies have proposed that eliminating or fully compensating for these mechanical causes can positively affect the course of the pathological process in the joint [5, 6], which is the basis of the practicality of using joint-sparing reconstructive surgeries. However, the value of these interventions for developed arthrosis remains debatable [7]. Many experts consider early osteoarthritis as a contraindication to this intervention because of the risk of rapid progression of the pathological process [8, 9]. In addition, other adverse prognostic factors include severe underdevelopment and deformity of the acetabulum, significant proximal and lateral displacement of the femoral head, and impairment of its sphericity [11, 12, 13]. On the other hand, other studies have proposed triple pelvic osteotomy as an alternative to early arthroplasty [7, 10].

This study aimed to evaluate the short- and medium-term effects of reconstructive interventions performed on young patients with dysplastic coxarthrosis.

## Methods

### Study design

This retrospective cohort study analyzed the results of the treatment of 30 patients (27 women, 3 men) with dysplastic coxarthrosis aged 14 to 40 years. We distributed the patients into two groups on the basis of age. Group 1 comprised 19 patients aged 14 to 18 years ( $15.2 \pm 0.5$  years); whereas group 2 comprised 11 patients aged 19 to 40 years ( $25.5 \pm 1.5$  years).

In all cases, congenital hip dysplasia led to the pathological process.

The *inclusion criteria* included grades I to II of arthrosis, severe acetabular dysplasia (Tönnis angle  $> 20^\circ$ ), grades II to III of dislocation based on the Tönnis classification [14], Wiberg angle of  $5^\circ$  or lower, and a follow-up period of at least 2 years.

The *exclusion criteria* included grades 0 and III arthrosis, moderate acetabular dysplasia (Tönnis angle  $\leq 20^\circ$ ), grade I dislocation, Wiberg angle of more than  $5^\circ$ , and a follow-up period of less than 2 years.

### Surgical technique

The indications for extraarticular joint-sparing reconstructive interventions were established by considering the type of articular surfaces and the value of the index of congruence of the articular surface (ICAS) [16]. With a congruence index of 1.1 to 1.5, the acetabulum was reoriented via pelvic osteotomy in 22 cases [17] or via periacetabular osteotomy in 5 cases. Although periacetabular osteotomy is similar to the R. Ganz technique [18] in the nature of the impairment of the bone integrity, they differed in the way of changing the spatial position and fixing the acetabular fragment. With an ICAS of more than 1.5, pelvic osteotomy was supplemented with iliac bone osteotomy in 10 cases to change the spatial position of the cavity vault. On the other hand, pelvic osteotomy was combined with the formation of a shelf according to L. Staheli to increase the cavity volume in two cases with an ICAS of less than 1.1 [19]. The proximal femur in all cases received reconstructive intervention. Most cases (21) underwent intertrochanteric osteotomy to correct cervical-diaphyseal disorders in the frontal and horizontal planes. Meanwhile, nine cases underwent double transtrochanteric osteotomy. The osteotomized fragments and the joint during pelvic osteotomy were fixed with the Ilizarov apparatus. In addition, decompression of the articulation was performed during treatment. The duration of hardware treatment lasted  $73.0 \pm 3.2$  days. During periacetabular osteotomy, combined osteosynthesis performed by fixing the pelvic bone with screws and fixing the joint and fragments of the femur with the apparatus. The duration of hardware treatment lasted  $40.0 \pm 2.0$  days. The rehabilitation period after dismantling the apparatus lasted  $9.3 \pm 0.4$  months.

### Evaluation of results

We assessed functional outcomes using the Merle d'Aubigne–Postel scale and assessed the radiographic parameters using the Severin and Tönnis criteria and the assessment system of the G.A.

Ilizarov National Medical Research Center for Traumatology and Orthopedics. We determined X-ray signs of pathology using radiographs of the hip joint, performed in the anteroposterior projection. We also determined the radiographic parameters of the angle of inclination of the cavity bearing surface (WBS), the acetabular coefficient (AC), the indices of sphericity of the acetabular cavity and the head (ISH), ICAS, the Wiberg angle (CEA), the degree of coverage of the head with an acetabular roof (AHI), cranial displacement index (SL), and lateral displacement angle (LDA). In addition, we used the Tönnis classification to determine the severity of arthrosis and the Coleman criteria, modified by the authors of the article [16], to determine the nature of the articular surfaces.

### Statistical analysis

Using Microsoft Excel 2010 software to analyze the results, we compiled the unweighted variation series from quantitative data and determined the means, their error, and statistical significance. We processed the data using non-parametric tests such as the Wilcoxon test and Mann–Whitney *U*-test.

### Results

In group 1, the initial functional indicator was  $14.7 \pm 0.1$  points, with pain at  $4.50 \pm 0.13$ , range of motion at  $4.8 \pm 0.2$ , and physical activity at  $4.6 \pm 0.15$ . The leading radiological signs of pathology include acetabular dysplasia and decentration of the femoral head. Meanwhile, the mean bearing surface inclination reached  $39.5^\circ \pm 2.0^\circ$ , AC reached  $130.0 \pm 5.4$  (100–200), and the bone coverage index reached  $0.35 \pm 0.06$  (0.20–0.60). The distribution of joints based on the grade of dislocation showed 12 joints with grade II and 7 joints with grade III. The distribution based on the grade of arthrosis by Tönnis showed 13 joints with grade I and 6 joints with grade II. The distribution based on the type of congruence by Coleman showed 9 joints with grade I, 6 joints with grade II, 3 joints with grade III, and 1 joint with grade IV.

In group 2, the initial functional index was  $13.1 \pm 0.5$  points, with pain at  $4.50 \pm 0.15$ , range of motion at  $4.40 \pm 0.25$ , and motor activity at  $4.20 \pm 0.15$ . The mean bearing surface inclination

scored  $34.0^\circ \pm 2.5^\circ$ , AC scored  $170 \pm 5$  (140–210), and the bone coverage scored  $0.42 \pm 0.05$  (0.4–0.6). The distribution of joints based on the grade of dislocation showed 10 joints with grade II and 1 joint with grade III; the distribution based on the grade of arthrosis according to Tönnis showed 8 joints with grade I and 3 joints with grade II; on the other hand, the distribution based on the type of congruence according to Coleman showed 7 joints with grade I and 4 joints with grade II.

We analyzed the results on the basis of the follow-up period from 2 to 18 years, with an average follow-up period of  $6.8 \pm 1.5$  years in group 1 and  $4.1 \pm 0.7$  years in group 2.

We obtained a higher functional result in patients of group 1 ( $16.0 \pm 0.5$  points), with an increase of 1.3 points. The result was considered good (15–16 points) in 15 cases and satisfactory (12–14 points) in three cases. The functional indicator in one patient was 11 points, corresponding to a poor result. On the other hand, the average score increased by 1.9 points in group 2, amounting to  $15.0 \pm 0.4$  points. The result of treatment was considered good in seven cases and satisfactory in four.

The X-ray data in both groups showed a statistically significant improvement in indicators characterizing the state of the acetabulum and articular ratios (Table 1).

Using the Severin criteria, radiographic results in group 1 were classified as Ia in 7 cases, IIa in 7 cases, IIb in 2 cases, and III in 3 cases. The severity of arthrosis remained unchanged in 13 cases, moved up one grade in one joint, and decreased in 4 cases. Results also showed a progression of arthrosis by two grades in one case. Distribution of joints based on the Tönnis criteria showed grade I in 16 joints, grade II in 2 joints, and grade III in 1 joint. Congruence of articular surfaces improved in 5 joints. The distribution of joints based on the type of congruence according to Coleman showed type I for 14 joints, type II for 2 joints, and type III for 3 joints. On the basis of the criteria by the G.A. Ilizarov National Medical Research Center for Traumatology and Orthopedics, 14 cases had good results ( $2.70 \pm 0.03$ ) whereas 4 cases had satisfactory results ( $1.98 \pm 0.08$ ). However, one case had a poor outcome (1.60). The proportion of good results was 74%.

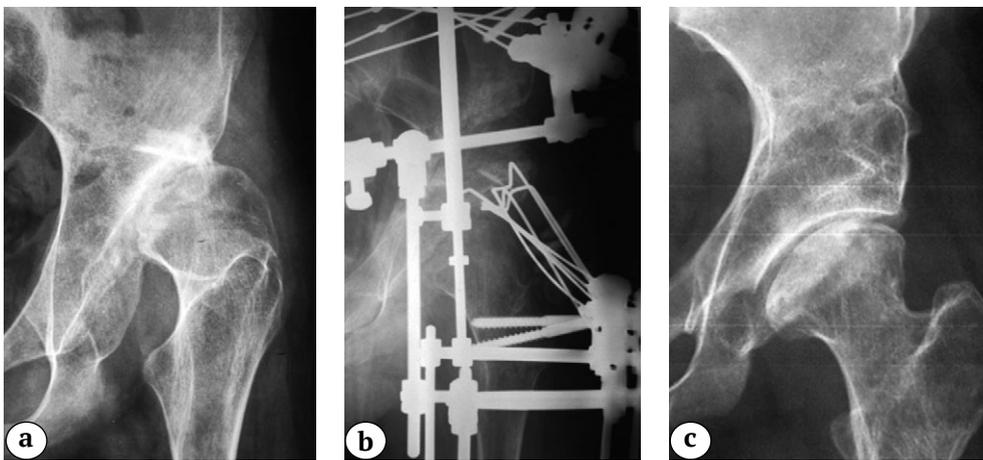
Figure 1 presents a sample case from group 1.

Table 1

## Changes in radiometric parameters over time in patients with coxarthrosis

X-ray indicator	Patient group			
	1 (25 joints)		2 (14 joints)	
	Before treatment	Follow-up examination	Before treatment	Follow-up examination
WBS, deg.	39.5 ± 2.0	8.0 ± 3.0*	34.0 ± 2.5	9.0 ± 1.5*
AC	130.0 ± 5.4	18.0 ± 1.5*	170.0 ± 5.0	185.0 ± 1.8
AHI	0.35 ± 0.05	0.92 ± 0.05*	0.42 ± 0.03	0.85 ± 0.06*
CEA, deg.	1.4 ± 1.6	30.0 ± 1.9*	1.2 ± 1.7	27.0 ± 0.8*
LDA, deg.	38.0 ± 2.5	22.0 ± 2.0*	35.0 ± 3.0	25.0 ± 1.3*
SL, mm	29.0 ± 3.0	5.0 ± 0.2*	25.0 ± 3.5	3.0 ± 0.6*

\*Statistically significant differences from the baseline,  $p < 0.05$ .



**Fig. 1.** X-ray images of a 14-year-old patient; dysplastic coxarthrosis, stage II; dislocations, stage III: a – before treatment; b – during treatment; c – 7 years follow-up

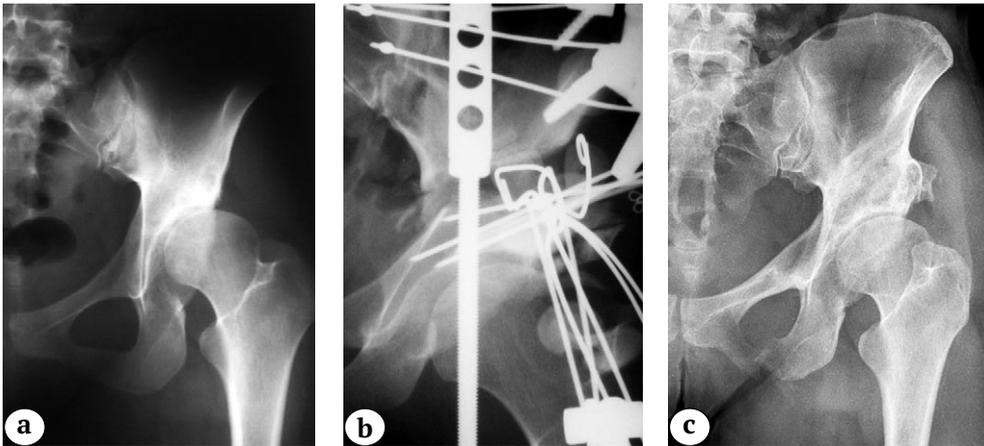
Using the Severin criteria, radiographic results in group 2 showed 3 cases with Ia, 6 with IIa, and 2 with III. The severity of arthrosis remained unchanged in 10 cases, but one joint had a progression by one grade. Distribution of joints based on the Tönnis criteria showed 7 with grade I and 4 with grade II. The congruence of the articular surfaces improved in three joints. The distribution of joints based on the type of congruence according to Coleman showed 9 joints with type I, 1 with type II, and 1 with type IV.

Figure 2 presents a sample case from group 2. On the basis of the criteria of the G.A. Ilizarov

National Medical Research Center for Traumatology and Orthopedics, seven cases had good results ( $2.56 \pm 0.01$ ), while 3 cases had satisfactory results ( $2.10 \pm 0.05$ ). However, one case had a poor outcome (1.36). There were 63% of good results.

### Complications

In 3 cases from group 1, superficial inflammation of the soft tissues around the apparatus fixing elements was stopped using conservative measures. In one case, an intraarticular fracture of the fixing elements occurred, requiring additional surgical intervention.



**Fig. 2.** X-ray images of a 20-year-old patient; dysplastic coxarthrosis, stage II; dislocations, stage II; a – before treatment; b – during treatment; c – 16 years follow-up

## Discussion

Although arthroplasty has known advantages and high efficiency, this method may not always be the surgery of choice for adolescents and young adults with dysplastic coxarthrosis because of the high probability of repeated, usually more aggressive intervention [20]. Therefore, improving and implementing joint-saving surgeries are preferred in the orthopedic rehabilitation of these patients. Theoretically, restoring articular relationships by changing the spatial position and shape of the articular components should reduce intraarticular pressure and have a positive effect on the course of the pathological process in the joint [7, 17].

Although adequate reconstructive intervention slows down the progression of arthrosis, the intervention does not prevent it [21]. Previous studies showed that the proportion of joints in which arthrosis progressed after surgery varied from 5% to 31% [22, 23, 24]. Other studies found that 5% to 15% of cases required arthroplasty after joint-sparing intervention [25, 26, 27]. Adverse prognostic factors include age, signs of developed arthrosis, severe cavity dysplasia, proximal and lateral displacement of the head, deformity, and incongruence of the articular surfaces [11, 12, 13, 28, 29, 30]. Korytkin et al. noted that in a group of patients older than 18 years with hip dysplasia with minimal dislocation and without pronounced degenerative changes, 6% required arthroplasty during the first 3 years after reconstructive intervention [31]. In addition, Kamosko

et al. found that in a group of adolescent patients with signs of developed arthrosis at the end of the rehabilitation period, 7% of cases presented with articulation decompensation in the form of a rapid progression of degenerative-dystrophic changes, requiring joint replacement [32].

In this study, we excluded patients (grade 0 arthrosis, grade I dislocation, spherical head, moderate acetabular dysplasia) who were considered the best candidates for joint-sparing intervention by Trousdale and Cabanela, [33]. Thirty percent of joints had grade II arthrosis. Eight cases registered grade III dislocation, whereas four cases had head deformity.

We detected 6.7% of joints with arthrosis progression. All cases had grade I arthrosis before the surgery. We associated a poor outcome in a teenage patient with technical errors during surgery (intraarticular location of fixing elements). In a patient from group 2, the formed incongruence of the articular surfaces possibly caused the pathological process progression.

Because of the limited number of patients and a short average follow-up period, we could not objectively assess the impact of reconstructive surgery on the pathological process. Nevertheless, despite the adverse prognostic indicators in most cases, it should be noted that joint-sparing intervention did not lead to joint decompensation.

Previous studies found that the restoration of articular relationships can stabilize and even regress degenerative-dystrophic changes in the joint [34, 35, 36]. Other studies noted that the pro-

portion of joints that had reversal of degenerative-dystrophic changes varied from 6% to 91% [32, 34, 36]. This difference may be associated with the initial grade of arthrosis and the different criteria used to interpret radiographic results [10, 14, 32]. In our study, we noted an improvement in 4 joints only in group 1. In addition, structural changes in the components of the joints remained at the same level in 80% of cases, suggesting a slowdown in the progression of arthrosis.

Analysis of the treatment results according to age showed that higher functional results were achieved in group 1 despite the more pronounced initial anatomical disorders in the group. Differences in radiographic results between both groups were not statistically significant, probably due to the higher adaptive capacity of adolescents.

Previous studies found that complications in the form of heterotopic ossification (4%–8%), neurological disorders (1%–15%), and the formation of false joints (1%–2%) usually occur after performing reorienting osteotomies [22, 25, 26, 27]. In this study, all complications (13.3%) were associated with the use of hardware fixation, with the treatment outcome in one case being significantly affected by a complication.

The Ilizarov apparatus is commonly used in the treatment of patients in both groups for fixing osteotomized bone fragments. Its disadvantages include significant inconvenience for the patient, the need for prolonged medical supervision, and a long rehabilitation period (8–10 months). Previous studies showed that the duration of the recovery period can be reduced to 3–6 months with the use of modern internal fixators [36]. This difference may be partly due to the different criteria for completing the rehabilitation period. We believe that a full load on the limb (the end of the recovery period) is acceptable when the mobility in the joint and the strength of the gluteal muscles are restored in a functionally beneficial range. Another important factor that increases the recovery process duration is the long-term (70–75 days) hip joint fixation, which increases its contracture. This is one of the controversial elements of the technology. On the one hand, joint immobilization causes degenerative changes in the articular cartilage. On the other hand, clinical data show that prolonged fixation of the joint in combination with supportive distraction

does not lead to irreversible changes. We assume that nonarticulating hardware fixation of the joint with decompression elements can ensure mutual adaptation of the articular components after the restoration of articular relationships, as confirmed to a certain extent in the analysis of the results our study.

This technique's advantages include the patient's early motor activity and the load on the limb, reduction of surgical complexity and injury rate, and flexibility in positioning bone fragments and articular components during the surgery and in the postoperative period. Using the apparatus provides the necessary mobility of the cavity, virtually eliminating delayed consolidation at the osteotomy sites.

## Conclusions

The differentiated use of reconstructive interventions can slow down the progression of the pathological process in joints with developed arthrosis and initial incongruence of the articular surfaces and can be used as a temporary alternative to arthroplasty in adolescents and young patients.

## Disclaimers

### *Authors' contributions*

All authors made equal contributions to the study and the publication. 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.

**Funding source.** This study was not supported by any external sources of funding.

**Competing interests.** The authors declare that they have no competing interests.

**Ethics approval.** The study was approved by the local ethics committee of National Ilizarov Medical Research Center for Traumatology and Orthopedics, protocol No 2 (57), 17.05.2018.

**Consent for publication.** Written consent was obtained from the patients or their legal representatives for publication of relevant medical information and all of accompanying images within the manuscript.

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