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# Evaluation of Clinical and Radiographic Outcomes Following Dega Acetabuloplasty in 11 Children With Developmental Dysplasia of the Hip and 13 Children With Cerebral Palsy

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Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
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**Background:** Dega acetabuloplasty is commonly used to correct acetabular deficiency in children with developmental dysplasia of the hip (DDH) and cerebral palsy (CP). This retrospective study aimed to evaluate the clinical and radiographic outcomes following Dega acetabuloplasty in 11 children with DDH and 13 children with CP.

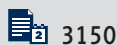
**Material/Methods:** We retrospectively analyzed 32 hips in 24 patients (8 males, 16 females; mean age, 61.35±41.09 months) who underwent Dega acetabuloplasty by a single surgeon between September 2015 and May 2019. The cohort included 11 patients with DDH (14 hips) and 13 patients with CP (18 hips). Radiographic outcomes were evaluated using the acetabular index in DDH hips and the migration index in CP hips at preoperative, postoperative, and final follow-up assessments.

**Results:** The mean follow-up duration was 28.1 months for DDH hips and 13.8 months for CP hips. Proximal femoral osteotomy was added in selected cases. In the DDH group, the mean acetabular index decreased from 34.9°±4.8° preoperatively to 19.5°±4.3° postoperatively and 16°±6° at final follow-up ( $P<0.001$ ). In the CP group, the mean migration index decreased from 85.3%±17.8% preoperatively to 8.1%±8.3% postoperatively and 17.8%±24.2% at final follow-up ( $P<0.001$ ).

**Conclusions:** Early-to-midterm results suggest that Dega acetabuloplasty appears to be a safe and effective method for improving radiographic parameters in hip dislocations in patients with DDH and CP.

**Keywords:** Hip Joint • Orthopedics • Acetabuloplasty

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## Introduction

Developmental dysplasia of the hip (DDH) and hip dislocation due to neuromuscular diseases such as cerebral palsy (CP) are disorders seen in children which cause serious functional disorders if left untreated [1,2].

DDH represents a spectrum of abnormalities ranging from hip instability and acetabular dysplasia to subluxation and frank dislocation, which can result in insufficient femoral head coverage and long-term structural deformity [3]. In children with CP, hip pathology usually develops progressively due to spasticity and muscle imbalance, leading to lateral migration of the femoral head, acetabular dysplasia, subluxation, and eventual dislocation. These abnormalities can cause pain, difficulties with sitting and perineal care, and deterioration in quality of life [4].

DDH is commonly managed nonoperatively in early infancy; however, delayed diagnosis can require surgical treatment and may be associated with complications such as avascular necrosis, residual dysplasia, and coxarthrosis [5-9]. In older children, surgical treatment can range from soft-tissue procedures to femoral and pelvic osteotomies. Several pelvic osteotomies have been described for the management of acetabular dysplasia, including Salter, Dega, Pemberton, San Diego, and triple pelvic osteotomy [9,10].

Dega pelvic osteotomy is a reshaping acetabuloplasty originally described by Dega for the treatment of acetabular dysplasia in children [11]. It is an incomplete transiliac osteotomy in which the medial cortex is preserved, allowing controlled hinging and reorientation of the acetabular roof to improve femoral head coverage. One of the main advantages of this technique is that the correction can be tailored according to the location and degree of acetabular deficiency by adjusting the osteotomy direction and graft placement. Because of this versatility, Dega osteotomy has been widely used in the treatment of developmental and neuromuscular hip disorders, including DDH and CP [11,12].

Previous studies have reported favorable outcomes following Dega acetabuloplasty in children with developmental and neuromuscular hip disorders. Grudziak and Ward reported satisfactory radiographic correction in patients with DDH [13]. Karlen et al demonstrated that Dega osteotomy is a versatile procedure in developmental and neuromuscular hip pathologies [14]. In addition, Aksoy et al evaluated acetabular development after Dega acetabuloplasty in DDH and reported favorable radiographic improvement during follow-up [15]. However, studies evaluating the outcomes of Dega acetabuloplasty simultaneously in children with DDH and children with CP remain limited. Therefore, in this retrospective study, we aimed to evaluate the clinical and radiographic outcomes following Dega acetabuloplasty in children with DDH and children with CP.

## Material and Methods

### Ethics Approval and Consent

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Akdeniz University Faculty of Medicine (approval No: 1028; approval date: November 6, 2019). Written informed consent for surgical treatment and for the scientific use of clinical data and images was obtained from the parents and/or legal guardians of the patients.

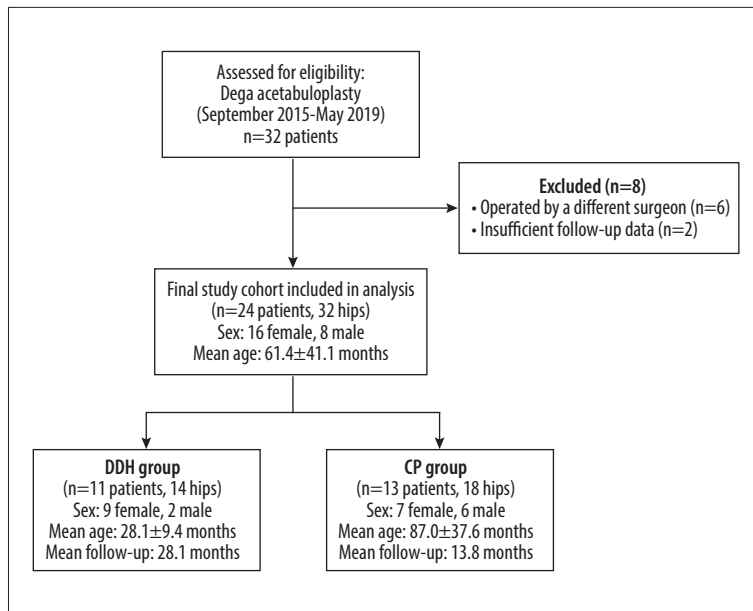
### Study Design and Patient Selection

We conducted a retrospective, single-center study at the Department of Orthopedics and Traumatology, Akdeniz University (Antalya, Türkiye), covering the period from September 2015 to May 2019. During this period, we initially screened 32 consecutive patients who underwent Dega acetabuloplasty for hip dislocation due to DDH or CP. Patients were excluded if the operation was performed by a different surgeon or if they had insufficient follow-up data (n=8). After these exclusions, the final study cohort consisted of 24 patients (8 males, 16 females; mean age: 61.35±41.09 months; range, 19 to 148 months). Among these 24 patients, a total of 32 hips were operated and evaluated (Figure 1). The sex and disease distribution of the study cohort is summarized in Table 1. All operations in the final cohort were performed by a single senior surgeon, with the authors actively participating in the surgical procedures.

The diagnoses of the patients were confirmed through a detailed review of medical records. DDH was diagnosed based on clinical examination findings and standard plain radiographs. For the CP group, the diagnosis of neuromuscular hip dysplasia was established using pediatric neurology consultation notes in conjunction with plain radiographic evaluations.

### Data Collection and Radiographic Outcome Evaluation

Data extraction was performed rigorously and included demographic data, clinical characteristics, and surgical details, which were retrieved from the hospital's electronic medical records and detailed operative notes. Clinical outcome assessment was based on postoperative complications, redislocation status, and follow-up records, rather than on a formal functional scoring system, due to the retrospective design of the study. All radiographic parameters, including the pre- and postoperative AI for patients with DDH and the MI for patients with CP, were precisely measured using the hospital's digital picture archiving and communication system. The primary radiographic outcomes were changes in the AI in DDH hips and the MI in CP hips across the preoperative, immediate postoperative, and final follow-up assessments. The AI was measured on anteroposterior pelvic radiographs as the angle between



**Figure 1.** Flow diagram of the study cohort illustrating patient screening, exclusions, and final subgroup allocations for developmental dysplasia of the hip (DDH) and cerebral palsy (CP).

**Table 1.** Sex and disease distribution of patients.

Group	Female	Male	Patient	Hip	Right	Left	Bilateral
DDH	9	2	11	14	5	3	3
CP	7	6	13	18	6	2	5

DDH – developmental dysplasia of the hip; CP – cerebral palsy.

the acetabular roof and the horizontal line connecting the tri-radiate cartilages (Hilgenreiner line). The MI was calculated as the percentage of the ossified femoral head displaced laterally past the lateral margin of the acetabulum (Perkins line) [16,17].

Complete data sets were available for all 32 hips included in the final analysis; there were no missing values for the primary radiographic outcomes or demographic variables, and no missing data imputation was required.

To ensure consistency, all radiographic measurements were performed by a single orthopedic surgeon (G.N.D.) on preoperative, immediate postoperative (within 24 hours), and final follow-up radiographs. While this author participated in the surgical procedures, all operations were primarily performed and supervised by the senior surgeon (M.S.E.). The final follow-up radiographs of patients with CP were obtained and measured at a mean of 13.8 months, whereas those of patients with DDH were obtained and measured at a mean of 28.1 months. All values were recorded.

### Surgical Technique

Every operation was conducted with the patients under general anesthesia. Since intraoperative fluoroscopy was required,

a radiolucent table was used. The patient was placed in the supine position. The operation area was prepared and draped from the umbilicus to the toes [12]. A bikini incision, a modification of the Smith-Petersen incision described by Salter and Dubos, was used [10]. The incision, transverse or oblique, was made starting from the middle of the anterior iliac crest and continued 6 to 8 cm by bending in the iliac spina to align the lateral of the patella. By staying close to the tensor muscle, damage to the lateral femoral cutaneous nerve was avoided. This nerve is most easily found between the tensor and sartorius muscles, below the fascia and 1 to 2 cm below the anterior superior iliac spine. Once identified, the nerve was carefully retracted and protected. The iliac apophysis was palpated and incised longitudinally using a scalpel. The muscles adhering to the apophysis were elevated from the medial and lateral aspects of the iliac bone using a periosteal elevator [18]. If open reduction was required, the rectus femoris muscle originating from the anterior inferior iliac spine was identified anterior to the joint capsule. The proximal tendon of the rectus femoris was detached to facilitate exposure of the capsule. The hip joint capsule was then exposed and incised in a T-shaped fashion, allowing adequate visualization of the femoral head and acetabulum. Subsequently, open reduction of the hip joint was performed [12,18].

**Table 2.** Demographic data, radiographic data, and treatment of patients with developmental dysplasia of the hip (DDH).

Hip No.	Sex	Age at surgery (y)	Hip (R/L)	Follow-up time (mo)	AI preoperative	AI postoperative	Final AI	Treatment
1	M	1.6	L	19	43.7	29.9	23.9	Dega + VDRO
2	F	1.6	R	19	31.2	20	19.5	Dega
3	M	3.3	R	40	35.1	19.2	18	Dega
4	F	1.7	L	20	35.1	26	24	Dega
5	F	2.9	R	34	28.5	17.9	15	Dega
6	F	2.1	R	25	34.6	18.3	22.4	Dega
7	F	2.1	L	25	31.4	22	19.5	Dega
8	F	2.2	L	26	34.5	17.9	21	Dega
9	F	1.9	L	22	41.6	17	10	Dega + VDRO
10	F	2.3	R	27	38.2	19	7.8	Dega
11	F	3.8	R	45	29.4	18	9.1	Dega + VDRO
12	F	3.9	L	47	28.7	21	7.5	Dega + VDRO
13	F	1.9	R	23	39.9	16.4	13.8	Dega + VDRO
14	F	1.8	R	22	37.5	11.6	12	Dega
		Mean 2.3		Mean 28.1	Mean 34.9	Mean 19.5	Mean 15.9	

DDH – developmental dysplasia of the hip; AI – acetabular index; L – left; R – right; F – female; M – male; VDRO – varus derotational osteotomy.

Iliac osteotomy was started from the lateral cortex. The orientation of the osteotomy was curvilinear when viewed from the lateral cortex. Osteotomy was started just above the anterior inferior iliac spine. Without entering the acetabulum, it extended over the acetabulum to the medial cortex. The medial cortex was left uncut. After osteotomy, the desired area to increase the coverage of the femoral head could be observed intraoperatively directly. Preservation of the sciatic notch permitted closure in both the anterior and lateral directions. A Kirschner wire was used as a guidewire and placed on the desired line under the guidance of fluoroscopy. The procedure was continued with an osteotome. The first osteotomes used were thin and straight (0.64 cm or 1.3 cm). After the first incision line was made, the osteotomy could be reached in the desired direction with the help of curved osteotomes [12]. Of note, with increased experience, the procedure can be done without fluoroscopy, as in Dega’s original description [11,12]. After completing the osteotomy, the site was distracted using lamina spreaders, and a greenstick fracture was created medially. Keeping the medial intact provided stability. The graft was adjusted according to the osteotomy line. If a concomitant proximal femoral osteotomy was performed, the excised femoral bone wedge was utilized as a graft. If proximal femoral osteotomy was not planned, a triangular graft was taken from the iliac wing. The grafts were

placed where the acetabulum was required to cover properly. In case of DDH, acetabular insufficiency was mostly anterior. If the Dega acetabuloplasty was planned on such a hip, it would be appropriate to place the graft predominantly anterior to the osteotomy line to increase anterior coverage. The graft was stable as soon as it was placed, as the recoil was provided by the intact medial corner. The operation was terminated after radiographic control. If the rectus was cut, it was sutured to its place. The apophysis was closed with the help of a thick Vicryl. The skin and subcutaneous tissues were covered without a drain [12,18]. Following Dega osteotomy for DDH, a hip spica cast was applied in all cases. After 6 weeks of immobilization in the cast, the use of an abduction brace was recommended for an additional 6 weeks. In patients with CP who underwent Dega osteotomy, bilateral long-leg casts were applied, and a bar was placed between the legs to maintain 45° of abduction. The cast was removed after 6 weeks. Rehabilitation was initiated in both groups after 6 weeks.

**Statistical Analysis**

Statistical analysis was performed using SPSS for Windows version 29.0 software (IBM Corp, Armonk, NY, USA). The unit of analysis for all statistical tests was the individual hip, rather

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**Table 3.** Demographic data, radiographic data, and treatment of patients with cerebral palsy (CP).

Hip No.	Sex	Age at surgery (y)	MI preoperative	MI postoperative	Final MI	Follow-up time (mo)	Hip (R/L)	Treatment
1	M	11.2	69.2	0	7	15	R	Dega + VDRO
2	F	3.1	100	22	100	14	L	Dega + VDRO
3	M	12.4	100	17	15	13	R	Dega + VDRO
4	M	12.4	60.9	10	0	12	L	Dega + VDRO
5	F	7.7	63	7.3	35	12	R	Dega + VDRO
6	F	4.9	100	0	19	13	R	Dega + VDRO
7	F	4.9	100	0	15.7	13	L	Dega + VDRO
8	M	6.5	74.6	15.9	33.2	32	R	Dega + VDRO
9	F	12	43.4	10.5	0	21	L	Dega + VDRO
10	M	3.3	100	6.5	0	19	R	Dega + VDRO
11	M	9	100	0	0	17	R	Dega + VDRO
12	F	6.4	70.3	18.2	16.8	1	R	Dega + VDRO
13	F	3.7	84.6	6.2	0	1	R	Dega + VDRO
14	F	3.8	85.8	8.3	3.9	4	L	Dega + VDRO
15	M	6	100	0	36	3	L	Dega + VDRO
16	F	8.1	82.8	0	0	6	R	Dega + VDRO
17	F	8.2	100	23.9	13.5	5	L	Dega + VDRO
18	M	6.9	100	0	25	49	R	Dega + VDRO
		Mean 7.2	Mean 85.3	Mean 8.1	Mean 17.8	Mean 13.8		

MI – migration index; L – left; R – right, F – female; M – male; VDRO – varus derotational osteotomy.

than the patient, as bilateral procedures were evaluated independently. The Kolmogorov-Smirnov test was used to check the normality distribution of the continuous variables. Continuous data were expressed as mean±standard deviation (SD) or median (min-max), while categorical data were expressed as number and frequency. Because AI and MI represent different radiographic outcomes relevant to DDH and CP, respectively, the DDH and CP groups were analyzed separately. To evaluate the primary radiographic outcomes, direct comparisons were made between the preoperative and final follow-up measurements (AI for the DDH group and MI for the CP group), as these time points represent the baseline and clinical endpoint of the study. Immediate postoperative values were reported descriptively to demonstrate early correction, but were not included in the primary statistical comparisons. Paired comparisons across these 2 time points within the same hips were analyzed using the paired *t* test for normally distributed variables and the Wilcoxon signed-rank test for non-normally distributed variables. A *P* value of <0.05 was considered statistically significant.

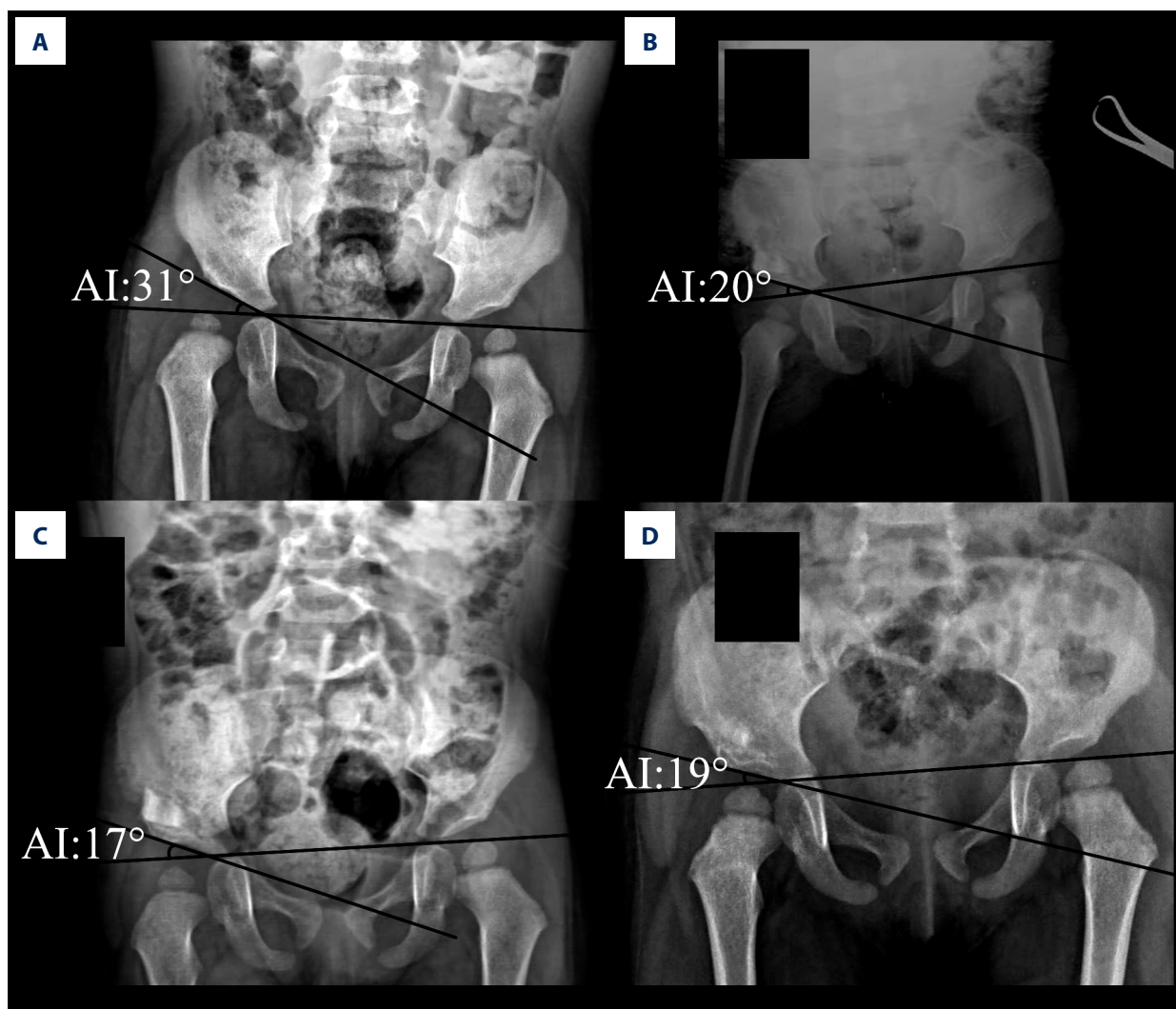
## Results

### Patient Characteristics

The final cohort consisted of 24 patients (32 hips), divided into a DDH group (11 patients, 14 hips) and a CP group (13 patients, 18 hips). The mean age at the time of surgery was 28.1±9.4 months for the DDH group and 87.0±37.6 months for the CP group. The mean follow-up duration was 28.1 months for DDH hips and 13.8 months for CP hips. Detailed demographic, radiographic, and treatment data for the DDH and CP hips are presented in **Tables 2 and 3**, respectively.

### Radiographic Outcomes in the DDH Group

Eleven patients (14 hips) with DDH underwent surgical treatment. Patients in the DDH group were classified according to the preoperative Tönnis classification. Of the 14 DDH hips, 5 were grade 4, 5 were grade 2, and 4 were grade 1. Postoperative



**Figure 2.** Serial anteroposterior pelvic radiographs of a 20-month-old female patient with right-sided developmental dysplasia of the hip (DDH) who underwent right-sided Dega acetabuloplasty. (A) Preoperative radiograph demonstrating right acetabular dysplasia, with an acetabular index (AI) of 31°. (B) Early postoperative radiograph showing improved acetabular coverage after right-sided Dega osteotomy, with an AI of 20°. (C) Radiograph obtained at 1.5 months after surgery showing continued improvement, with an AI of 17°. (D) Radiograph obtained at 12 months after surgery demonstrating maintenance of correction, with an AI of 19°.

radiographs demonstrated reduction to Tönnis grade 1 in all DDH hips. The AI of 11 patients (14 hips) with DDH was measured. The mean AI of 14 hips was  $34.9^{\circ} \pm 4.8^{\circ}$ . The mean value decreased to  $19.5^{\circ} \pm 4.3^{\circ}$  on the immediate postoperative radiograph (obtained within the first postoperative day), and it was  $16^{\circ} \pm 6^{\circ}$  at the final follow-up visit, indicating a statistically significant difference between preoperative and final follow-up values ( $P < 0.001$ ) (Figure 2).

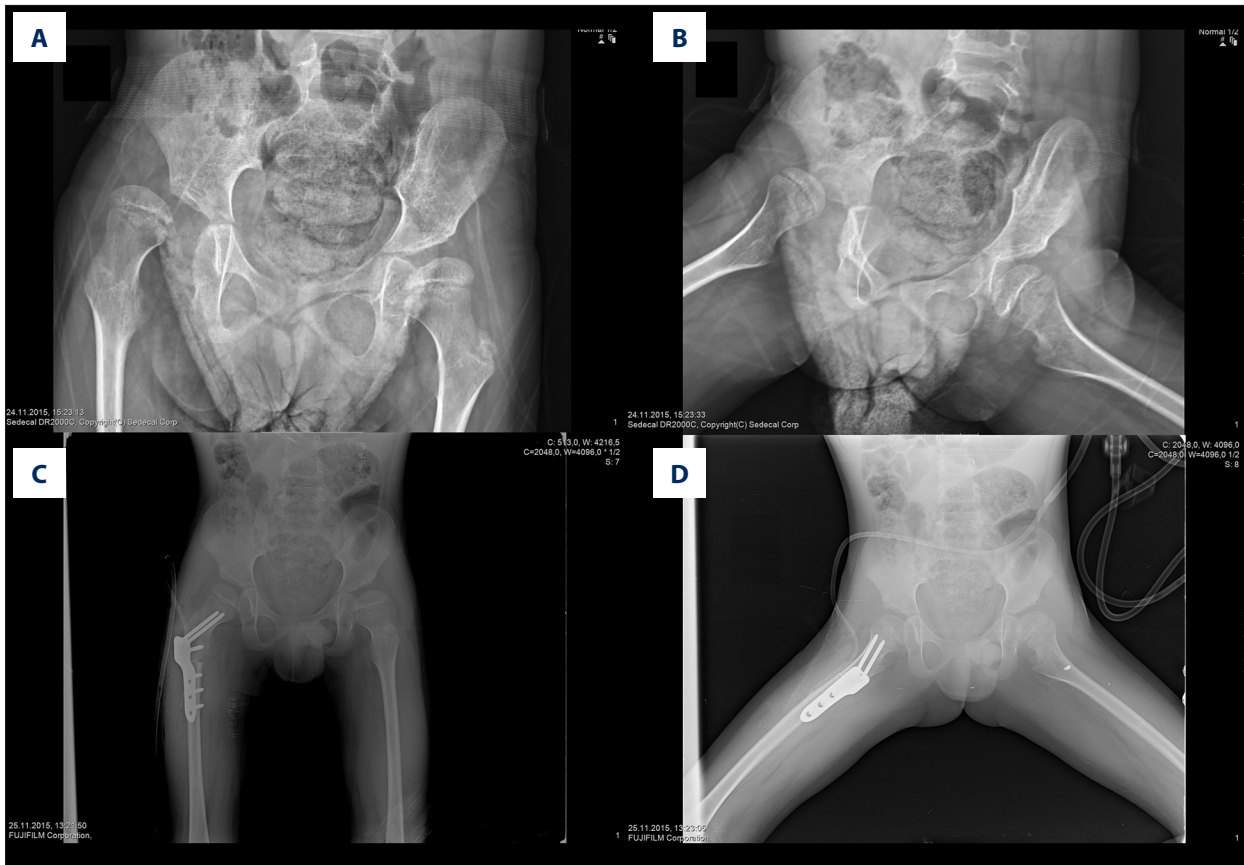
#### Radiographic Outcomes in the CP Group

Thirteen patients (18 hips) with CP were operated. A representative case is shown in Figure 3. The mean pre- and postoperative

MI values were  $85.3\% \pm 17.8\%$  and  $8.1\% \pm 8.3\%$ , respectively. In the final follow-up visit, the mean MI was  $17.8\% \pm 24.2\%$ , showing a statistically significant difference between preoperative and final follow-up values ( $P < 0.001$ ). The overall radiographic outcome values for both groups are summarized in Table 4.

#### Complications and Additional Procedures

Proximal femoral osteotomy was additionally performed in 23 cases when indicated. No intraoperative complications were observed.



**Figure 3.** Preoperative and early postoperative radiographs of a 10-year-old male patient with cerebral palsy (CP) and right hip dislocation who underwent surgical treatment. **(A)** Preoperative anteroposterior pelvic radiograph demonstrating dislocation of the right hip. **(B)** Preoperative lateral radiograph confirming dislocation of the right hip. **(C)** Early postoperative anteroposterior radiograph showing reduction of the right hip after surgery. **(D)** Early postoperative lateral radiograph confirming reduction of the right hip.

**Table 4.** Summary of acetabular index (AI) values in hips with developmental dysplasia of the hip (DDH) and migration index (MI) values in hips with cerebral palsy (CP).

	Preoperative	Postoperative	Final visit
DDH: AI±SD	34.9°±4.8°	19.5°±4.3°	16°±6°
CP: MI±SD	85.3%±17.8%	8.1%±8.3%	17.8%±24.2%

SD – standard deviation.

## Discussion

In this retrospective study, Dega acetabuloplasty resulted in significant radiographic improvement in children with DDH and those with CP. In the DDH group, the AI decreased significantly from the preoperative evaluation to the final follow-up. Similarly, in the CP group, the MI showed a significant reduction over the same period. In addition, postoperative reduction was achieved in all DDH hips, and no intraoperative complications were observed. These findings suggest that Dega

acetabuloplasty provides effective early-to-midterm radiographic correction in both patient groups.

In their study, Grudziak and Ward evaluated 24 hips of 22 children. The average age ranged between 10 months and 5 years, and the patients had hip problems including hip dysplasia, subluxation, and luxation. The hips were evaluated radiographically and using the AI, and the Shenton line was examined. The average preoperative AI was 33°, decreasing to 12° in the postoperative period. Consistent with their study,

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in our study, the mean AI was  $34.9^{\circ}\pm 4.8^{\circ}$  preoperatively, while it was measured as  $19.5^{\circ}\pm 4.3^{\circ}$  in the postoperative period. However, in their study, Grudziak and Ward evaluated 22 patients with DDH, while we evaluated 14 patients with DDH in our study [13].

In another study, Karlen et al performed Dega acetabuloplasty in patients with DDH and CP. They evaluated 50 hips of 44 patients. The average follow-up was 53 months. Similar to our study, they observed no intraoperative complications. The average AI decreased from  $37^{\circ}$  to  $13^{\circ}$  at the final follow-up, indicating a  $24^{\circ}$  correction. In our study, we achieved a  $19^{\circ}$  correction. In the same study, the average MI in 24 hips of 22 children with CP decreased from 84% to 14%. In our study, the MI in 13 patients with CP and 18 hips decreased from 85.3% preoperatively to 17.8% at final follow-up. Furthermore, in the study of Karlen et al, 1 patient experienced redislocation due to a traffic accident and was reoperated. Similarly, in our study, 1 patient with CP experienced redislocation during the follow-up period, resulting in a final MI of 100%. In the aforementioned study, graft collapse occurred in 1 patient and the graft was displaced in another, requiring redo surgery. Except for the single case of redislocation, none of our other patients experienced such severe postoperative complications [14].

Our findings in the DDH group are also consistent with those of Aksoy et al, who evaluated 35 patients (43 hips) with DDH treated with Dega acetabuloplasty and reported improvement in the mean AI from  $35^{\circ}$  preoperatively to  $20^{\circ}$  in the early postoperative period and to  $13^{\circ}$  at final follow-up, with radiographic improvement in 42 of 43 hips. Similarly, in our DDH group, the mean AI decreased from  $34.9^{\circ}\pm 4.8^{\circ}$  preoperatively to  $19.5^{\circ}\pm 4.3^{\circ}$  postoperatively and to  $16^{\circ}\pm 6^{\circ}$  at final follow-up. Although our final follow-up AI was slightly higher than that reported by Aksoy et al, our results likewise support the radiographic effectiveness of Dega acetabuloplasty in DDH hips [15].

The main strength of this study is that it is one of the few in the literature evaluating hip dislocations treated with Dega acetabuloplasty in patients with DDH and those with CP. Furthermore, with the widespread implementation of routine screening programs and the advancement of the Graf ultrasonographic method, DDH is increasingly being detected and managed early, effectively halting its progression. As a result, the incidence of advanced-stage DDH requiring complex surgical interventions is expected to decline significantly in the coming years. Consequently, clinical series documenting the surgical management and outcomes of advanced DDH, such as the present study, will become increasingly rare and highly valuable reference points in future orthopedic literature.

Nonetheless, there are several limitations to this study. First, the retrospective, single-center design can introduce selection

bias, and the results reflect specific institutional practice patterns that may not be widely generalizable. Second, the sample size is relatively small due to the scarcity of cases meeting the strict inclusion criteria. Third, all operations were performed by a single senior surgeon, which introduces surgeon-specific technique bias. Fourth, the statistical non-independence of bilateral hips (treating each hip as a separate unit) could potentially influence the variance of our estimates. Fifth, our mean follow-up durations (13.8 months for CP and 28.1 months for DDH) represent early-to-midterm outcomes. In the context of Dega acetabuloplasty literature, follow-up periods of 1 to 3 years are commonly classified as early-to-midterm outcomes, reflecting initial graft incorporation and maintenance of reduction, while long-term durability requires 5 to 10 years or more of observation. Therefore, while our observation period is sufficient to evaluate these initial parameters, the long-term durability of these radiographic corrections must be investigated in future studies [19,20]. Finally, evaluating hip dislocations with different etiopathogenesis within the same cohort limits subgroup-specific statistical power. Additionally, while radiographic measurements were performed by a single author (G.N.D.) to ensure consistency, this author was also part of the surgical team, which can introduce potential observer bias.

## Conclusions

In conclusion, Dega acetabuloplasty appears to be a safe and effective method for improving radiographic outcomes in children with DDH and CP in the early-to-midterm period. However, further multicenter prospective studies with longer follow-up are needed to confirm the long-term durability of these results.

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## Department and Institution Where Work Was Done

This study was performed at the Department of Orthopedics and Traumatology, Akdeniz University Hospital, Antalya, Türkiye.

## Ethics Approval and Consent

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Akdeniz University Faculty of Medicine (approval No: 1028; approval

date: November 6, 2019). Written informed consent for surgical treatment and for the scientific use of clinical data and images was obtained from the parents and/or legal guardians of the patients.

### Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to institutional restrictions.

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