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ORIGINAL ARTICLE

Abduction Orthosis in Treatment of Primary Acetabular Dysplasia: Results of Three Years Follow-up

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Abstract

Background: Acetabular dysplasia (AD) may appear after six-months-old despite normal previous physical and ultrasonographic examination, and management remains unclear. The purpose of the current study was to evaluate the success of abduction orthosis in the treatment of primary AD patients.

Methods: Patients presented with AD between 2010-2017 were retrospectively reviewed. The study included AD patients who had stable hip joints on previous physical examination and Graf type1 on ultrasonography when younger than six months. AD was diagnosed according to the age-related acetabular index (AI) values. Abduction orthoses were applied full-time for five months plus part-time for three months. AI was re-measured at the sixth month, at the end of the first and third year. AI change was compared between dysplastic and nondysplastic hips.

Results: It was evaluated 60 hips of 39 patients with AD treated with abduction orthosis at the median age of 6 months. The mean AI was 31.4 (range: 29-35)°±2.1° in dysplastic hips. AI decreased to 26.5°±2.2°, 24.5°±2°, 21°±2.1° at sixth months, first and third years after treatment; respectively. The mean AI of non-dysplastic hips was 25.3°(range: 22-28)±2.1°; and decreased to 22.6°±2.4°, 21.1°±2°, 17.9°±1.8° at sixth months, first and third years follow-ups, respectively. At the end of the first six months, dysplastic hips had significantly better improvement in AI (4.9±2.1°) compared to non-dysplastic hips (2.7°±0.8°) ($p<0.001$). There was no significant difference in AI improvement after six months.

Conclusion: Primary acetabular dysplasia should not be ignored despite normal previous physical and ultrasonographic examination. Abduction orthosis may be used in the treatment of children with primary AD older than six months.

Keywords: Hip Dysplasia, Abduction Brace, Acetabular Index.

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INTRODUCTION

Developmental dysplasia of the hip (DDH) denotes a wide spectrum of pathologic conditions, ranging from subtle acetabular dysplasia to irreducible hip dislocation. The main factors for the normal development of acetabulum are a stable, concentrically reduced femoral head into the acetabular cavity and adequate femoral head growth. Despite a normal acetabulum-femoral head positioning, in some cases, the development of acetabulum may remain inadequate. This condition is defined as acetabular dysplasia and can be secondary to treatment or primary in case of inadequate development of acetabulum.

Despite the growing number of cases presenting with clinically stable, reduced hips but with an increased age-related acetabular index (AI) on the anteroposterior (AP) pelvic radiographs after the age of six month; in the literature, there is little data about identifying those patients. Furthermore, management is still controversial. Spontaneous resolution of dysplasia without intervention is unlikely in children over the age of 6 months (1). When DDH is recognized in the first 6 months of life, treatment with a Pavlik harness frequently results in an excellent outcome (2-4). In contrast, treatment of older children may be challenging due to the lower efficacy and difficulty of using the Pavlik harness. There is increasing data in the literature about abduction orthosis that can be used in the treatment of DDH patients older than six months of age instead of Pavlik harness (5-8).

The aim of the current study was to evaluate the success of abduction orthosis in treating acetabular dysplasia patients with an increased age-related AI on AP pelvic X-rays with clinically normal hips on both previous physical and ultrasonographic examinations.

MATERIALS AND METHODS

The study protocol was approved by the Dışkapı Yıldırım Beyazıt Training and Research Hospitals' Ethics Committee (Date: 22.11.2016 – No: 32/18), and it was performed in accordance with the ethical standards laid down in the Declaration of Helsinki. Written informed consent was obtained from all subjects.

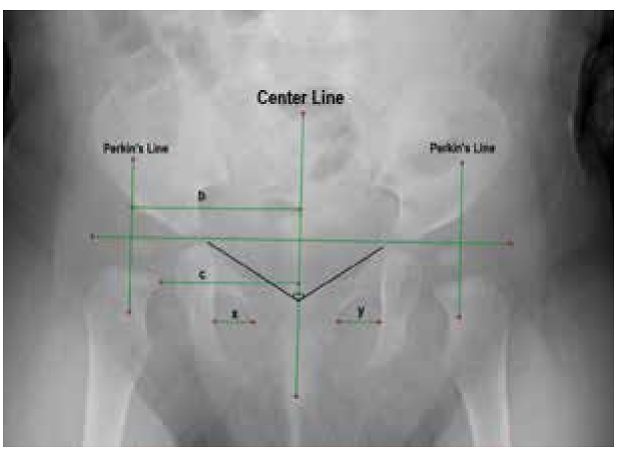
Patients who presented with DDH to our department between January 2010 and January 2017 were retrospectively reviewed. On previous physical examination, acetabular dysplasia patients with increased age-related AI had stable hip joints (Ortolani test and Barlow maneuvers were negative), and Graf type 1 hip on ultrasonography when younger than six months were included study. Patients with teratologic hips, syndromic dysplasia, and those who required closed or open reduction were excluded. Sixty eligible hips of 39 patients treated with abduction orthoses and followed at least three years completed the study. Sex, family history of DDH, and other risk factors for DDH, including firstborn status, multiple gestations, delivery presentation (such as vertex and breech), oligohydramnios, swaddling for each patient, were recorded.

The angle of the acetabular index(AI) measured from the pelvic AP radiograph is an easy and reliable method for diagnosing acetabular dysplasia (9-11). Initial AI was measured, acetabular dysplasia was diagnosed by AI according to the age-related values given by Tönnis (12) (Table 1). Acetabular dysplasia was classified into two categories: mild dysplasia as between 1-2 standard deviations; and severe dysplasia as above two standard deviations at the beginning and end of the three-year follow-up. In order to diagnose primary acetabular dysplasia, it is necessary to rule out hip dislocation. So, the femoral head must be developed adequately and concentrically reduced into the acetabular cavity. For the definition of the concentrically reduced femoral head into the acetabular cavity, we evaluated two conditions: first, the femoral head should be located in the inferomedial quadrant of Perkins; second, eccentration index of Smith (c/b index) (13) should be within normal ranges. In order to minimize errors due to pelvic rotation in both the longitudinal and transverse body axis, measurements were made on radiographs which pelvic rotation(x/y) and the AP pelvic tilt index(symphysis-os ischium angle) is normal range as previously described (12) (Figure 1).

Table 1. Age-related acetabular index according to Tönnis

	Girls				Boys			
Ages	*Mild dysplasia above (S)*		*Severe dysplasia above (2S)*		*Mild dysplasia above (S)*		*Severe dysplasia above (2S)*	
	right	*left*	*right*	*left*	*right*	*left*	*right*	*left*
5-6 months	27.3	29.3	31.8	34.1	24.2	26.8	29.0	31.6
7-9 months	25.3	26.6	29.4	31.1	24.6	25.4	28.9	29.5
10-12 months	24.7	27.1	28.6	31.4	23.2	25.2	27.0	29.1
13-15 months	24.6	26.9	29.0	31.7	23.1	24.0	27.5	27.7
16-18 months	25.0	26.1	29.3	30.4	23.8	25.8	28.1	30.0
3-5 years	17.9	21.2	21.3	25.8	19.2	19.8	23.5	23.8

Figure 1. Parameters measured on pelvic radiography



Abduction orthoses were applied in patients with acetabular dysplasia for five months (range 4-6 months) full-time (only one hour of brace-free time was allowed for bathing, diaper changes etc.). If improvement was achieved in follow-up visits, families were instructed to use braces part-time (mean 12 hours a day) for three months (range 2-4 months) more. Braces were custom-made for each patient individually. Abduction braces are semi-rigid orthoses that maintain 45° abduction and 30-40° flexion of bilateral hips and reduce femoral head into the acetabulum. It allows partial hip movements while knees are free to move so that patients can sit.

AI was re-measured at the sixth month, at the end of the first year, and third year. (Figure 2-5) Changes in the AI values between the initial and follow-up visits were evaluated. In the current study, all radiographic measurements were made by a single, experienced researcher. An intraclass correlation coefficient (ICC) analysis was also performed. Digital PACS software was used for radiographs, which had been shown good reliability and reproducibility (14).

Figure 2. Acetabular Index at initial X-ray

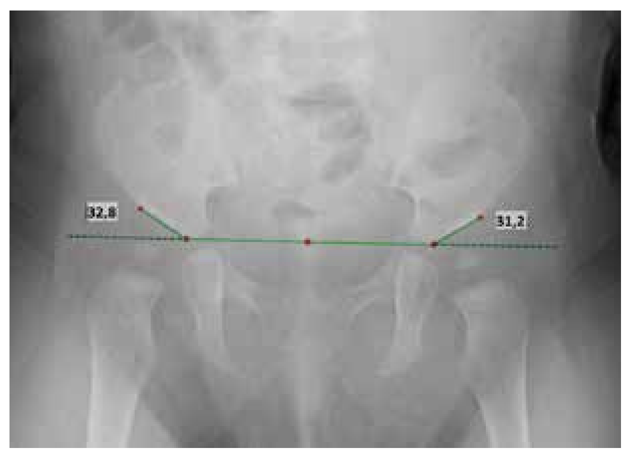


Figure 3. Acetabular Index at sixth-month follow-up

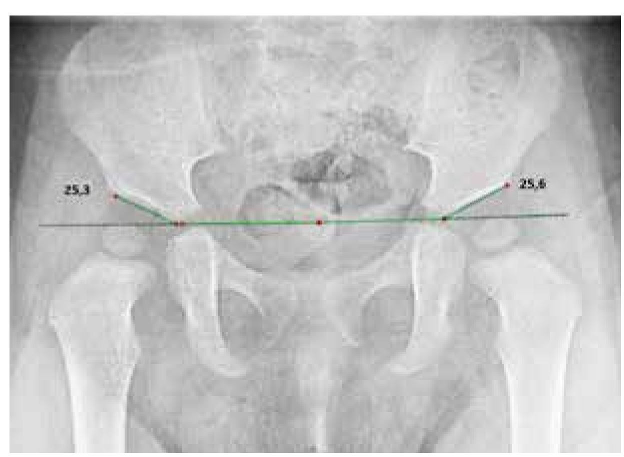


Figure 4. Acetabular Index at first-year follow-up

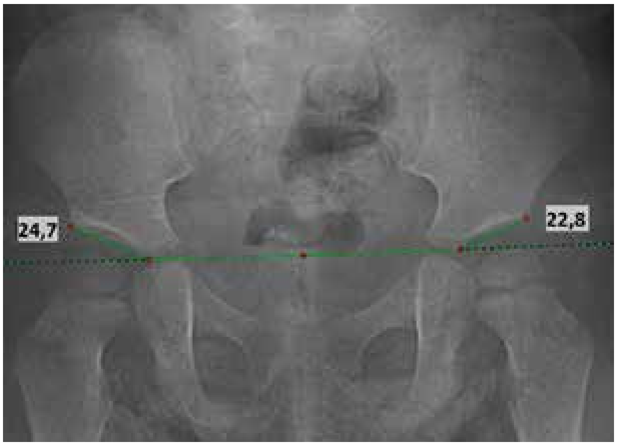
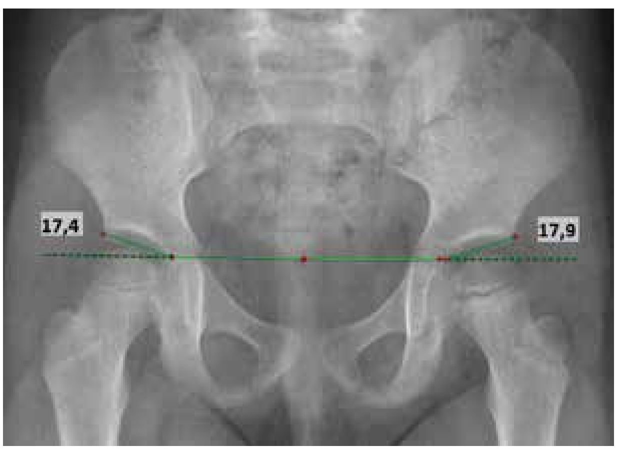


Figure 5. Acetabular Index at third-year follow-up



Since there is no control group in the current study due to ethical considerations regarding left children untreated, we compared the change in AI between the dysplastic hips group and the non-dysplastic hips group.

Statistical analysis was performed using the statistical software SPSS for Windows, version 26. Shapiro-Wilks test was used to evaluate the distribution of continuous variables. Data are presented as mean-SD after testing for normal distribution. If the test for normal distribution failed, the median (minimum-maximum) values were given. Nominal variables are shown as the number of cases and percentage (%). The significance of the differences between the dysplastic and non-dysplastic hips was investigated using Student's t-test and the Mann-Whitney U test. The Chi-square and Fisher's exact Chi-square test were used to test the difference in nominal data between the groups. A multivariate analysis of variance (ANOVA) was used to test time effects combined with group effects on the dependent variables (e.g., AI). The Bonferroni test was used (for all changes) to understand when and how the time was different. A p-value of below 0.05 was considered statistically significant.

RESULTS

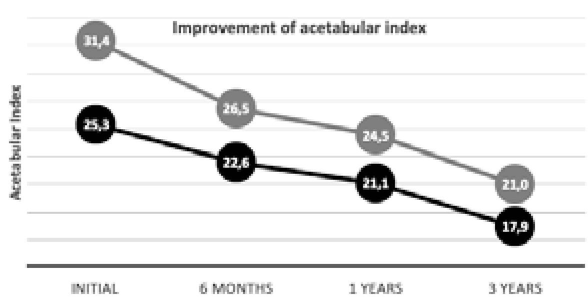
It was identified 96 dysplastic patients who met inclusion criteria from patients admitted to our clinic for DDH. Fifty-seven patients were excluded from the study (due to inappropriate radiographs in 37 patients, inadequate data in 16 patients, inability to use the brace in 2 patients, and closed reduction because of subluxation in 2 patients). We evaluated 60 hips of 39 patients with acetabular dysplasia treated with abduction brace at the median age of 6 months old (range 5- 10 months). 34 (87%) of patients were females, 21 (54%) patients had bilateral acetabular dysplasia. 27 (45%) of 60 hips were right-sided, 33 (55%) hips were left-sided. According to Tönnis classification; 33 (55%) hips (23 left/10 right) had mild dysplasia, and 27 (45 %) hips (10 left/17 right) had severe dysplasia. The demographics and baseline clinical characteristics of the patients who completed the study were summarized in Table 2.

Table 2. Demographic and clinical characteristics of patients

Age at initial examination (months) *[median (min-max)]*	6 (5-10)
Gender, *[n (%)]*	
Male	5 (13)
Female	34 (87)
Risk Factor, *[n (%)]*	18 (46)
Family history of DDH	12 (31)
First Born	9 (23)
Swaddling	1 (3)
Oligohydramnios	2 (5)
Breech presentation	4 (10)
Location *[n (%)]*	
Unilateral	18 (46)
Right	6 (15)
Left	12 (31)
Bilateral	21 (54)
Tönnis *[n (%)]*	n:60
Mild Dysplasia	33 (55)
Right	10 (17)
Left	23 (38)
Severe Dysplasia	27(45)
Right	17(28)
Left	10(17)
DDH: Developmental dysplasia of the hip	

The mean AI was 31.4°±2.1° (range: 29-35°) at the initiation of the brace treatment of 60 dysplastic hips. After abduction orthosis treatment, AI decreased to 26.5°±2.2° at six months follow-up, to 24.5°±2°, and 21°±2.1° at 12 months and 36 months; respectively. The decrease in AI value was statistically significant in all follow-up ($p<0.001$). The mean AI change was 4.9°±2.1 in the first six months, 2°±1.3 in the second six months of period, and 3.5°±1.7 in the subsequent two years. The improvement in AI was significantly better in the first six months compared to the second six months and subsequent two years ($p<0.001$). The mean AI of 18 non-dysplastic hips was 25.3°±2.1° (range: 22-28°) before bracing. AI decreased to 22.6°±2.4°, 21.1°±2°, and 17.9°±1.8° at six months, 12 months, and 36 months follow-up visits after treatment, respectively. The decrease in AI value was statistically significant in all follow-up($p<0.001$) (Figure 6).

Figure 6. Improvement of Acetabular Index



When we compare dysplastic and non-dysplastic hips, AI decreased more in dysplastic hips in all follow-up. At the end of the first six months of follow-up, dysplastic hips had significantly better improvement in the AI of 4.9±2.1° compared with non-dysplastic hips, which had improvement in AI of 2.7°±0.8° ($p<0.001$). There was no significant difference between the two groups in terms of improvement in AI after six months follow-up visit (6-12 months p: 0.175; 6-36 months p: 0.134; 12-36 months p:0.38).

At the end of three years follow up period, dysplastic hips were reclassified according to Tönnis: 14 of mild dysplastic and 6 of severe dysplastic hips were stratified into normal group, and also 18 of severe dysplastic hips were stratified into mild dysplasia group; while the remaining 18 mild and four severe dysplastic hips had shown no improvement. Follow-up was continued without surgical intervention due to the absence of luxation or subluxation in nonresponders to acetabular bracing.

None of the patients had avascular necrosis or complications of using a brace.

DISCUSSION

The current study aims to evaluate primary acetabular dysplasia, excluding residual acetabular dysplasia secondary to management with surgery or conservative method, and this is the most significant difference from the earlier studies in the literature (15). Our findings show that abduction orthosis is an effective method in the treatment of patients with acetabular dysplasia. Regarding dysplastic hips, nearly half (47%) of the average 10.4 degrees improvement in AI during a three-year follow-up period occurred in the first six months of abduction orthosis. 37% of AI improvement in non-dysplastic hips was observed in the same period (Figure 4). AI improvement after the first six months did not differ between dysplastic and non-dysplastic hips groups. Salter reported that acetabular remodeling slows down after 18 months of age (16). It was considered that AD could be treated with abduction orthosis more effectively in this highest remodeling time.

Acetabular dysplasia could be easily underestimated due to late-onset symptoms or even asymptomatic contrary to hip dislocation, but prevalence and importance are more than predicted. In a systematic review of the literature conducted by Shaw and et al. (15), radiographic evidence of late dysplasia was present in 9,49% hips and 4,14% hips requiring additional surgery of 6029 hips treated with the Pavlik method an average of 5.29 years follow-up. Dornacher et al. detected residual dysplasia in 30% of their patients on pelvic X-rays when children started walking even after successful ultrasound-monitored treatment (17). Sarkissian et al. showed that 17% of all infants, who had achieved both normal ultrasonographic and clinical examinations at an average of three months, demonstrated radiographic signs of acetabular dysplasia at the age of average six months (18). Based on the findings, they suggested radiographic follow-up in this population of infants through at least walking age to allow timely diagnosis and early intervention of residual acetabular dysplasia. Management of acetabular dysplasia remains unclear despite high prevalence. Especially treatment between 6 months and 18 months is highly controversial; because the effectiveness of Pavlic harness decreases after the age of 6 months, and the pelvic osteotomy is recommended after 18 months of age. Expecting and waiting for enough acetabular remodeling to enhance normal development and optimal femoral coverage with aging is not realistic and also leads to late interventions and results with more complicated dysplasia cases. It will be unexpected to resolve spontaneously (1). Pavlik harness is an effective and reliable method in the treatment of DDH, but effectiveness decreases in infants older than six months of age and even older than four months(19). Abduction orthosis is increasingly used in this age group of patients after unsuccessful results of Pavlik harness in these older and more active children. There is little data about using abduction orthoses in the treatment of acetabular dysplasia in the literature. Gans et al. studied infants with stable, treated DDH but residual acetabular dysplasia at six months of age, started bracing when the 6-month radiograph demonstrates an AI>30 degrees, whereas others do not; compared the analysis of treated with abduction bracing or observation, part-time bracing significantly improved the acetabular index between 6 and 12 months of age(6).

Dysplastic hips were reclassified according to Tönnis' gender and age-related classification at the end of the three-year follow-up period. Although significant improvement in AI of 28 severe and 32 mild dysplastic hips with the establishment of abduction orthosis, 4 (7%) hips was still found severe dysplastic, and 36 (60%) hips were mild dysplastic at the end of three years follow up period. Four still severe dysplastic hips were followed up without treatment due to the non-existence of luxation or subluxation. 2 of the hips achieved normal AI at an average of 5 years of age, and the remaining two hips achieved it at about six years of age. It could be expected the vast majority of hips may be achieved normal values of AI if the follow-up period had been longer.

There are some limitations of the current study. First, a small number of primary acetabular dysplasia cases were eligible for our inclusion criteria despite a 6-year study period. The second was the absence of a control group which was followed without treatment. Because the inclusion of a control group including untreated children with AD is unethical, we could emphasize that unilateral dysplastic hips benefited more than their symmetric normal hips with the treatment of abduction orthosis. Therefore, we could not argue the superiority of abduction orthosis to observation without treatment. Similarly we could not argue treatment differentiation of primary acetabular dysplasia from the residual dysplasia cases secondary to conservative or surgical management. A third of the limitation was an accumulation of the cases in a range of age, so we cannot comment about abduction orthosis is effective into which age and how long we should continue bracing the patients. The most important strength of the current study is the long follow-up period with three years, which we believe is long enough to demonstrate the effectiveness and safety of abduction orthosis.

In conclusion, acetabular dysplasia may appear after six months old despite normal previous physical and sonographic examination. Abduction orthosis may be used in the treatment of children with primary acetabular dysplasia older than six months of age. AI improved significantly better in dysplastic hips compared to non-dysplastic hips in the first six months of an orthosis. The current study does not conclude that abduction orthosis is better than the natural course of dysplasia since a control group is absent. However, abduction orthosis is a safe, effective, and conservative method that may reduce the risk for early-onset osteoarthritis and the need for future surgical management. There is a need for future studies to assess which age effectivity lasts and how long orthosis should continue to apply.

Declarations

The authors received no financial support for the research and/or authorship of this article. There is no conflict of interest.

The study protocol was approved by the Dışkapı Yıldırım Beyazıt Training and Research Hospitals' Ethics Committee (Date: 22.11.2016 – No: 32/18), and it was performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

REFERENCES

1. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. J Am Acad Orthop Surg. 2001;9(6):401–11.
2. Filipe G, Carlioz H. Use of the Pavlik harness in treating congenital dislocation of the hip. J Pediatr Orthop. 1982;2(4):357–62.
3. Pavlik A. The functional method of treatment using a harness with stirrups as the primary method of conservative therapy for infants with congenital dislocation of the hip. 1957. Clin Orthop Relat Res. 1992;89(281):4–10.

4. Walton MJ, Isaacson Z, McMillan D, Hawkes R, Atherton WG. The success of management with the Pavlik harness for developmental dysplasia of the hip using a United Kingdom screening programme and ultrasound-guided supervision. J Bone Joint Surg Br. 2010;92(7):1013-6.
5. Sankar WN, Nduaguba A, Flynn JM. Ilfeld abduction orthosis is an effective second-line treatment after failure of Pavlik harness for infants with developmental dysplasia of the hip. J Bone Joint Surg Am. 2015;97(4):292-7.
6. Gans I, Flynn JM, Sankar WN. Abduction bracing for residual acetabular dysplasia in infantile DDH. J Pediatr Orthop. 2013;33(7):714–8.
7. Hedequist D, Kasser J, Emans J. Use of an abduction brace for developmental dysplasia of the hip after failure of Pavlik harness use. J Pediatr Orthop. 2003;23(2):175–7.
8. Wahlen R, Zambelli PY. Treatment of the developmental dysplasia of the hip with an abduction brace in children up to 6 months old. Adv Orthop. 2015;2015.
9. Broughton NS, Brougham DI, Cole WG, Menelaus MB. Reliability of radiological measurements in the assessment of the child’s hip. J Bone Joint Surg Br. 1989;71(1):6-8.
10. Portinaro NM, Murray DW, Bhullar TP, Benson MK. Errors in measurement of acetabular index. J Pediatr Orthop. 1995;15(6):780-4.
11. Spatz DK, Reiger M, Klaumann M, Miller F, Stanton RP, Lipton GE. Measurement of acetabular index intraobserver and interobserver variation. J Pediatr Orthop. 1997;17(2):174-5.
12. Tönnis D. Normal values of the hip joint for the evaluation of X-rays in children and adults. Clin Orthop Relat Res. 1976;119:39–47.
13. Smith WS, Badgley CE, Orwig JB, Harper JM. Correlation of postreduction roentgenograms and thirty-one-year follow-up in congenital dislocation of the hip. J Bone Joint Surg Am. 1968;50(6):1081–98.
14. Segev E, Hemo Y, Wientroub S, Ovadia D, Fishkin M, Steinberg DM, et al. Intra- and interobserver reliability analysis of digital radiographic measurements for pediatric orthopedic parameters using a novel PACS integrated computer software program. J Child Orthop. 2010;4(4):331–41.
15. Shaw KA, Moreland CM, Olszewski D, Schrader T. Late acetabular dysplasia after successful treatment for developmental dysplasia of the hip using the Pavlik method: A systematic literature review. J Orthop. 2018;16(1):5-10.
16. Salter RB. Role of innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip in the older child. J Bone Joint Surg Am. 1966;48(7):1413-39.
17. Dornacher D, Cakir B, Reichel H, Nelitz M. Early radiological outcome of ultrasound monitoring in infants with developmental dysplasia of the hips. J Pediatr Orthop Part B. 2010;19(1):27–31.
18. Sarkissian EJ, Sankar WN, Zhu X, Wu CH, Flynn JM. Radiographic Follow-up of DDH in Infants: Are X-rays Necessary After a Normalized Ultrasound? J Pediatr Orthop. 2015;35(6):551-5.
19. Ömeroğlu H, Köse N, Akceylan A. Success of Pavlik Harness Treatment Decreases in Patients ≥ 4 Months and in Ultrasonographically Dislocated Hips in Developmental Dysplasia of the Hip. Clin Orthop Relat Res. 2016;474(5):1146-52.