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ORIGINAL ARTICLE

Single-Center Experience of Surgical Treatment of Subjects with Late-Presenting Developmental Dysplasia of the Hip

Geç Dönem Tedavi Edilen Gelişimsel Kalça Displazisi Olan Olguların Cerrahi Tedavisinde Tek Merkez Deneyimi

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ABSTRACT

Aim: This study aimed to delineate the single-center experience surrounding the long-term consequences of surgical reconstruction in subjects with late-presenting DDH (developmental dysplasia of the hip).
Methods: We analyzed 23 hips of 21 subjects aged >6 years who underwent surgical interventions such as pelvic osteotomy, open reduction, femoral shortening, and derotation, for developmental hip dysplasia.
Results: After a median follow-up of 23.34 (8–120) months, there were no noteworthy alterations in the Harris score and anteversion. Nevertheless, significant improvements were observed in SHARP, CE angle, and depth and width index over the follow-up duration. Using Sever's radiological criteria, 87.1% of subjects achieved excellent and good results. Assessment of femoral head avascular necrosis, based on Bucholz and Ogden's classification, produced the subsequent findings: 52% of hips were Type I; 13% Type II; 22% Type III; and 13% were categorized as Type IV.
Conclusion: Despite achieving favorable postoperative radiological outcomes, there is a noticeable decline in clinical success in these subjects, especially as their age increases. Additionally, they face an elevated risk of avascular necrosis. Based on the preoperative and postoperative changes in radiological measurements such as Sharp, ACE, D/G, and Anteversion, a 75% radiological success rate is juxtaposed with a 50% clinical success rate in the postoperative evaluations, underscoring this contrast. Crucially, the success rate of surgical corrections in late-presenting DDH depends on the age of the patient, with the success rate decreasing with advancing age.

Keywords: Developmental dysplasia of the hip, Triple pelvic osteotomy, Femoral osteotomy, Hip joint, Hip preservation

ÖZ

Amaç: Bu çalışma, geç ortaya çıkan GKD'li (gelişimsel kalça displazisi) olgularda cerrahi rekonstrüksiyonun uzun vadeli sonuçlarına ilişkin tek merkez deneyimini tanımlamayı amaçlamıştır.
Yöntemler: Gelişimsel kalça displazisi nedeniyle pelvik osteotomi, açık redüksiyon, femoral kısaltma ve derotasyon gibi cerrahi girişimler uygulanan 6 yaşından büyük 21 olgunun 23 kalçası analiz edildi.
Bulgular: Ortanca 23.34 (8-120) aylık takip sonrasında, Harris skoru ve anteversiyonda kayda değer bir değişiklik olmadı. Bununla birlikte, SHARP, CE açısı ve derinlik ve genişlik indeksinde takip süresi boyunca anlamlı iyileşmeler gözlendi. Sever'in radyolojik kriterleri kullanılarak, olguların %87.1'inde mükemmel ve iyi sonuçlar elde edildi. Bucholz ve Ogden'in sınıflandırmasına göre femur başı avasküler nekrozu değerlendirildiğinde aşağıdaki bulgular elde edildi: Kalçaların %52'si Tip I; %13'ü Tip II; %22'si Tip III ve %13'ü Tip IV olarak kategorize edildi.
Sonuçlar: Ameliyat sonrası olumlu radyolojik sonuçlar elde edilmesine rağmen, bu olgularda, özellikle yaşları arttıkça, klinik başarıda gözle görülür bir düşüş vardır. Ayrıca, bu kişiler yüksek avasküler nekroz riskiyle karşı karşıyadır. Sharp, ACE, D/G ve Anteversion gibi radyolojik ölçümlerin preop ve postop değişimlerine göre %75'lik radyolojik başarı oranı ile postop klinik değerlendirmeler sonrası %50'lik klinik başarı oranının yan yana gelmesi bu zıtlığı vurgulamaktadır. Daha da önemlisi, geç ortaya çıkan GKD'de cerrahi düzeltmelerin başarı oranı hastanın yaşına bağlıdır ve yaş ilerledikçe başarı oranı düşmektedir.

Anahtar Kelimeler: Gelişimsel kalça displazisi, Üçlü pelvik osteotomi, Femoral osteotomi, Kalça eklemi, Kalça koruma

Introduction

Developmental dysplasia of the hip (DDH) can lead to morphological alterations in both the acetabular and femoral sides, resulting in severe bony anatomy distortion and soft tissue contractures around the hip. Therefore, a comprehensive pre-surgical evaluation of subjects is critical. [1–2] Late-presenting DDH patients often experience early hip osteoarthritis, limb length inequality, and significant disability. [3–4] Arthroplasty remains the most viable surgical option for reconstructing the hip joint in late-presenting DDH patients. [5] However, there is a lack of clear evidence on the optimal age for reconstructive surgery in these patients, and the results of surgical reconstruction techniques vary across different studies. [6–7] This study aims to investigate the long-term outcomes of surgical reconstruction in subjects with late-presenting DDH, based on a single-center experience.

Methods

Study population

This retrospective study was conducted at a single center. Ethics approval was procured from the Clinical Ethics Committee of the University Hospital (Date:

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22.04.2016, Approval Number: 802). All procedures were carried out in accordance with the ethical principles laid down in the Declaration of Helsinki.

The cohort consisted of 21 patients (encompassing 23 hips) underwent surgical reconstruction for late-presenting DDH. The median age of the patients was 9.56 years, ranging from 6 to 13 years. Of the patients, 2 (9.5%) were male and 19 (90.5%) were female (table 1). Exclusion criteria included inflammatory diseases, teratological or secondary DVHs, anatomical issues associated with the femur head, flexion angle of the hip <80°, and abduction-adduction angle <45°. Patients with a history of previous pelvic or femoral surgery, neuromuscular disorders, or cognitive or communication difficulties that would prevent participation in rehabilitation were also excluded. Subjects with severe acetabular dysplasia (CE angle <10°) were excluded as they required a different surgical approach. All subjects underwent physical examination, radiography, and clinical history evaluation to confirm the diagnosis of developmental hip dysplasia, and MRI was employed to confirm the diagnosis in cases of ambiguity in the radiographic findings.

14 of 23 patients underwent triple pelvic osteotomies, open reduction, femoral shortening, and derotation. The procedure was planned as two operations. In the first operation, an ischial osteotomy and ipsilateral skeletal traction from the supracondylar region were performed. In the second operation, these 14 patients underwent triple pelvic osteotomies, open reduction, femoral shortening, and derotation. Two patients underwent only Chiari osteotomy while the other two underwent femoral osteotomy and derotation in addition to Chiari osteotomy. One patient underwent a different surgical procedure, while another underwent a Pembersal osteotomy, femoral shortening and derotation. Two patients, both 6 years old, underwent only femoral shortening and derotation because the ischium did not close during the procedure.

The primary objective of this study was not to compare different surgical techniques with one another, but rather to assess the overall clinical and radiological outcomes of surgical interventions for developmental dysplasia of the hip (DDH) as age progresses. The diverse surgical approaches employed were tailored to provide the best possible treatment for each individual patient. The collective evaluation of these varying approaches reflects the broad spectrum of patients considered and the clinical challenges encountered. We aimed to provide a general perspective on how the response to surgical treatment evolves with age. Consequently, all these distinct surgical methodologies have been assessed collectively in the context of the study's overarching outcomes.

Written informed consent was obtained from all parents before enrollment, and the study was approved by the Institutional Review Board and conducted in accordance with the Helsinki Declaration. Subjects who were unable to follow the postoperative rehabilitation program or attend follow-up appointments were excluded from the study.

Surgical technique (triple osteotomy)

The surgical techniques employed in this cohort comprised triple pelvic osteotomy, open reduction, femoral shortening, and derotation. Two surgeons participated in this study. The primary surgeon had experience with over 100 cases, while the secondary surgeon had engaged in 16 procedures. The respective roles and contributions of both surgeons during the surgical process were thoroughly assessed in this investigation. In this study, the surgical technique used was a triple pelvic osteotomy, open reduction, femoral shortening, and derotation for the treatment of developmental hip dysplasia. This condition occurs when the hip joint does not develop properly and can lead to dislocation or subluxation of the hip joint. The goal of the surgery was to correct the hip joint deformity and improve hip joint function.

All patients were operated on under general anesthesia in the supine position, with the hip elevated by a silicone pad. The average duration of the surgical procedure was 95 minutes. First, an ischial osteotomy was performed in a side-up position with 90° hip flexion. For the second session of the procedure, subjects were kept under traction for one week. The procedure was carried out while the patient was in the supine position. The iliac osteotomy was performed using a Gigli saw through the spina iliaca anterior, superior, and inferior, and from posterior to anterior. For the acetabular osteotomy, the acetabulum was initially rotated laterally. Then, an iliac wedge graft was obtained and grafted between the acetabulum and the ilium. Two mm Kishner-wires were used for fixation of the acetabulum. There were no intraoperative complications.

Post-operative protocol

In this study, all subjects underwent early rehabilitation to promote early functional recovery and prevent prolonged immobilization. The patients began physiotherapy on the first postoperative day, which included exercises to strengthen the quadriceps, gluteal, and lower limb muscles, as well as mobilization of the hip and knee joints. The average duration of physiotherapy rehabilitation was 2 months. After being discharged from the hospital, all patients were instructed to continue the exercises and follow the rehabilitation protocol. They were advised to avoid weight-bearing for at least 6 weeks postoperatively and gradually resume weight-bearing as tolerated.

Follow-up

Patients were followed up for a median duration of 23.34 months, ranging from 8–120 months (table 1). It should be noted that one of the patients, who was followed up for 8 months, was not available for the 12th-month follow-up due to loss of follow-up. Radiological assessments were used to observe the changes from the preoperative phase to the most recent follow-up. Additionally, outcome measures such as the Harris score, SHARP angle, CE angle, and depth-width indices were meticulously evaluated. All

subjects were re-evaluated at the 6th week, the 3rd month, the 6th month, and the 12th month, and each year following the procedure, with the exception of the aforementioned patient. In the materials and methods section of the study, several parameters were employed to evaluate the results of the surgical intervention for developmental hip dysplasia. These parameters were chosen because they are commonly utilized in similar studies and offer crucial insights into the efficacy of the surgical technique.

Firstly, the Harris Hip Score (HHS) was used to evaluate the functional outcomes of the surgical intervention. The HHS is a widely used scoring system that assesses hip function and pain. The score ranges from 0-100, with higher scores indicating better outcomes. Patients were categorized into four subgroups according to their HHS score: poor (less than 70), fair (70-80), good (80-90), and excellent (90-100). The HHS was chosen because it is a reliable and valid measure of hip function and has been widely used in similar studies.[10]

Secondly, radiological measurements were performed to assess the anatomical outcomes of the surgical intervention. The following measurements were taken pre- and postoperatively: acetabular anteversion, acetabular inclination angle, and acetabular depth and width index. The CE angle (center-edge), femur head coverage ratio, and vertical center anterior (VCA) angles were only measured postoperatively. These measurements were chosen because they provide important information on the anatomical changes that occur after the surgical intervention.[11]

Finally, hip range of motion (ROM) was assessed as described by Harris et al. Hip ROM is an important parameter to evaluate the functional outcomes of the surgical intervention. Patients with limited hip ROM may experience pain and functional limitations.

Overall, these parameters were chosen because they provide a comprehensive evaluation of the functional and anatomical outcomes of the surgical intervention. They are also commonly used in similar studies, which allows for comparison of results between different surgical techniques and patient populations.

Statistical analysis

All analyses were performed on SPSS v21 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to test data distribution. The homogeneity of variances was assessed with the Levene test. Data are given as mean ± standard deviation and frequency (percentage) for categorical variables. A paired samples t test or Wilcoxon test was performed to compare the preoperative values of the radiological measurements and the values obtained at follow-up. P values <0.05 were defined as statistically significant.

Results

The median age of the study population was 9.56 (6–13) years. Table 1 presents the demographic features and surgical procedures for which the subjects were scheduled. Following a median of 23.34 (8–120) months of follow-up, no significant changes occurred in the Harris score and anteversion. However, SHARP, CE angle, and depth and width indexes improved significantly during the follow-up period (Table 2). The change in radiological measurements from the preoperative period to the last follow-up is listed in table 3. Excellent and good results were obtained in 87.1% of the subjects according to the Sever's radiological criteria (Figure 1). Evaluation of the femoral head avascular necrosis according to Bucholz and Ogden's classification revealed the following results: 52% of the hips were Type I; 13% of the hips Type II; 22% of the hips Type III; and 13% of the hips were Type IV (Figure 2). Flexion contracture developed in three subjects aged 11 years and in one subject aged 13 years who underwent triple pelvic osteotomy, open reduction, femoral shortening, and derotation. Some degree of effective ROM was obtained in these subjects after manipulation and soft tissue loosening exercises. However, the clinical results were not favorable for these subjects. It should be noted that while some patients showed favorable outcomes in short-term follow-ups, these results might change in longer-term follow-ups, suggesting a potential increase in complications over time. A femoral head fracture developed in one subject who underwent manipulation following the flexion contracture. Subluxation developed in one subject who underwent triple pelvic osteotomy, open reduction, femoral shortening, and derotation. We performed open reduction and self-procedure to relieve subluxation. Subluxation developed in another subject who was initially treated with Chiari pelvic osteotomy. Pembersal osteotomy, open reduction, and derotation were performed in this subject; however, the clinical results were fair. The genu valgum deformity developed at the 6th year of the follow-up in one subject (Figures 4).

Table 1. Demographic features and follow-up data of teh study population

Attribute	Value
Average	9.56 years
Age range	6 to 13 years old
Follow-up period	Median: 23.34 months
Follow-up range	8 to 120 months
Male percentage	9.5% (2 patients)
Female percentage	90.5% (19 patients)

Table 2. The mean change in radiological parameters during follow-up

	Preoperative	Postoperative	P value
Harris score	63	65	NS
Sharp	56	45	p<0.05
ACE	34	21	p<0.05
D/G	30	37	p<0.05
Anteversion	18	16	NS

Table 3. The change in radiological parameters for each subject during the follow-up

Subject	Age-Gender	Type of surgery	Preoperative Harris score	Postoperative Harris score	Acetabular index preoperative	Acetabular index postoperative	Preoperative sharp	Postoperative sharp	Preoperative D/G	Postoperative D/G	Preoperative anteversion	Postoperative anteversion	AMK angle	LMK angle	Tönnis	Acetabular coverage
1	9-female	Stell	58	35	40°	20°	60°	48°	39	36	20°	18°	45°	35°	17°	80%
2	11-male	Stell	59	58	18°	18°	55°	35°	45	34	27°	20°	38°	25°	15°	73%
3	8-female	Self	60	88	20°	22°	50°	43°	33	33	18°	14°	40°	38°	11°	100%
4	13-female	Chiari+-femoral osteotomy	61	56	35°	16°	60°	29°	30	28	12°	18°	55°	60°	5°	100%
5	6-female	Double osteotomy	62	96	30°	18°	40°	52°	21	29	12°	12°	50°	60°	13°	100%
6	6-female	Double osteotomy	63	96	34°	27°	52°	30°	35	44	14°	20°	40°	45°	15°	100%
7	13-male	stell	64	38	40°	17°	67°	42°	23	27	12°	13°	46°	50°	15°	100%
8	10-female	Chiari+-femoral osteotomy	65	68	32°	22°	60°	45°	28	41	12°	9°	40°	45°	14°	100%
9	11-female	chiari	66	83	34°	15°	58°	40°	28	40	20°	18°	38°	25°	17°	80%
10	6-female	Double osteotomy	67	38	37°	19°	56°	41°	34	40	18°	15°	38°	34°	18°	100%
11	7-female	steel	68	68	32°	25°	65°	40°	26	30	16°	17°	37°	36°	14°	90%
12	9-female	chiari	69	94	36°	24°	58°	50°	34	31	14°	14°	38°	29°	9°	82%
13	14-female	stell	70	38	35°	18°	54°	44°	36	32	24°	16°	36°	37°	16°	88%
14	13-female	stell	71	38	35°	26°	67°	53°	39	36	25°	15°	46°	45°	14°	100%
15	10-female	stell	72	84	33°	25°	64°	43°	28	63	20°	17°	42°	13°	15°	95%
16	9-female	stell	73	78	28°	27°	55°	42°	26	36	16°	18°	38°	35°	11°	100%
17	11-female	chiari	74	68	35°	23°	65°	49°	41	33	20°	15°	37°	25°	10°	80%
18	12-female	stell	75	84	42°	19°	70°	40°	24	40	18°	15°	40°	56°	10°	97%
19	10-female	Pemberal	76	58	34°	24°	59°	50°	22	40	17°	17°	39°	38°	13°	80%
20	9-female	stell	77	38	53°	25°	65°	55°	26	38	25°	12°	39°	53°	14°	100%
21	9-female	stell	78	38	40°	29°	64°	50°	39	38	19°	20°	39°	35°	17°	80%
22	6-female	stell	79	58	33°	22°	62°	48°	21	38	16°	18°	40°	40°	13°	80%
23	8-female	stell	80	68	33°	8°	50°	60°	14	43	20°	18°	41°	30°	8°	100%

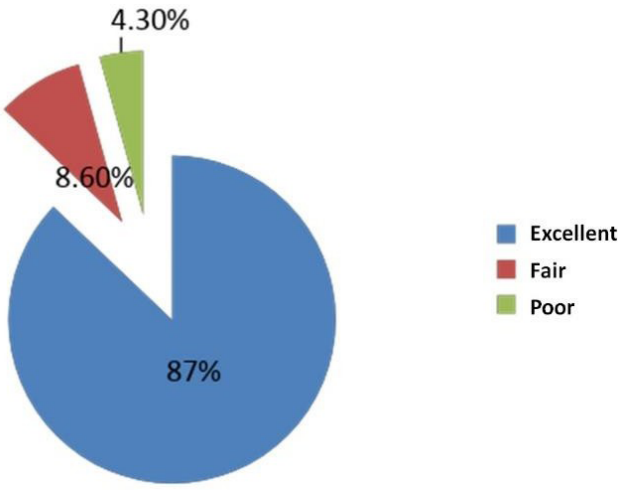

Figure 1. Our results according to the Sever's radiological criteria

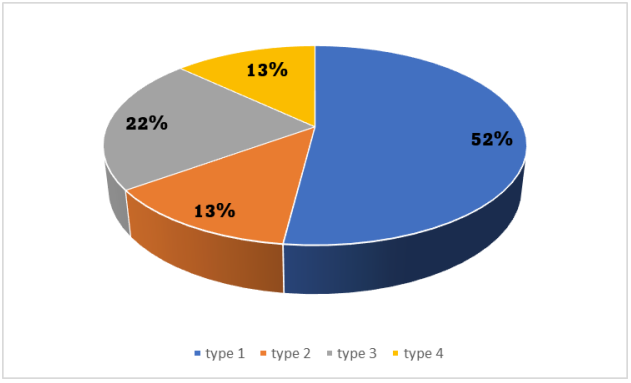

Figure 2. Types of avascular necrosis observed in our subjects according to the Ogden classification

Figure 3. Preoperative and postoperative 12th months X-rays of as subject receiving triple pelvic osteotomy, femoral shortening, and derotation surgery

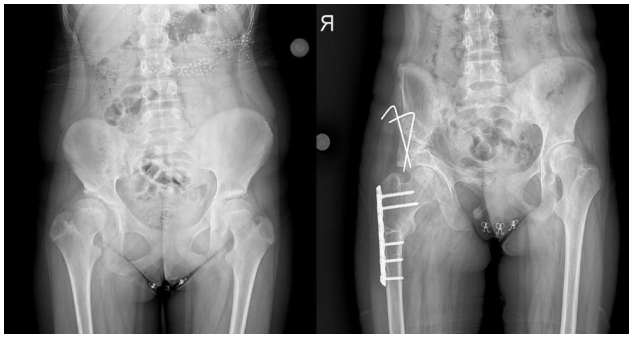

Figure 4. Preoperative and postoperative 6th months X rays following triple pelvic osteotomy, femoral shortening and derotation surgery

Figure 5. The amount of femoral shortening in one of the study subjects

Discussion

Late-presenting DDH constitutes a significant problem limiting the functionality of the subjects, particularly in undeveloped countries. The surgical treatment of DDH becomes complicated, and the success rate of the surgery decreases with increasing age. Severe contracture of the tendon capsule surrounding the hip, decreased depth of the acetabulum, increased anteversion of the femur, hypertrophic inverted labrum, and the above-ground location of the femoral head are the main undesirable changes in the hip joint that affect the surgical success and avascular necrosis along with the redislocation. Since closed reduction is not feasible in subjects with the above-mentioned changes in the hip joint, open surgery is recommended in these subjects. Surgical treatment aims to achieve a near-normal hip joint both anatomically and functionally. Surgical correction in DDH is intended to achieve normal anatomy with an appropriate reduction of the hip joint and to prevent degenerative joint disease.

In subjects with excellent correction, the anatomical and functional prognosis is also excellent. However, even in subjects with moderate results, surgical correction facilitates further arthroplasty. Nevertheless, open surgery, including several osteotomy techniques, may lead to avascular necrosis and contractures. There are controversial results concerning the surgical treatment of the subjects >8 years of age; while some of the studies report encouraging data regarding radical reduction, others indicate that surgical correction does not influence hip anatomy in these subjects. [12,13] The acetabulum is located more laterally and anteriorly in subjects with DDH. The anteversion of the acetabulum is increased in subjects with a late-presenting DDH, and thus coverage of the acetabulum is decreased.

Salter's innominate osteotomy technique demonstrated a 93% success rate in the treatment of the DDH in subjects aged 1.5–3 years; however, the success rate in subjects aged 4-6 years was 56%. [4–14] Similar results were obtained in other studies, which reported a mean success rate of 90% in subjects aged between 1.5 and 4 years and 56% in subjects aged >7 years. [1] Kapukaya et al.12 reported a success rate of 62.5 percent with surgical correction in subjects with late presenting DDH who were aged between 7 and 10 years. [1] The results of the present study are consistent with previous data. In 53% of the subjects with late-presenting DDH, we achieved good, very good, or excellent results, and in 14% of the study population, we achieved fair results. According to the Sever's radiological criteria, excellent results were obtained in 87.2% of our study population. The Harris hip score increased from 63 points to 65 points; however, the difference was not statistically significant. Although these 'poor' results are not indicative of complete success, they provide a foundation for patients to respond better to a possible arthroplasty in future years. Given the absence of long-lasting prostheses for use in young adults, these 'fair' results can more appropriately be categorized as having poor success.

The upper-age limit in subjects with late-presenting DDH is still a matter of debate. [1] The study of Klisic et al. (13) showed a success rate of 86% in subjects aged between 7 and 8 years, while the success rate decreased to 38% in subjects aged between 11 and 15 years. [1] Browne et al. (15) have recommended 15 years as the upper-age limit for the surgical treatment of subjects with late-presenting DDH. [1] However, the debate on the upper-age limit of surgical correction of late-presenting DDHs continues. The median age of the study population enrolled in our study was 9.56 (6–13) years, which is relatively higher than that of the previous studies. Postoperative subluxation necessitating revision was encountered in three of the study subjects. A superficial or deep infection has not developed in any of the study subjects.

Length discordance of less than 1 cm between the extremities was encountered in 6 subjects, and a length discordance of 1-2 cm was encountered in 1 subject. The rate of extremity discordance is similar to that reported by Mergen et al. (15). The example of the amount of bone removed from the femur is illustrated in figure 5.

The association between traction application and the development of the avascular necrosis is not clear. Several reports indicate that traction reduces the rate of avascular necrosis when applied preoperatively, particularly in subjects scheduled for shortening osteotomy. 21 of the 23 hips underwent surgery in our study received supracondylar femoral traction. In our study, 30 percent of three hips were completely normal with respect to the presence of avascular necrosis according to the Bucholz and Ogden classification. In addition, 38% of the hips were type I, 9% type II, 14% type III, and the rest, 9%, were type IV. These findings are also compatible with the previous results of Eren et al.16 and Daoud A et al.17, which indicated a vascular necrosis rate of 80% and 63%, respectively in subjects underwent radical reduction surgery for DDH. We consider that traction facilitates surgical correction through approximating the femoral head and acetabulum. [1][1] However, longer follow-up is required to draw any conclusions regarding the potential clinical benefits of supracondillary femoral traction in subjects scheduled for surgery for late-presenting DDH. [1]

The rate of postoperative subluxation was 13% in our series. This is somewhat lower than that reported by Tönnis D. et al. (24), which is as high as 30%. Another complication of the DDH surgery, a femoral head fracture, was encountered in one of the subjects. This patient was operated on using two cannulated screws. In addition, flexion contracture, one of the late complications of the DDH surgery, was observed in four of our study subjects. Two of these subjects were treated with closed reduction under general anesthesia, and one other received soft tissue loosening. However, closed manipulation was unsuccessful in one of the subjects who developed flexion contracture.

Study limitations

Although this study provides valuable insights into the use of the triple pelvic osteotomy technique for the treatment of developmental hip dysplasia, it is important to acknowledge some limitations. One of the limitations is the relatively small sample size of the study, which may limit the generalizability of the findings. Additionally, the study only included patients who underwent the triple pelvic osteotomy technique, so the results may not be applicable to patients who receive other surgical treatments for developmental hip dysplasia. Another limitation is the lack of a control group, which makes it difficult to compare the outcomes of the surgical treatment to non-surgical treatments or to other surgical techniques. Finally, the follow-up period of 5 years may not be long enough to fully evaluate the long-term outcomes and potential complications of the procedure. These limitations should be considered when interpreting the results of this study.

Conclusion

Our findings indicate that various factors should be kept in mind during the decision-making process for the treatment of subjects with late-presenting DDH. The aim of the surgical correction should focus on achieving excellent postoperative results. However, as the age of the patients increases, despite good radiological outcomes after DDH surgery, we observe a decline in clinical success. Our results show that even in subjects with favorable postoperative radiological results, the clinical success rate is disappointingly low, and the risk of avascular necrosis is heightened. Specifically, the ratio of the radiological success rate of 75% contrasts with a clinical success rate of only 50%. This study underscores that the success rate of the surgical correction in late-presenting DDH is intrinsically dependent on the age of the patient, with outcomes being more favorable when surgeries are performed at a younger age. As age advances, the likelihood of successful outcomes diminishes, making it imperative to consider the age factor when contemplating surgery for late-presenting DDH.

Ethical Declarations

Ethics Committee Approval: The study was carried out with the permission of University Hospital, Clinical Ethics Committee (date:22.04.2016, approval number: 802).

Informed Consent: Written informed consent was obtained from all patients.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declares that this study has received no financial support.

Author Contributions: All the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

List of Abbreviations:

DDH - Developmental Dysplasia of the Hip

HHS - Harris Hip Score

ROM - Range of Motion

MRI - Magnetic Resonance Imaging

CE - Center-Edge

VCA - Vertical Center Anterior

SPSS - Statistical Package for the Social Sciences

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