Kocatepe Tıp Dergisi
Kocatepe Medical Journal
24:8-14 / Ocak 2023 Sayısı

ARAŞTIRMA YAZISI / RESEARCH ARTICLE

DÖRT YAŞINDAN BÜYÜK GELİŞİMSEL KALÇA DİSPLAZİSİ OLAN HASTALARDA, TEK AŞAMALI AÇIK REDÜKSİYON, FEMORAL KISALMA VE SALTER OSTEOTOMİSİ'NİN RADYOLOJİK SONUÇLARINI, İLK AMELİYAT YAŞI NASIL ETKİLER ?

HOW DOES INITIAL SURGERY AGE AFFECT THE RADIOLOGICAL RESULTS OF SINGLE-STAGE OPEN REDUCTION, FEMORAL SHORTENING, AND SALTER'S OSTEOTOMY IN PATIENTS OVER THE AGE OF FOUR WITH DEVELOPMENTAL HIP DYSPLASIA ?

Hakan BAHAR[1], Mehmet Fırat YAĞMURLU[2]

[1]Türkiye Sağlık Bilimleri Üniversitesi Metin Sabancı Baltalimanı
Kemik Hastalıkları Eğitim ve Araştırma Merkezi, Ortopedi ve Travmatoloji Ana Bilim Dalı
[2]Yeni Safa Hastanesi, Ortopedi ve Travmatoloji Kliniği

ÖZET

AMAÇ: Pediatrik ortopedide, tedavisi en tartışmalı konulardan biri, Gelişimsel Kalça Displazisidir (GKD). Tanı ve tedavi zamanlaması, bu durumu başarılı bir şekilde tedavi etmek için ana hedeftir. Özellikle gelişmekte olan ülkelerde ilerleyen yaşa kadar teşhis edilemeyen vakalar halen görülmektedir. Gecikmiş tanı ve tedavi , ilerleyen yaşla birlikte daha kapsamlı ameliyatlara yol açar ve düşük memnuniyet oranlarına neden olabilir. Bu çalışmanın amacı, Gelişimsel Kalça Displazisi'nin tek aşamalı tedavisinin sonuçlarına, hasta yaşının etkisini değerlendirmektir.

GEREÇ VE YÖNTEM: 2004 ve 2010 yılları arasında hastanemizde tedavi edilen 23 hasta (34 kalça) çalışmaya dahil edildi. Ortalama ameliyat yaşları 7,5 olan hastalara açık redüksiyon, femoral kısaltma ve Salter innominate osteotomi'yi içeren tek basamaklı tedavi uygulandı. Radyolojik sonuçlar, asetabular indeksteki, asetabuler açıdaki ve Severin radyolojik sınıflamasına göre düzelme ve son takiplerindeki Bucholz ve Ogden avasküler nekroz (AVN) sınıflamasına göre değerlendirildi.

BULGULAR: Hastalarımızın ortalama takip süremiz 60 ay (24 ila 84 ay arası) idi. Asetabuler indeks, ameliyat öncesi 39.7°±1.4° (25° - 52° arası) iken ameliyat sonrası 21.8°±1.8° saptandı. Ameliyat sonrası çekilen pelvis grafilerinde ölçülen asetabuler açıda ortalama düzelme miktarı 17.9°±0.8° saptandı. Bucholz ve Ogden AVN sınıflamasına göre; 1 hastada Tip 1 (% 2.9) ve 1 hastada Tip 3 (% 2.9) AVN saptandı. Radyolojik olarak 8 yaş ve altındaki çocuklarda başarı oranı (85.7%) belirgin olarak yüksekti. (p =0.008)

SONUÇ: Asetabuler indeks ve Severin'in radyolojik sınıflamasındaki düzelmeye göre, 4 - 8 yaş aralığında tedavi edilen GKD'nin tek basamaklı tedavisi sonrası başarılı sonuçlar elde edilir. Ancak 8 yaştan daha büyük çocukların radyolojik sonuçları 8 yaş altındakilere göre daha kötü sonuçlanmaktadır.

ANAHTAR KELİMELER: Gelişimsel Kalça Displazisi, Kalça, Femur, Ostetotomi

ABSTRACT

OBJECTIVE: One of the most controversial issues in pediatric orthopedics is Developmental dysplasia of the hip (DDH). The timing of diagnosis and treatment are is the main goal to treat this condition successfully. Neglected cases that may remain undiagnosed until advancing age are still seen especially in developing countries. Delayed diagnosis and treatment with advancing age leads to more extensive surgery and cause low satisfactory rates. The aim of this study is to evaluate the effect of patients' age on the results of single-stage treatment of Developmental Dysplasia of the Hip.

MATERIAL AND METHODS: 23 patients (34 hips) treated in our hospital between 2004 and 2010 were included in the study. Single-stage treatment including open reduction, femoral shortening, and Salter's innominate osteotomy was applied to patients whose mean age of surgery was 7.5 years. Radiological results were evaluated in terms of improvement in the acetabular index, in the acetabular angle and according to Severin's classification, and Bucholz and Ogden's avascular necrosis (AVN) classification at the final follow-up.

RESULTS: The average follow-up period was 60 (range: 24 - 84) months. While the acetabular index was 39.7°±1.4° (range: 25°-52°) preoperatively, it was measured as 21.8°±1.8° postoperatively. The mean amount of improvement in the acetabular angle was 17.9°±0.8°. According to Bucholz and Ogden's classification, one patient (2.9%) had Type 1 AVN and one patient (2.9%) had Type 3 AVN. Radiologically, the success rate (85.7%) was significantly higher in children aged 8 years and younger (p = 0.008).

CONCLUSIONS: According to the improvement in the acetabular index and Severin's radiological classification, successful results are obtained after a single-step treatment of DDH, which is treated in the 4-8 age range. However, the radiological results of children older than 8 years are worse than those under 8 years old.

KEYWORDS: Developmental Hip Dysplasia, Hip, Femur, Osteotomy

Geliş Tarihi / Received: 15.08.2021
Kabul Tarihi / Accepted: 21.02.2022
Yazışma Adresi / Correspondence: Dr. Hakan BAHAR
Türkiye Sağlık Bilimleri Üniversitesi, Metin Sabancı Balta Limanı Kemik Hastalıkları Eğitim Araştırma Merkezi
Ortopedi ve Travmatoloji Ana Bilim Dalı
E-mail: drhakanbahar@gmail.com
Orcid No (Sırasıyla): 0000-0003-1987-0463, 0000-0001-5782-0390
Etik Kurul / Ethical Committee: Metin Sabancı Balta Limanı Kemik Hastalıkları Eğitim Araştırma Merkezi Etik Kurulu (29.06.2010/74).

INTRODUCTION

One of the most challenging conditions in pediatric orthopedics is Developmental dysplasia of the hip (DDH) (1). The timing of diagnosis and treatment is the main goal to treat this condition successfully. DDH, which is diagnosed early in infants aged 0-6 months, can be successfully treated with conservative treatment methods such as the Tubingen device (2, 3). However, neglected cases are still seen that may remain undiagnosed until advancing age especially in developing countries and among low socioeconomic groups (4). It leads to more extensive surgery with advancing age. Also, it can cause low satisfactory rates dues to pronounced acetabular dysplasia, permanent dysplastic changes, the elongated joint capsule, retraction of the muscles around the hip and loss of function in the hip, abnormal gait, and ultimately osteoarthrosis in early adulthood (5 - 7). Although the details of the surgical strategy differ from one center to another, skin traction is not recommended preliminary before the surgery, the common approach is to release the soft tissue contractures, reduce the femoral head to its original location, and increase the acetabular coverage (8). With the advancing age, debates continue regarding the timing of these surgeries. Reducing the hip with developmental dislocation of the hip, especially after the age of 4 is a difficult task with frequent complications (4, 6).

Persistent acetabular dysplasia is another important problem among patients with late-detected developmental hip dislocation. The acetabulum is shallow and dysplastic in these patients, since the stimulating effect of the femoral head on the development of the acetabulum disappears. Closed or open reduction without bone alignment, also depending on the age-related developmental capacity of the acetabulum, has been associated with permanent dysplasia (8, 9). The evolution of the acetabular index is the most important parameter to predict persistent acetabular dysplasia. If residual acetabular dysplasia is present, a surgeon should perform pelvic or femoral osteotomies (10). Pelvic osteotomy increases the coverage of the femoral head, provides stability, and prevents residual dysplasia (8). Due to the pressure-generating effect of the tendon and the capsule and the muscle contractures around the hip and on the femoral head that develop during and after reduction, avascular necrosis (AVN) is commonly encountered (4, 7).

Single-stage surgical treatment of DDH includes open reduction, femoral shortening, and pelvic osteotomy. While this procedure is performed in patients over the age of 4, it is technically dependent and requires experience (4, 6, 7). The current literature requires new studies with a large number of patients who have undergone single-stage surgical treatment of DDH with long follow-ups.

In this study, we aimed to evaluate the effect of patients' age on the results of single-stage treatment of Developmental Dysplasia of the Hip.

MATERIAL AND METHODS

The files of the patients between the ages of 4 and 12 years, whose triradiate cartilages were not closed and treated between 2004 and 2010 at the Metin Sabancı Baltalimanı Bone Health Research Hospital were retrieved and reviewed. Eight patients diagnosed with a neuromuscular disease and teratologic dislocation of the hip were excluded from the study. The clinical and radiological results of one-stage surgical treatment performed on 34 hips of 23 patients (15 females, 8 males) diagnosed with DDH were retrospectively evaluated. The patients had a mean age of 7.5±3 (range: 4 to 12) years at the time of surgery and were followed up for a mean period of 60±8 (range: 24 to 84) months. Eleven patients had bilateral DDH.

Preoperative, early postoperative, and final follow-up radiographs were evaluated by an independent orthopedic surgeon other than the performing surgeon. The patients were followed up every six weeks for the first two visits, while the third follow-up was on the 24th week, and the fourth follow-up was on the 48th week. The patients were checked on an annual basis thereafter. The degree of hip dislocation on the preoperative radiographs was evaluated using the Tönnis classification. Final radiographs were evaluated based on Severin's radiological criteria and the postoperative acetabular index (11).

All final follow-up radiographs were examined for the presence of AVN in the femoral head and were classified according to Bucholz and Ogden's classification in the case of AVN (12).

Ethical Committee

This retrospective study was performed under the approval of Metin Sabancı Baltalimanı Bone Health Research Hospital Ethics Committee (29.06.2010/74) and conducted in accordance with the Declaration of Helsinki.

Surgical Technique

All surgeries were performed by a single surgeon. Skeletal traction was not applied initially. The hip joint was approached with a Smith-Peterson incision, and a long lateral incision starting from the greater trochanter was made for femoral osteotomy. Salter's pelvic osteotomy was performed in 34 hips to realign the acetabulum. Femoral shortening and derotation were performed from the proximal of the femur, through the intertrochanteric area. The amount of femoral shortening and derotation was decided during surgery. After the first osteotomy, the femoral head was reduced to the acetabulum, and the overlapping femoral segment on the osteotomy line was resected. The average amount of shortening was 1.7±0.25 (range:1 to 3) cm. Derotation was performed in case anterior instability was observed while reducing the femoral head to the realigned acetabulum. Ten patient's proximal femur were derotated from 10° to 20° to provide adequate stabilization. Capsulorrhaphy was not performed in any patient. The initial, postoperative, and final follow-up radiographs of our 7-year-old patient with bilateral Tönnis Stage 4 DDH are given in **Figures (1, 2, 3).**

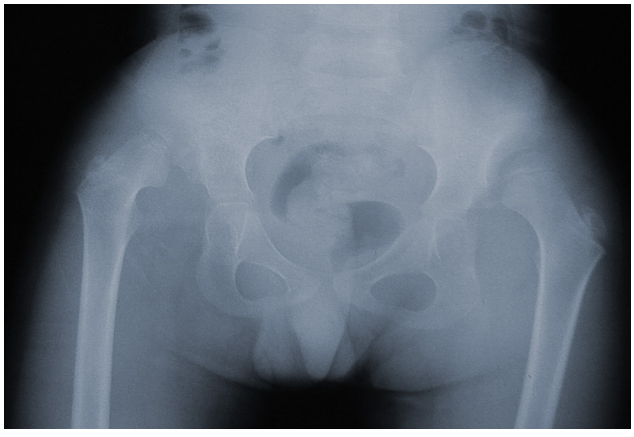

Figure 1: Standing anteroposterior radiograph showing the pelvis before surgery.

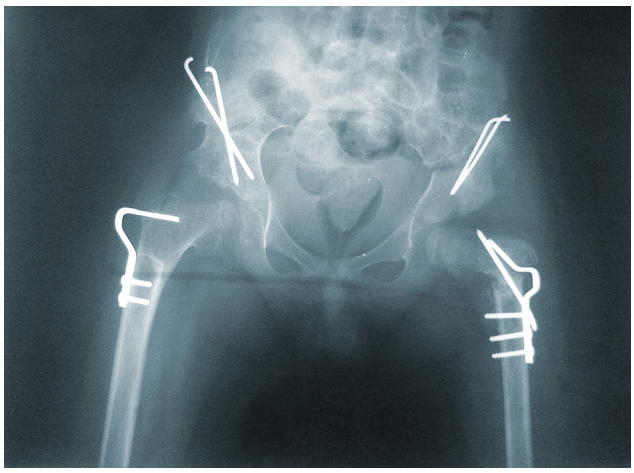

Figure 2: Standing anteroposterior radiograph showing the pelvis after Salter's pelvic osteotomy, femoral shortening, and intertrochanteric derotation osteotomy.

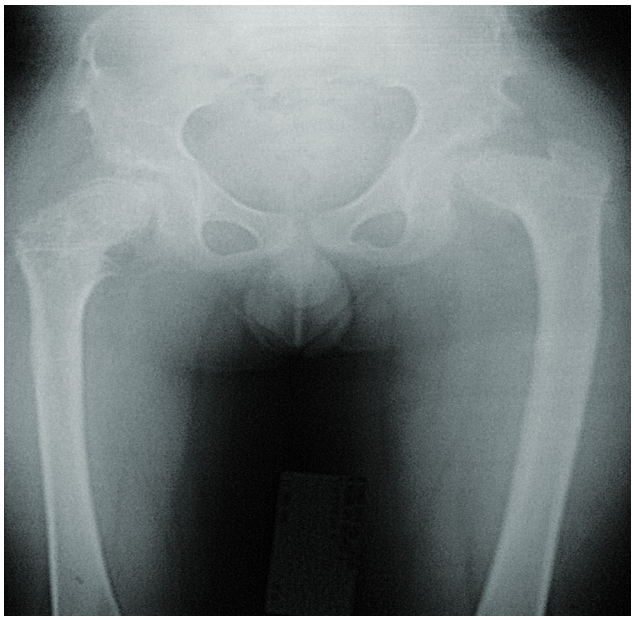

Figure 3: Anteroposterior radiograph of the pelvis at the 6th year final follow-up.

Postoperative Carepatient

All patients were immobilized in a pelvic pedal cast for six weeks with their hips in 20° to 60° of flexion, 30° to 60° of abduction, and neutral to 15° of internal rotation. After the cast was removed, range of motion exercises was initiated and the patients were allowed to put on as much weight as they could tolerate. No additional orthoses were used. The plates and screws used for the fixation of the femoral osteotomy and the Kirschner wires used for fixation of Salter's innominate osteotomy were removed after a mean period of 9±3 (range: 6 to 12) months.

Statistical Analysis

Statistical evaluations were made using the NCSS 2007 software for Windows. The paired t-test was employed to evaluate the pre- and

post-treatment values, while the chi-square and McNemar's tests were used to evaluate the qualitative data. Statistical significance was set at $p<0.05$.

RESULTS

According to the Tönnis classification, 27 hips were Grade 4, and seven hips were Grade 3. A total of 17 right hips and 17 left hips were operated on. While the acetabular index was 39.7°±1.4° (range: 25° to 52°) preoperatively, it was measured as 21.8°±1.8° postoperatively. The mean amount of improvement in the acetabular angle measured on the pelvic radiographs taken on the first postoperative day was 17.9°±0.8°. According to Severin's classification, 13 hips (38.2%) were Class 1, eight hips (23.5%) were Class 2, nine hips (26.5%) were Class 3, two hips (5.9%) were Class 4, and two hips (5.9%) were Class 6. According to Bucholz and Ogden's classification, one patient (2.9%) had Type 1 AVN, and one patient (2.9%) had Type 3 AVN. One patient who developed redislocation refused to undergo surgery again. Osteosynthesis was performed on one patient with a fracture that was detected on the femoral osteotomy line. This patient did not have any radiological problems. Infection, implant failure, or wound problems were not encountered in any patient. Radiological grades were significantly lower in patients who were older than 8 years, ($p=< 0.00015$). The cut-off point for age was taken as 8 years regarding the results of the Chi-square statistics. Satisfactory results for children who were 8 years or younger (85.7%) were significantly better than that of the children who were older than 8 years (33.3%), ($p=< 0.008$). Our radiological results are summarized in the table **(Table 1)**.

Table 1: Radiological results of the patients.

Patient no.	Age (years)	Involved hip	Follow-up period (months)	Preop. Tönnis Stage	Preop. AI (right)	Postop. AI (right)	Follow-up AI (right)	Preop. AI (left)	Postop. AI (left)	Follow-up AI (left)	Severin Class (right)	Severin Class (left)
1	12	Bilateral	78	4	44	26	26	45	28	27	3	3
2	12	Right	80	4	48	30	30				4	
3	9	Bilateral	76	4	45	29	27	46	28	26	2	2
4	6	Bilateral	84	4	38	22	18	39	22	19	2	1
5	6	Bilateral	74	4	35	17	16	38	22	20	1	1
6	6	Left	76	3				28	12	10		2
7	11	Right	12	4	49	30	30				6	
8	5	Bilateral	72	4	36	20	18	38	20	17	1	1
9	6	Left	70	3				39	24	24		1
10	9	Left	69	4				48	30	28		3
11	4	Right	72	4	44	28	23				1	
12	4	Bilateral	58	4	41	24	22	42	23	20	3	1
13	9	Left	62	4				52	29	34		4
14	4	Bilateral	56	4	25	12	10	29	15	12	1	1
15	7	Bilateral	55	4	34	19	20	38	22	20	2	3
16	5	Right	56	4	43	23	20				1	
17	12	Bilateral	49	3	51	28	34	48	25	29	6	2
18	12	Left	46	4				33	15	15	3	
19	9	Bilateral	44	4	44	25	20	47	29	29	2	3
20	4	Bilateral	38	4	34	18	18	36	19	16	1	1
21	8	Left	26	3				35	15	16		3
22	9	Right	24	3	33	15	15				3	
23	7	Right	25	3	29	13	12				2	

AI: acetabular index.

DISCUSSION

The main goal of the treatment of DDH is to obtain a painless, stable, non-functional hip with a normal gait and to protect it from early osteoarthrosis. This can only be achieved with a concentrically reduced hip. In a logistic regression analysis where they analyzed the effect of age at initial treatment on the development of AVN, they reported that their model predicted 83.9% accurately and the probability of AVN development was higher in those with advanced age at initial treatment (13). Achieving successful results gets harder as patients get older (4, 8, 14).

According to the consensus among researchers, the earliest age at which Salter's innominate osteotomy can be applied is 18 months (8). If the osteotomy is to be performed at an earlier age, the innominate bone and graft thicknesses are quite insufficient. In this case, the surgical intervention is likely to result in loss of correction (8). Taghi et al. reported that the group with a mean age of 24.7 months at the first operation and undergoing Salter innominate osteotomy had a success rate of 86% according to the Severin score (15). According to Chapchal (16), the age at which the treatment is initiated is the most important factor in determining the treatment protocol. The author reported very successful results in patients between 18 months and 3 years of age and in cases where the acetabular index did not exceed 35°. In another study conducted by Gulman et al. on patient groups of 18 months to 4 years, 4 to 6 years, and over 6 years of age who underwent innominate osteotomy, the researchers reported that the most successful results were obtained in the 18 months to 4 years group (17). Salter, with his 15 years of experience and his study with Dubos (18), obtained excellent and good results in 93.6% of the patients in the 1.5 to 4 years age group, while this rate decreased to 56.7% in the 4 to 10 years age group. According to Salter, the upper age limit for innominate osteotomy is 6 years (18). However, with the addition of femoral shortening, the surgery could be performed on patients between the ages of 8 and 12 years (8). Weinstein et al. (19) operated on 32 hips of 25 patients with a mean age of 4 years and 2 months, where the oldest patient was 8 years and 2 months. They additionally performed femoral shortening in 21 hips. The authors re-

ported radiologically successful results in 75% of their series according to Severin's classification and Type 4 AVN in three patients. Baki et al. (20) treated 15 hips (15 patients) with developmental dysplasia in a single-stage surgery with open reduction and Salter innominate osteotomy via a medial approach, and radiologically classified 10 hips as Class 1, four as Class 2, and one as Class 3 according to Severin's criteria, for patients who were followed up for an average period of 9.6 (range:4 to 14) years postoperatively. The authors also reported that none of their patients had AVN. In Ryan et al.'s study (6) in which the results of the operative treatment of congenital hip dislocation in 18 children (25 hips) were observed, the researchers reported excellent results in seven hips, good results in 11 hips, moderate results in four hips, and poor results in three hips based on Severin's classification. The authors also detected AVN necrosis in the proximal femur in four patients. In their study, Williamson et al. (21) reported that femoral osteotomy and pelvic osteotomy gave better results in patients with congenital hip dislocation over 3 years of age with a long follow-up period. In addition, the same patient group had better radiological results on the fifth year final follow-up radiographs when compared to the patients who underwent femoral osteotomy alone. In another study, Konya et al. reported that Tönnis and Steel osteotomies offer satisfactory short-term results in the surgical treatment of adult patients with mild to moderate dysplasia (22). In our study, the CE angle of patients who were operated on before the age of 8 years as higher at the final follow-up. In addition, our radiological results were better in patients who were operated on before the age of 8 years. In the 4 to 8 years age group, the success rate had risen to 85%. Worse results were obtained in patients over 8 years of age (28.5%).

The prevalence of AVN in the 4 - 8 years group ranges between 3% and 60% (8). In a systemic review of comparative studies, they reported that the complication rate for Salter innominate osteotomy was 9.4% and AVN was the most common complication (23). In another study, they reported that combining Salter innominate osteotomy with anterior open reduction has the lowest rate of AVN, and best clinical and radiological results in walking ages (24). It has been asserted that femoral shortening facilitates reduction in children over 3 years of age (8). Schoenecker and Strecker (25) have shown that this procedure reduces the incidence of AVN when performed on older children. The same authors compared femoral shortening with direct traction and demonstrated that femoral shortening was more effective in preventing AVN in their small series. Karakaş et al. (4) performed femoral shortening, varisation, and derotation osteotomy together with innominate osteotomy in their study where they did not apply any preoperative traction to any patient. The authors reported AVN in 7.27% of the cases (4 hips) following single-stage surgery performed on 55 hips and recounted that femoral shortening prevented excessive pressure that may develop in the femoral head, thereby reducing the AVN incidence. McKay, on the other hand, reported AVN in 15% of their series and stated that patients with bilateral DDH had better results in terms of osteonecrosis after single-stage surgery in patients younger than 5 years of age (26). Gulman et al., on the other hand, reported an AVN rate of 63.3% in their series, 34.6% of which were Type 2, Type 3, and Type 4 (17). In another study, Tuhanioglu et al. observed AVN in 11.11% of the cases in the Salter osteotomi group in their series (27). In our study, AVN of the femoral head was observed in two patients; according to Bucholz and Ogden's classification, one was Type 1 and one was Type 3 AVN. One patient who developed redislocation refused to undergo surgery again. Osteosynthesis was performed on one patient with a fracture that was detected on the femoral osteotomy line. This patient did not have any radiological problems. Infection, implant failure, or wound problems were not encountered in any patient. Although the selection of a small group of patients with Tönnis grade 4 hip may be considered a limitation of this study, our study is different from previous studies because it investigated the efficacy of a uniform treatment method in patients with Tönnis grade 4 hip involvement (28, 29)

In conclusion, the most important finding of our study is that radiological success in the middle term is highly dependent on the age of the

child. We also concluded that in DDH patients who were aged 4 to 8 years and were treated with a single-stage surgery with open reduction, pelvic osteotomy, and femoral shortening, successful results were obtained in the middle term according to Severin's classification, whereas radiological success was significantly low in the middle term in children aged 8 years and over.

REFERENCES

1. Kural B, Devecioğlu Karapınar E, Yılmazbaş P, Eren T. Risk Factor Assessment and a Ten-Year Experience of DDH Screening in a Well-Child Population. Biomed Res Int. 2019;(4):7213681.

2. Lyu X, Chen T, Yang Z, et al. Tubingen hip flexion splint more succesful than Pavlik harness for decentred hips after the age of three months. Bone Joint J. 2021;103-B (5):991-998.

3. Yegen M, Atalar H, Gunay C, et al. Reduction of the dislocated hips with the Tubingen hip flexion splint in infants. Int Orthop. 2019;43(9):2099-2103.

4. Karakaş ES, Baktir A, Argün M, Türk CY. One-stage treatment of congenital dislocation of the hip in older children. J Pediatr Orthop. 1995;15(3):330-6.

5. Terjesen T, Horn J. Management of late-detected DDH in children under three years of age: 49 children with follow-up to skeletal maturity. Bone Jt Open. 2020;1:55-63.

6. Ryan MG, Johnson LO, Quanbeck DS, Minkowitz B. One-stage treatment of congenital dislocation of the hip in children three to ten years old. Functional and radiographic results. J Bone Joint Surg Am. 1998;80(3):336-44.

7. Malvitz TA, Weinstein SL. Closed reduction for congenital dysplasia of the hip. Functional and radiographic results after an average of thirty years. J Bone Joint Surg Am. 1994;76(12):1777-92.

8. Herring JA. Tachdjian's Paediatric Orthopaedics. Vol 1. Section 2 6th ed. Philadelphia: Saunders, 2020 Nov;422-471.

9. Konya MN, Aydin BK, Yildirim T, Sofu H, Gürsu S. Does Previous Hip Surgery Effect the Outcome of Tönnis Triple Periacetabular Osteotomy? Mid-Term Results. Medicine (Baltimore). 2016;95(10): 3050.

10. Alfonso VP, Gaspar GM, Enrique GG, Luis M. Developmental dysplasia of the hip: update of management. EFORT Open Rev. 2019 17;4(9):548-556.

11. Lyu X, Fu G, Feng C, et al. Clinical and radiological outcomes of combined acetabuloplasty with acetabular redirectional osteotomy and femoral shortening for children older than 9 years of age with developmental dysplasia of the hip: a retrospective case series. J Pediatr Orthop B. 2020;29(5):417-423.

12. Pollet V, Bonsel J, Ganzeboom B, Sakkers R, Waarsing E. Morphological variants to predict outcome of avascular necrosis in developmental dysplasia of the hip. Bone Joint J. 2021;103-B(5):999-1004.

13. Hussain RN, Rad D, Watkins WJ, Carpenter C. The incidence of avascular necrosis following a cohort of treated developmental dysplasia of the hip in a single tertiary centre. J Child Orthop. 2021 1;15(3):232-240.

14. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation. Part II. J Bone Joint Surg Am. 2003;85(10):2024-35.

15. Baghdadi T, Bagheri N, Khabiri SS, Kalantar H. The Outcome of Salter Innominate Osteotomy for Developmental Hip Dysplasia before and after 3 Years Old. Arch Bone Jt Surg. 2018;6(4):318-323.

16. Chapchal G. Indications for the various types of pelvic osteotomy. Clin Orthop Relat Res. 1974;(98):111-5.

17. Gulman B, Tuncay IC, Dabak N, Karaismailoglu N. Salter's innominate osteotomy in the treatment of congenital hip dislocation: a long-term review. J Pediatr Orthop. 1994;14(5):662-6.

18. Salter RB, Dubos JP. The first fifteen year's personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. Clin Orthop Relat Res. 1974;(98):72-103.

19. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation. Part II. J Bone Joint Surg Am. 2003;85(10):2024-35.

20. Baki C, Sener M, Aydin H, Yildiz M, Saruhan S. Single-stage open reduction through a medial approach and innominate osteotomy in developmental dysplasia of the hip. J Bone Joint Surg Br. 2005;87(3):380-3.

21. Williamson DM, Glover SD, Benson MK. Congenital dislocation of the hip presenting after the age of three years. A long-term review. J Bone Joint Surg Br. 1989;71(5):745-51.

22. Konya MN, Tuhanioğlu Ü, Aslan A, et al. A comparison of short-term clinical and radiological results of Tönnis and Steel pelvic osteotomies in patients with acetabular dysplasia. Eklem Hastalik Cerrahisi. 2013;24(2):96-101.

23. Tejpal T, Shanmugaraj A, Gupta A, et al. Outcomes and complications of patients undergoing Salter's innominate osteotomies for hip dysplasia: a systematic review of comparative studies. J Hip Preserv Surg. 2021 19;7(4):621-630.

24. Kothari A, Grammatopoulos G, Hopewell S, Theologis T. How Does Bony Surgery Affect Results of Anterior Open Reduction in Walking-age Children With Developmental Hip Dysplasia? Clin Orthop Relat Res. 2016;474(5):1199-208.

25. Schoenecker PL, Strecker WB. Congenital dislocation of the hip in children. Comparison of the effects of femoral shortening and of skeletal traction in treatment. J Bone Joint Surg Am. 1984;66(1):21-7.

26. 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.

27. Tuhanioğlu Ü, Gültekin A, Oğur HU, Seyfettinoğlu F, Serarslan U. Comparison of the results of Pemberton and Salter osteotomies applied in developmental dysplasia of the hip. Kocaeli Med J. 2018;(2):81-86.

28. Subasi M, Arslan H, Cebesoy O, Buyukbebeci O, Kapukaya A. Outcome in unilateral or bilateral DDH treated with one-stage combined procedure. Clin Orthop Relat Res. 2008;466(4) : 830-836.

29. Wang TM, Wu KW, Shih SF, Huang Sc, Kuo Kn. Outcomes of open reduction for developmental dysplasia of the hip: does bilateral dysplasia have a poorer outcome? J Bone Joint Surg Am. 2013;95(12):1081-1086.