Joint Diseases and Related Surgery

Jt Dis Relat Surg
2024;35(1):202-208

ORIGINAL ARTICLE

Cakirgil method in the surgical treatment of older children with developmental dysplasia of the hip: Mid-term follow-up results of 17 hips and literature review

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ABSTRACT

Objectives: This study aimed to evaluate the results of the Cakırgil method in patients with advanced developmental dysplasia of the hip (DDH).

Patients and methods: Patients who underwent surgical treatment with the Cakırgil method between January 2011 and December 2022 with a diagnosis of DDH were retrospectively scanned. Thirteen patients (7 females, 6 males; 8.0±2.7 years; range, 5 to 12 years) with severe DDH were included in the study. The results of the Cakirgil method, including adductor tenotomy, open reduction, femoral shortening, varus and derotation osteotomy, and Dega acetabuloplasty, were retrospectively evaluated in 17 hips of these 13 patients. Clinical and radiological evaluation was performed according to the acetabular index, center edge angle, Severin score, and McKay criteria.

Results: Five patients had comorbidities. The mean follow-up period was 78.3±28.9 (range, 12 to 135) months. The acetabular index decreased from 35.24° to 22.06° and center edge angle improved from -34.71° to 26.59°. The Severin score decreased from 4.82 to 2.29 and the McKay criteria from 3.47 to 1.88. All changes were statistically significant ($p<0.001$). Redislocation was observed in only one hip.

Conclusion: Surgical treatment of the older patients with neglected DDH is technically difficult, and the results are prone to complications. The technique outlined by Prof. Dr. Güngör Sami Cakırgil, a renowned specialist in DDH surgeries in Türkiye who has made notable contributions to the relevant research, yields satisfactory outcomes when employed under suitable circumstances.

Keywords: Acetabular, developmental dysplasia of hip, osteotomy, pelvic, radical reduction.

Developmental dysplasia of the hip (DDH), if diagnosed at an early stage, is a disease that can be treated with various orthoses without the need for surgical intervention. Mask region-based convolutional neural network-based automatic segmentation of anatomical structures of newborn hips from Graf's ultrasonography images to delineate measurable images provided high success.[1] Nowadays, due to the increasing rate of deliveries in hospital conditions, routine physical examination, and widespread use of ultrasonography, surgical procedures are performed considerably less; nevertheless, they remain current. Although satisfactory results are obtained after surgical treatment at early ages, the chance of success of the surgical treatment decreases significantly in children over four to six years of age, and surgeries become technically more difficult.[2] The surgical treatment involves soft tissue procedures at early ages and bony procedures, mostly after 18 months of age.[3] Numerous surgical methods have been described for older patients.[4]

In this study, we evaluated the results of the surgical treatment using the method described

Received: October 31, 2023
Accepted: November 23, 2023
Published online: December 01, 2023

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Doi: 10.52312/jdrs.2023.1510

Citation: Tolunay T, Baymurat AC, Çalta MŞ, Atalar H. Cakirgil method in the surgical treatment of older children with developmental dysplasia of the hip: Mid-term follow-up results of 17 hips and literature review. Jt Dis Relat Surg 2024;35(1):202-208. doi: 10.52312/jdrs.2023.1510.

by Cakirgil,[2] performed on advanced-age DDH patients. In this method, adductor tenotomy, femoral shortening and derotation, open reduction of the hip, and Dega osteotomy are performed in the same session. The main known advantage of this method is that several surgical procedures can be successfully performed in a single session. In addition, in well-selected patients with advanced DDH, a high success rate can be achieved with a low risk of avascular necrosis (AVN).[2]

PATIENTS AND METHODS

Patients who underwent surgical treatment with the Cakirgil method at the Gazi University Faculty of Medicine, Department of Orthopedics and Traumatology between January 2011 and December 2022 with a diagnosis of DDH were retrospectively scanned. Seventeen hips of 13 patients (7 females, 6 males; 8.0±2.7 years; range, 5 to 12 years) with severe DDH were included in the study. The study included all patients who underwent Cakirgil surgery.

Patients were prepared and draped in the supine position under general anesthesia with the entire iliac wing, hip joint, and proximal femur exposed. First, adductor tenotomy was performed through a medial mini-incision over the adductor muscles. Then, an incision was made starting 3 cm posterior to the anterior superior iliac spine, extending towards the trochanter major and proceeding straight along the femoral shaft (Figure 2). After the fascia was opened along the incision line, the hip capsule was exposed with an anterolateral approach through the space between the tensor fascia lata and sartorius muscles. The anterior two-thirds of the iliac apophysis was resected up to the bone, divided in half, and subperiosteally stripped from the iliac wall. After placing a marker suture, the straight head of the rectus femoris muscle was elevated from the anterior inferior iliac spine (Figure 3). The tenotomy of the iliopsoas tendon was performed medial to the capsule. Following the opening of the joint capsule with a T-shaped incision, the ligamentum teres was excised. The fibrolipoid tissues (pulvinar) inside the acetabulum were excised.

At the proximal part of the femur, the fascia lata was dissected parallel to the skin incision, and the vastus lateralis muscle was released in an "L" shape with the help of electrocautery and stripped subperiosteally from the trochanter. After a transverse osteotomy was performed in the subtrochanteric region, the femoral head was reduced into the acetabulum. After applying manual traction to the extremity, the overlapping bone segment was observed, and this segment was removed. Then, after determining the appropriate varus and derotation, fixation was performed using a Harris-Müller plate and three cortical screws (Figure 4). Dega osteotomy was performed in the next step. The determined osteotomy line was approximately 7 to 10 mm superior to the superior border of the acetabulum. The osteotomy line was stretched to provide adequate

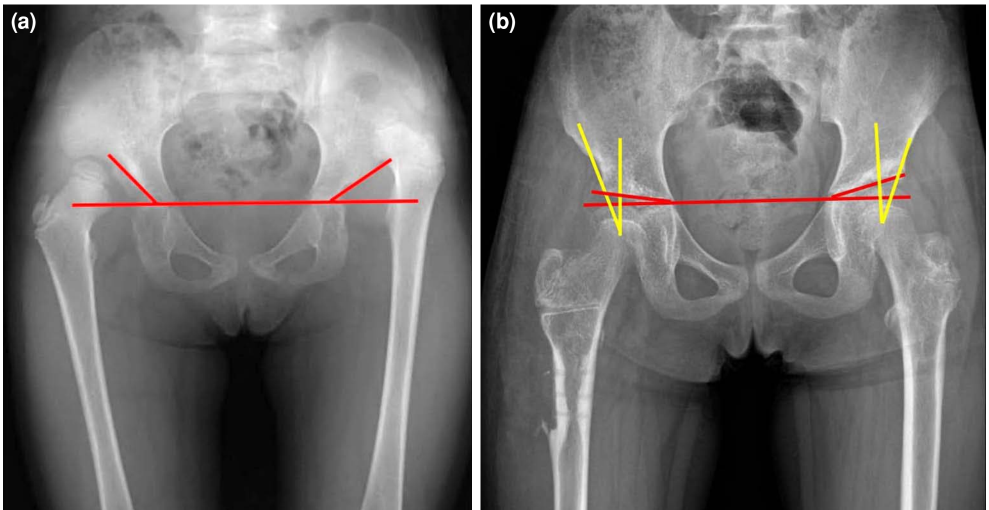

FIGURE 1. (a) Preoperative and **(b)** postoperative radiographs of a six-year-old patient who presented with bilateral DDH, 53 months postoperatively in the left hip and 24 months postoperatively in the right hip.
DDH: Developmental dysplasia of hip.

FIGURE 2. Anterolateral J-shaped incision. The incisions were made starting 3 cm posterior to the anterior superior iliac spine, extending towards the trochanter major and proceeding straight along the femoral shaft.

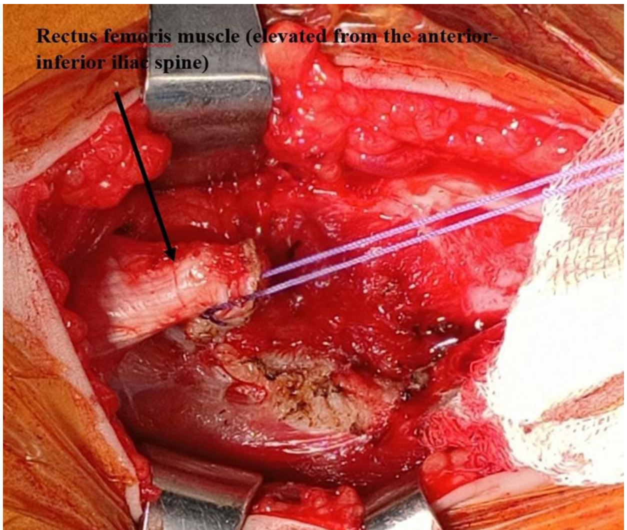

FIGURE 3. Marker suture passed through the straight head of the rectus femoris muscle, elevated from the anterior inferior iliac spine.

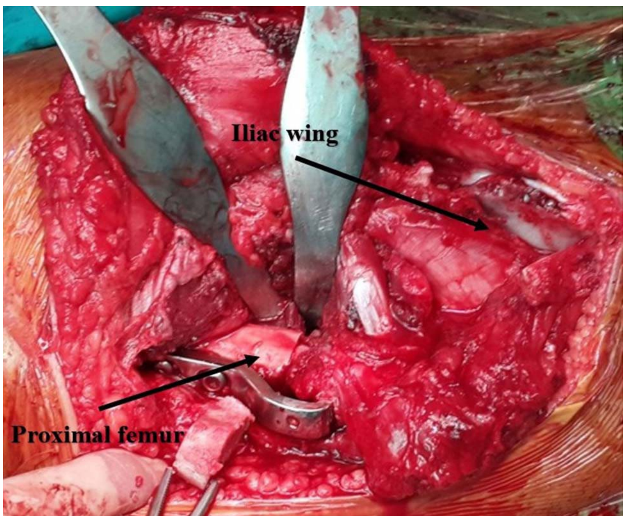

FIGURE 4. An image of proximal femoral osteotomy, followed by fixation with a Harris-Müller plate.

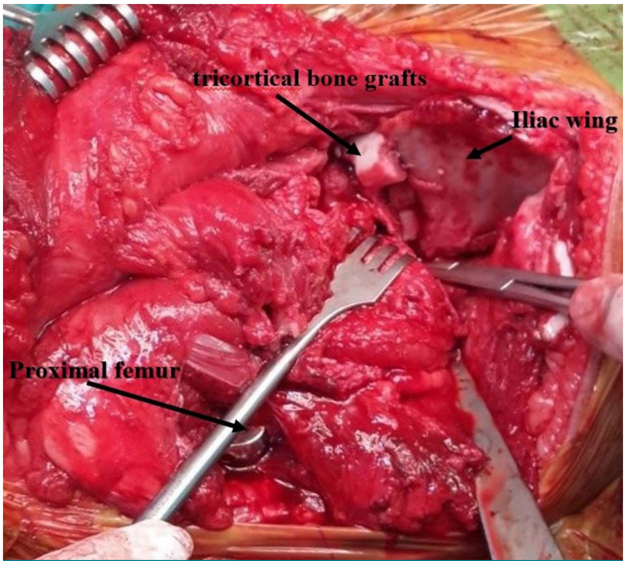

FIGURE 5. The placement of tricortical bone grafts harvested from the femoral osteotomy or iliac wing in the periacetabular osteotomy line to provide adequate acetabular coverage.

acetabular coverage, and the excised bone from the preceding femur osteotomy or the tricortical graft from the iliac wing was placed into the osteotomy line (Figure 5). Capsulorrhaphy was then performed, followed by the closure in a layered fashion. A hip spica cast was applied and was followed up for six weeks before its removal.

Clinical and radiologic follow-ups were performed at three weeks, six weeks, 12 weeks, six months, and then annually. Preoperative and postoperative acetabular index (AI) and center edge angles (CEAs) were measured on direct radiographs (Figure 1). Patients were evaluated clinically according to McKay's[5] classification (Table II) and radiologically according to Severin's[6] evaluation criteria (Table III). Clinical and radiologic evaluation data are presented in Table IV.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 28.0 software (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the demographic and clinical characteristics of the patients, which included computing means, medians, standard deviations, ranges for continuous variables, and frequencies and percentages for categorical variables. The Shapiro-Wilk test was employed to assess the normality of continuous variables appropriate for the study's sample size. To complement this, measures of skewness and kurtosis were also calculated for each variable to provide a more

TABLE I
Demographic characteristics and basic information of the patients

	n	%	Mean±SD	Min-Max
Age (year)			8.0±2.7	5-12
Follow-up period (month)			78.3±28.9	12-135
Sex				
Male	7	41.2		
Female	10	58.8		
Comorbidities				
Cerebral palsy and epilepsy	3	17.6		
Epilepsy	1	0.59		
Hydrocephalus	1	0.59		
Meningomyelocele	1	0.59		

SD: Standard deviation.

comprehensive understanding of their distribution characteristics. The Wilcoxon signed-rank test was used to compare the median scores preoperatively and postoperatively. This nonparametric approach was crucial for evaluating changes in variables that did not adhere to normal distribution assumptions. Due to the borderline nature of distribution, paired t-tests were utilized to compare the means of preoperative and postoperative scores. This analysis was vital for assessing the impact of the surgical intervention. In addition, paired samples correlation analyses and Spearman's rho test for correlation were performed. For all the recorded data, the distribution was approximately normal for most variables, as skewness and kurtosis fall within the typical range for a normal distribution.

RESULTS

Seven of the hips were right (41.2%), and 10 were left (58.8%). The mean follow-up was 78.3±28.9 (range, 12 to 135) months. Three patients had concurrent diagnoses of cerebral palsy and epilepsy, one patient had epilepsy alone, one patient had hydrocephalus, and another had spina bifida along with meningomyelocele (Table I).

TABLE II
McKay clinic assessment criteria

Grade	Result	Description
1	Excellent	Painless, stable hip; no limp, full range of motion (ROM), negative Trendelenburg sign
2	Good	Painless, stable hip; normal gait or slight limp, mild reduction in hip movements
3	Moderate	Minimal to moderate pain or painless limp, stable hip; moderate stiffness; positive Trendelenburg sign
4	Poor	Significant pain, unstable hip, advanced joint stiffness, positive Trendelenburg sign

TABLE III
Severin radiological assessment criteria

Group	Result	Radiological appearance
1	Excellent	Normal hip; CE angle >25
2	Good	Slight deformity in femoral head, neck and acetabulum; concentric reduction; CE angle >25
3	Moderate	Hip dysplastic, but no subluxation; CE angle <20
4	Poor	Subluxation present
5	Poor	False acetabulum in the femoral head
6	Poor	Complete dislocation

CE: Center edge.

For preoperative measurements, the mean AI was 35.24±8.243, and the mean CEA was −34.71±16.228. According to the Severin classification, 52.9% of the hips were classified as type 4 and 47.1% as type 5, resulting in a mean preoperative Severin score of 4.82±0.883. Based on the preoperative McKay criteria, 5.8% of the hips were classified as good, 41.3% as fair, and 52.9% as poor, resulting in a mean preoperative McKay grade of 3.47±0.624.

Analyzing the postoperative measurements of the same patients, the mean AI was 22.06±7.128, and the mean CEA was 26.59±10.344. According to the Severin classification, 47.1% of the hips were classified as type 2, 47.1% as type 3 and 5.9% as type 4, resulting in a mean Severin score of 2.29±0.588. Based on the postoperative McKay criteria, 35.5% of the hips were classified as excellent, 47.1% as good, 11.6% as fair, and 5.8% as poor, with a mean postoperative McKay score of 1.88±0.857 (Table V). There was significant improvement in AI, CEA, Severin score, and McKay criteria between preoperative and postoperative values (p<0.001 for all; Table V).

TABLE IV
Demographic, radiographic, and clinical characteristics of the patients

No	Age/Sex	Side	FU (months)	Preop AI	Preop CEA	Preop Severin score	Preop McKay grade	Postop AI	Postop CEA	Postop Severin score	Postop McKay grade
1	5/M	R	36	18	-26	4	2	14	22	2	1
2	12/M	L	12	35	-19	4	3	27	17	2	2
3	12/M	R	67	26	-53	5	3	17	34	2	1
4	6/F	L	75	28	-20	6	4	16	29	2	1
5	6/F	R	112	34	-24	6	4	24	20	2	2
6	11/F	L	135	40	-44	4	4	26	25	2	2
7	12/M	R	88	30	-41	4	4	18	18	2	1
8	5/M	L	67	33	-34	6	3	12	32	2	1
9	5/F	L	111	49	-33	4	4	25	11	2	3
10	8/F	L	96	46	-49	5	4	42	28	3	3
11	7/F	R	87	30	-25	4	3	16	50	2	2
12	8/F	L	75	30	-27	5	3	18	37	2	1
13	7/F	L	66	35	-29	4	3	20	24	2	2
14	10/F	R	91	45	-33	6	4	21	26	3	2
15	11/F	L	88	46	-35	6	4	25	20	3	2
16	6/M	L	69	40	-65	4	3	26	15	2	2
17	5/M	R	56	34	-60	5	4	28	44	4	4

L: Left; R: Right; Preop: Preoperative; Postop: Postoperative; AI: Acetabular index; CEA: Center edge angle; FU: Follow-up period.

TABLE V
Statistical analysis of clinical and radiological data

	Preoperative		Postoperative		
	Mean±SD	Min-Max	Mean±SD	Min-Max	*p*
Acetabular index	35.24±8.243	18-49	22.06±7.128	1-42	<0.001
Center edge angle	−34.71±16.228	−65-0	26.59±10.344	11-50	<0.001
Severin score	4.82±0.883	4-6	2.29±0.588	2-4	<0.001
McKay grade	3.47±0.624	2-4	1.88±0.857	1-4	<0.001

SD: Standard deviation.

No complications were encountered in the patients, except for one patient who had concomitant comorbidities of meningomyelocele and spina bifida, who had presented with a subluxated hip in the postoperative period. Otherwise, no redislocation was observed. No wound healing issue or infection was encountered in any of the patients.

DISCUSSION

As an effect of the screening program implemented in our country, early diagnosis and successful conservative treatment of DDH is possible.[7] In addition, cases of DDH may occur in children who were not included in the screening program or in conditions that adversely affect hip development over time at older ages, such as cerebral palsy.[8] Various osteotomies, such as Salter, Pemberton, Pembersal, and Tonnis, have been described for infantile DDH surgery, and successful results have been reported with these osteotomies.[9] Surgeries performed after the age of 4, when the acetabular remodeling capacity decreases, have a lower chance of success and are more technically challenging in this age group. The chances of success of the mentioned table ostetomies decrease, and other ostetomies, such as Dega, Chiari, Steell, and Triple, can be used.[10] The radical reduction procedure described by Chakirgil[11] is also this type of surgery, which includes the Dega osteotomy.

Dega osteotomy is a commonly used technique in DDH surgery. The first transiliac osteotomy was performed by Wiktor Dega in 1958 at the Poznan Hospital in Poland. Dega's method was briefly mentioned in a German publication in 1964[12] but was first described as a supraacetabular semicircular osteotomy in a Polish publication in 1969.[13] Dega's osteotomy starts just above the anteroinferior iliac spine, and when viewed from the lateral cortex, it is a curvilinear line. It proceeds cephalically toward the center of the acetabulum and curves posteriorly to end 1 to 1.5 cm anterior to the sciatic notch.[12,13] Dega osteotomy is generally used to treat acetabular dysplasia due to developmental disorders, such as spastic cerebral palsy and late-diagnosed DDH, in walking-age children older than four years.[14,15]

Previously, sequential surgeries were carried out at different times due to the concern that combining femoral and pelvic osteotomies with open reduction would increase the risk of AVN.[3] Over time, research has indicated that performing multiple procedures in a single session does not raise the likelihood of complications but rather has good to excellent outcomes of over 80%.[16] The Cakirgil procedure involves adductor tenotomy, anterolateral open reduction, femoral varization and shortening, as well as derotation and acetabuloplasty. Chakirgil[11] himself reported good to excellent results in 83% of patients with this procedure. This approach offers several advantages. It eliminates the need for traction, and all procedures can be completed in a single session with a single approach. Additionally, it involves the centralization of the femoral head through varization and derotation while increasing coverage in shallow acetabula using Dega.

The Cakirgil procedure can be used as an effective and safe method in patients at advanced ages with DDH. This single-session procedure reduces the risk of complications compared to consecutive operations.[17]

The limitations of this study are the small number of patients, its retrospective design, and the lack of a control group.

In conclusion, Cakırgil surgery is performed in patients with advanced DDH and is an extensive surgery. Extensive surgical procedures are prone to complications, such as infection, redislocation, AVN, injury to neurovascular tissues, hematoma, and arthrofibrosis. We attribute the low incidence of complications in our series to the fact that we were selective about the indication and the limited number of patients.

Ethics Committee Approval: The study protocol was approved by the Gazi University Faculty of Medicine Department of Surgical Medical Sciences Department of Orthopedics and Traumatology (date: 30.10.2023). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from the parents and/or legal guardians of the patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Idea/concept, control/supervision: H.A.; Design: H.A., T.T.; Data collection and/or processing, writing the article: M.Ş.C., A.C.B.; Analysis and/or interpretation, literature review: T.T., M.Ş.C.; References and fundings: A.C.B., H.A.; Materials: T.T., A.C.B.; Critical review: All authors.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Sezer A, Sezer HB. Segmentation of measurable images from standard plane of Graf hip ultrasonograms based on Mask Region-Based Convolutional Neural Network. Jt Dis Relat Surg 2023;34:590-7. doi: 10.52312/jdrs.2023.1308.

2. Cakirgil G. Treatment of congenital hip dislocation in juvenile and adolescent ages. Acta Orthop Traumatol Turc 1989;23:172-7.
3. Çiftçi S, Aydın BK, Öztürk M, Safalı S, Durmaz MS, Senaran H. Evaluation of iliopsoas tendon using shear wave elastography after open reduction surgery for developmental dysplasia of hip. Jt Dis Relat Surg 2022;33:385-92. doi: 10.52312/jdrs.2022.680.
4. Yonga Ö, Memişoğlu K, Onay T. Early and mid-term results of Tönnis lateral acetabuloplasty for the treatment of developmental dysplasia of the hip. Jt Dis Relat Surg 2022;33:208-15. doi: 10.52312/jdrs.2022.397.
5. McKay DW. A comparison of the innominate and the pericapsular osteotomy in the treatment of congenital dislocation of the hip. Clin Orthop Relat Res 1974;(98):124-32. doi: 10.1097/00003086-197401000-00013.
6. Severin E. Contribution to the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthrographic studies of recent cases. Acta Chir Scand 1941;(63):1-142.
7. Turkish General Directorate of Public Health-Children and Adolescent Health Department. Screening Programme in Developmental Dysplasia of the Hip: Republic of Türkiye Ministry of Health; 2013 [Cited: November 13, 2023]. Available at: https://hsgm.saglik.gov.tr/tr/tarama-programlari/gkd-tarama-programlari.html.
8. Dogruel H, Atalar H, Yavuz OY, Sayli U. Clinical examination versus ultrasonography in detecting developmental dysplasia of the hip. Int Orthop 2008;32:415-9. doi: 10.1007/s00264-007-0333-x.
9. Jäger M, Westhoff B, Zilkens C, Weimann-Stahlschmidt K, Krauspe R. Indications and results of corrective pelvic osteotomies in developmental dysplasia of the hip. Orthopade 2008;37:556-70, 572-4, 576. German. doi: 10.1007/s00132-008-1240-6.
10. Grudziak JS, Ward WT. Dega osteotomy for the treatment of congenital dysplasia of the hip. J Bone Joint Surg [Am] 2001;83:845-54. doi: 10.2106/00004623-200106000-00005.
11. Chakirgil GS. Radical reduction operation in the treatment of congenital dislocation of the hip. An analysis of 2,789 cases. Orthopedics 1987;10:711-20. doi: 10.3928/0147-7447-19870501-12.
12. Dega W. Difficulties in the surgical reposition of the obsolete congenital subluxation of the hip joint in children. Beitr Orthop Traumatol 1964;11:642-7.
13. Dega W. Selection of surgical methods in the treatment of congenital dislocation of the hip in children. Chir Narzadow Ruchu Ortop Pol 1969;34:357-66.
14. Mubarak SJ, Valencia FG, Wenger DR. One-stage correction of the spastic dislocated hip. Use of pericapsular acetabuloplasty to improve coverage. J Bone Joint Surg Am 1992;74:1347-57.
15. Rampal V, Klein C, Arellano E, Boubakeur Y, Seringe R, Glorion C, et al. Outcomes of modified Dega acetabuloplasty in acetabular dysplasia related to developmental dislocation of the hip. Orthop Traumatol Surg Res 2014;100:203-7. doi: 10.1016/j.otsr.2013.12.015.
16. Reichel H, Hein W. Dega acetabuloplasty combined with intertrochanteric osteotomies. Clin Orthop Relat Res 1996;(323):234-42. doi: 10.1097/00003086-199602000-00032.
17. Galpin RD, Roach JW, Wenger DR, Herring JA, Birch JG. One-stage treatment of congenital dislocation of the hip in older children, including femoral shortening. J Bone Joint Surg [Am] 1989;71:734-41.