

Diagnosis and Treatment Planning of Developmental Hip Dysplasia: Evaluation of Care Practices of the Members of the Turkish Pediatric Orthopedics Association

Yiğit Kültür¹, Mahmut Kürşat Özşahin², Bedri Karaismailoğlu², Ece Davutluoğlu², Mehmet Fatih Güven², Ali Şeker²

¹Department of Orthopedics and Traumatology, Yeni Yüzyıl University Gaziosmanpaşa Hospital, İstanbul, Turkey

²Department of Orthopedics and Traumatology, Cerrahpaşa Faculty of Medicine, İstanbul, Turkey

What is already known on this topic?

- Developmental dysplasia of the hip is one of the most important causes of childhood disabilities. Although there are accepted treatment algorithms for developmental dysplasia of the hip (DDH), diagnosis and treatment approaches can show variations in the management of DDH among physicians.

What this study adds on this topic?

- In this study, a standardization was tried to be formed based on the opinions of the Association of Turkish Pediatric Orthopedists. There is a selective screening program for DDH in our country. However, according to the results of our survey, members of the Association of Turkish Pediatric Orthopedists recommend universal screening and ultrasonography for every child.

ABSTRACT

Objective: Developmental dysplasia of the hip is one of the most important causes of childhood disabilities. Although there are accepted treatment algorithms for developmental dysplasia of the hip, diagnosis and treatment approaches can show variations in the management among physicians. This study aimed to develop a diagnosis and treatment algorithm for developmental dysplasia of the hip according to the preferences of members of the Turkish Pediatric Orthopedics Association.

Materials and Methods: An interview by telephone call was made with 76 orthopedists (group 1: more experienced 39 physicians, group 2: less experienced 37 physicians) who are members of the Turkish Pediatric Orthopedics Association. Participants were questioned about their demographic information, experiences, diagnostic criteria that they use for developmental dysplasia of the hip, and treatment approaches to patient scenarios of different ages.

Results: Most of the participants recommended universal screening at the age of 4 weeks. It was observed that the most significant physical examination finding was limited hip abduction, and the most frequently used radiographic evaluation on x-ray was acetabular index measurement. The most frequently used description for dysplasia was found as acetabular index $>30^\circ$.

Conclusions: Although there are some differences among orthopedists in the diagnosis, treatment, and follow-up approach of developmental dysplasia of the hip, there was no significant difference according to the experience-based grouping. The treatment algorithm, which was created with the most frequently given answers, was designed, which we think may be beneficial for pediatricians and orthopedists.

Keywords: Developmental hip dysplasia, hip dislocation, hip ultrasonography, pediatric orthopedics

INTRODUCTION

Developmental dysplasia of the hip (DDH) is one of the most important causes of childhood disabilities. Developmental dysplasia of the hip is a condition of shallow and underdeveloped acetabulum. The femoral head can be undercovered, subluxated, or dislocated. If left untreated, arthrosis of the hip joint is inevitable at later ages.^{1,2}

The incidence of DDH in Turkey is between 0.5% and 1.5%,³ and screening program is conducted as a selective screening.⁴ The main purposes of the program are examination of all neonates after birth before discharge, specific examination for hip dislocation of all babies in the neonatal period (3–4 weeks) by family physicians, and in case of any risk factor or

Corresponding author:

Yiğit Kültür

✉ yigitkulturr@hotmail.com

Received: June 30, 2022

Accepted: December 9, 2022

Publication Date: March 1, 2023

Content of this journal is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.



Cite this article as: Kültür Y, Özşahin MK, Karaismailoğlu B, Davutluoğlu E, Güven MF, Şeker A. Diagnosis and treatment planning of developmental hip dysplasia: Evaluation of care practices of the members of the Turkish pediatric orthopedics association. *Turk Arch Pediatr.* 2023;58(2):174–181.

positive physical examination finding, referral to the orthopedic clinics for further evaluation for DDH by hip ultrasonography (USG) in the first 3–6 weeks of life.

Although there are accepted treatment algorithms for DDH, diagnosis and treatment approaches can show variations in the management among physicians. Significant differences can be observed between physicians in diagnosis and treatment.^{5–7} Also there is limited information about current practice. The importance of screening all newborns with physical examination is well known.^{8,9} The main goal in the treatment of DDH is to provide concentric reduction of the hip in the acetabulum against the risk of avascular necrosis or coxarthrosis that may occur during follow-ups. Generally, the Pavlik harness is applied in the first 6 months, and then closed/open reduction and casting or surgery with osteotomy can be applied.^{9,10}

There is no single accepted guideline for the diagnosis and treatment of DDH. For this reason, there are differences in the approaches of physicians. The objective of this study is to reveal the differences and new trends, specify the most commonly used methods in the management of DDH, and eventually provide a standardized diagnosis and treatment algorithm. We think that diagnostic methods, the treatment algorithm, and the literature review will be beneficial for primary practitioners, pediatricians, and orthopedists.

MATERIALS AND METHODS

Hip dysplasia can be treated by all orthopedists and it is included in the core education curriculum of orthopedics. But it is known that so many orthopedists do not prefer to treat these patients and consult them with higher-level health facilities. There is no pediatric orthopedics subspecialty in Turkey. It is very difficult to get reliable information related to DDH from all orthopedists; therefore, we collaborated with members of the pediatric orthopedic society to make the study group more homogeneous.

An interview by telephone call and e-mail was made with 135 orthopedists who are members of the Turkish Pediatric Orthopedics Association between January 2020 and May 2020. Seventy-six members of the association agreed to participate in the survey.

Groups

The participants in the study were divided into 2 groups according to the duration of their experience in pediatric orthopedics. Those with more than 10 years of experience in pediatric orthopedics were grouped as group 1 (39 physicians), and those with less than 10 years of experience were grouped as group 2 (37 physicians).

Questionnaire

The questionnaire consisted of demographic information, diagnosis, and treatment options. In demographic information, it was learned in which hospitals the physicians work (academic, state, private clinic), how many years they have been involved in pediatric orthopedics, the percentage of DDH cases of participants, the number of patients with DDH follow/treat in 1 year. Survey questions about the diagnosis were screening methods (universal vs. selective), the most preferred screening type (physical examination, radiology,

physical examination+radiology), the most preferred radiological screening method, the most preferred physical examination test, when the USG scanning should be done, when the second evaluation in type 2a hips should be applied, when direct radiography is recommended to be used, the most preferred radiographic parameters and radiographic position preferences. Questions about treatment were recommendations for dysplasia and dislocations in 6-week-old, 6-month-old, 9-month-old, 12-month-old, 15-month-old, and 18-month-old children, whether they could expect remodeling in dysplasia cases, the preferred osteotomy types, and whether arthrography was used. Participants could give more than 1 answer to questions.

Ethical Statement

Ethics Committee approval was obtained from İstanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty Ethical Council with the number 20.11.2019-177968.

Statistical Analysis

Statistical Package for the Social Sciences 15.0 program (SPSS Inc.; Chicago, IL, USA) was used for statistical analysis. While evaluating the study data, chi-square analysis was used to determine the relationship between qualitative data as well as descriptive statistical methods (frequency, ratio). Fisher exact test was used in some of the evaluations. Significance was evaluated at $P < .01$ and $P < .05$ levels.

RESULTS

Fifty-six percent ($n = 76$) of the participants agreed to be included in the study. Sixty-seven percent of the participants were practicing in academic hospitals, and 23% were working in state hospitals and private clinics. The average duration of pediatric orthopedic practice was 15.15 (range: 3–44, $SD \pm 10.49$) years. Their experiences in DDH are shown in Table 1. Screening, diagnosis, and treatment preferences are listed later.

Screening

All participants stated that screening for DDH is required. The universal screening method was preferred most frequently (72%), followed by selective screening (28%). It was emphasized

Table 1. Participants Experiences with Developmental Hip Dysplasia

	Group 1	Group 2	Total
A			
0%–25%	27 (45%)	33 (55%)	60
25%–50%	8 (80%)	2 (20%)	10
50%–75%	2 (100%)	0 (0%)	2
75%–100%	1 (100%)	0 (0%)	1
Total	38 (52.1%)	35 (47.9%)	73
B			
<50	9 (52.9%)	8 (47.1%)	17
50–100	7 (70%)	3 (30%)	10
>100	2 (40%)	3 (60%)	5
Total	18 (56.3%)	14 (43.7%)	32

A, The percentage of DDH cases of participants among total pediatric patients;

B, The number of patients with DDH follow/treat in last year;

DDH, developmental dysplasia of the hip.

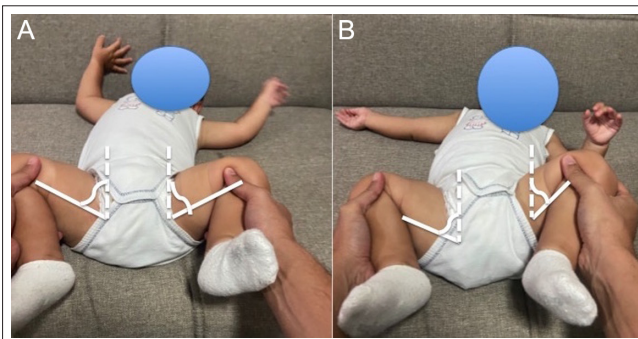


Figure 1. Examination of hip abduction. (A) The hips have to be abducted symmetrically. (B) The angles lesser than 70° and asymmetric hip abductions are suspicious for developmental dysplasia of the hip.

that as a screening method, radiological imaging, and physical examination should be performed together (88%). The most preferred radiological imaging method for screening was USG alone (72%), while the use of USG and x-ray together was preferred less frequently (23%). No statistically significant difference was detected between the groups ($P > .05$)

Physical Examination

The most preferred physical examination method was the hip abduction test (37.3%) (Figure 1). The percentages of other tests were as follows: Ortolani test (27.6%), Barlow test (11.2%), assessing the leg length discrepancy (8.2%), Galeazzi sign (5.2%), and asymmetric skin fold (3.7%).

Ultrasonography

When the participants were asked about the most appropriate time of screening with USG, the percentages were as follows: at the fourth week of life (45.8%), at the sixth week (18.1%), at the third week (12.5%), and at the first week (11.1%). The most frequently given answer for the latest age that USG can be used effectively was the sixth month of age (64.7%). The answers to the question about the time when should re-evaluation has to be done in the patient who has type 2a hip were as follows: at the third month (37%), 4 weeks later (33%), and 3 weeks later (29%) (Table 2).

Radiography

The most frequently given answer for the time to start using direct radiographs for evaluation was at the sixth month (58%), while only 20% chose the fifth month. The acetabular index was the most frequently used parameter in radiographic measurements (31.8%), followed by Shenton–Menard's line (21%), Perkins line (11.7%), ossified nucleus (8.9%), medial joint distance (7%), Hilgenreiner's line (6.1%), and center edge angle (6.1%). The preferred radiography positions were anteroposterior (66.1%), frog leg (19.3%), and Von Rosen (11.9%) (Figure 2 and Table 3).

Treatment

The majority of participants in both groups reported that 6-week dysplasia and dislocation cases should be treated with a Pavlik harness. In addition, most of the participants recommended non-surgical treatment methods for up to 18 months in isolated dysplasia cases. In cases of dislocation, casting with open or closed reduction is recommended for the period from 6 weeks to 18 months. In cases of dislocation after 18 months,

it was observed that osteotomy was added to the casting performed together with the open or closed reduction.

Some physicians prefer to give a chance for remodeling and wait for any surgical intervention until a certain age in dysplasia cases. Ninety percent of the participants agreed with that approach. It was observed that the participants preferred pelvic osteotomy (66%) more frequently than femoral osteotomy (31%). Among the pelvic osteotomies, it was found that Salter (57%), Dega (22%), and Pemberton (18%) osteotomies were performed. It was seen that the most commonly used femoral osteotomy was shortening+derotation (29%), while the second was shortening+derotation+varus osteotomy (25%).

It was seen that 80% of the participants prefer to use arthrography for evaluation of the hip during reduction. Also, it was observed that participants in group 2 use arthrography more commonly compared to group 1 ($P = .005$). The approach to the scenario of a patient with normal USG findings at the age of 6 weeks but dysplasia findings on a radiograph at 6 months of age was asked to the participants. Eighty-eight percent prefer to determine the treatment according to the current radiograph.

An alternative treatment algorithm was created by summarizing the recommended diagnostic and treatment methods in cases of dysplasia and dislocation (Figure 3).

DISCUSSION

Ensuring standardization in the diagnosis and treatment of DDH is important in providing appropriate treatment and reducing differences in patient care. Although there are accepted diagnosis and treatment methods for DDH, standardization has not been achieved worldwide.^{8,11} Roposch et al⁶ found that poor consistency among surgeons was found in rating the 37 different DDH diagnostic criteria. There is also no international consensus on the surgical treatment of DDH. Feeley et al⁷ recommended the establishment of an international working group with large-scale studies in the treatment of DDH and the development of an international guideline on this subject.

Early diagnosis and treatment are very important in DDH. For this reason, the importance of screening programs is well known. Clinical examination in DDH screening is valuable in evaluating functional and structural abnormalities but may be insufficient in evaluating stable hips.¹² For this reason, delayed admissions are present in clinical screening programs.^{13,14} Tönnis¹⁵ suggested that screening by physical examination would not be sufficient and that all newborns should be screened with USG. Although there is selective screening for DDH in our country, most of the Turkish Pediatric Orthopedics Association members recommend universal screening according to our study.

Universal DDH screening in the fourth week was recommended by most of the participants in this study. It is recommended to use both physical examination and USG for screening. It is reported in the literature that late admission to physicians with universal screening programs is almost zero.¹² In universal screening, the rate of first surgery due to DDH was found to be significantly lower than in selective screening.^{12,16} The

Table 2. Parameters Related to Screening, Physical Examination, and USG

	Group 1	Group 2	Total	P
Screening method				
Universal	24 (46.2%)	28 (53.8%)	52 (100%)	.152 ^a
Selective	13 (65%)	7 (35%)	20 (100%)	$\chi^2 = 2054$
Total	37 (51.4%)	37 (51.4%)	72 (100%)	
The most preferred screening method				
Physical exam+radiology	32 (50%)	32 (50%)	64 (100%)	
Physical exam	3 (75%)	1 (25%)	4 (100%)	.623 ^b
Radiology	2 (50%)	2 (50%)	4 (100%)	$\chi^2 = .945$
Total	37 (51.4%)	35 (48.6%)	72 (100%)	
The most preferred radiological screening method				
USG	26 (50%)	26 (50%)	52 (100%)	.668 ^b
X-ray	1 (33.3%)	2 (66.7%)	3 (100%)	$\chi^2 = .808$
USG+x-ray	10 (58.8%)	7 (41.2%)	17 (100%)	
Total	37 (51.4%)	35 (48.6%)	72 (100%)	
The most preferred physical examination test				
Ortolani test	18	19	37	.173 ^b
Barlow test	0	15	15	$\chi^2 = 11.534$
Hip abduction test	23	27	50	
Leg length discrepancy	5	6	11	
Limp	2	4	6	
Asymmetric skin fold	1	4	5	
Galeazzi test	2	5	7	
Allis test	1	0	1	
Klisc test	0	1	1	
Total	52	82	134	
When the USG screening should be done (week)?				
Week				
1	3 (37.5%)	5 (62.5%)	8 (100%)	.393 ^b
2	1 (100%)	0 (0%)	1 (100%)	$\chi^2 = 7357$
3	6 (66.7%)	3 (33.3%)	9 (100%)	
4	17 (51.5%)	16 (48.5%)	33 (100%)	
5	1 (100%)	0 (0%)	1 (100%)	
6	6 (46.2%)	7 (53.8%)	13 (100%)	
8	1 (20%)	4 (80%)	5 (100%)	
12	2 (100%)	0 (0%)	2 (100%)	
Total	37 (51.4%)	35 (48.6%)	72 (100%)	
When the second evaluation in type 2a hips should be applied?				
Week				
4 weeks	13 (61.9%)	8 (38.1%)	21 (100%)	.406 ^a
3 weeks	8 (44.4%)	10 (55.6%)	18 (100%)	$\chi^2 = 1804$
3 months (12 weeks)	10 (43.5%)	13 (56.5%)	23 (100%)	
Total	31 (50%)	31 (50%)	62 (100%)	

^aPearson chi-square test.

USG, ultrasonography.

optimum time for anUSG screening has not been clarified. Although there are some suggestions that it should be done on the 28th day, there are also opinions stating that it should be done on the 8th week.^{17,18} In a study, the 22nd day was found as the threshold value and it was said that screening should be performed on the 22nd day or later.¹⁹ There are many studies in the literature stating that physical examination alone is not sufficient and screening with USG is necessary.²⁰⁻²²

In this study, the most significant physical examination finding was the hip abduction and the Ortolani tests, respectively. In

many studies, it has been stated that the unilateral hip abduction test has the highest sensitivity and specificity, and it is the most important indicator of hip pathology, especially in restrictions above 20°. ²³⁻²⁵ Ortolani and Barlow are tests with high specificity but low sensitivity in the hands of inexperienced physicians, thus making them inadequate to be used as a screening test.²¹⁻²³ Conversely, in another recent study, members of the British Society of Children's Orthopedic Surgery reported that they use the Ortolani and Barlow tests more than the hip abduction test.¹¹ In our study, asymmetric skin fold was one of the least preferred methods of diagnosis by physical examination. In the

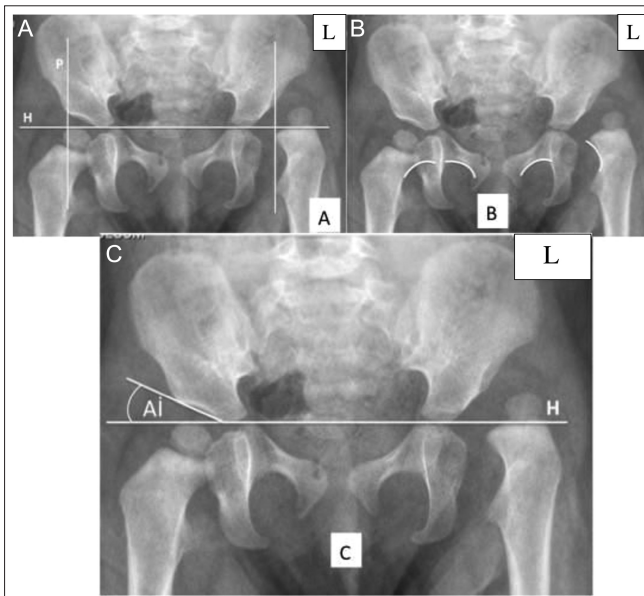


Figure 2. Radiological parameters used in the evaluation of developmental dysplasia of the hip. L, left. (A) Pelvis anteroposterior view (AP)x-ray. H, Hilgenreiner line; P, Perkins line. The femoral head has to be in the lower medial quadrant. On the x-ray, the left femoral head is dislocated. (B) Pelvis AP x-ray. The Shenton-Menard line is intact on the right side (normal hip) but broken on the left (dislocated hip). (C) Pelvis AP x-ray. AI, acetabular index; H, Hilgenreiner line.

study of Kang et al.²⁶ the only finding was asymmetric skin fold in 78.4% of the babies who were referred from another center with the suspicion of DDH, and DDH was not detected in any of them. The clinical value of the asymmetric skin fold in the diagnosis of DDH is low and it is not recommended to be used alone.

Spontaneous normalization of type 2A hips is common in the literature, but worsening can be seen in 5%-10% of them. Female sex and an alpha value lower than 55° were found to be risk factors for worsening.^{27,28} Although there are studies suggesting that a control USG examination 1 month later after detection of type 2a hip in the first USG examination, there are also studies suggesting a control USG examination to be performed in the third month.^{18,27,29} In our study, most of the participants recommended that the control USG should be performed in the third month (12th week) of life in type 2a hips,

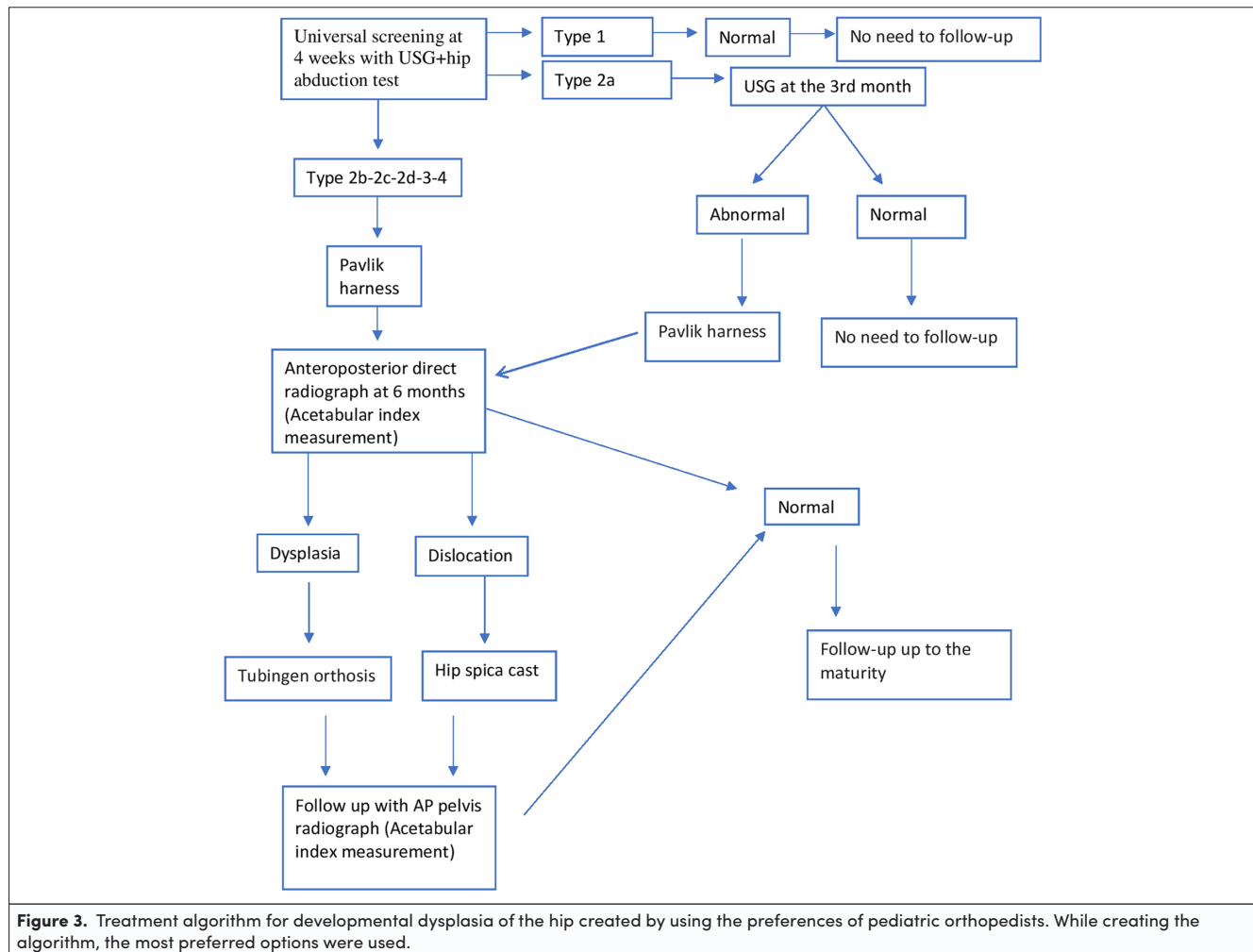
In this study, it was observed that USG was used most frequently until the sixth month, and direct radiography was used most frequently after the sixth month. Acetabular index and Shenton-Menard line were the most frequently used parameters evaluated in radiographs. Although radiographic evaluation is recommended after 4-6 months, there are studies reporting that USG can be used for up to 7 months.³⁰ Acetabular index is the most commonly used parameter in developmental hip dysplasia. A recent study suggested that the acetabular index is the most effective indicator in predicting residual

Table 3. Radiography-Related Parameters

Month	Group 1	Group 2	Total	P
When the direct radiography screening should be done (month)				
2	2 (100%)	0 (0%)	2 (100%)	.436 ^b
3	3 (75%)	1 (25%)	4 (100%)	$\chi^2 = 5884$
4	4 (66.7%)	2 (33.3%)	6 (100%)	
5	7 (50%)	7 (50%)	14 (100%)	
6	18 (46.2%)	21 (53.8%)	39 (100%)	
7	0 (0%)	1 (100%)	1 (100%)	
8	0 (0%)	1 (100%)	1 (100%)	
Total	34 (50.7%)	33 (49.3%)	67 (100%)	
The most preferred radiographic view (multiple views can be chosen)				
Anterior-posterior	37	35	72	.263 ^b
Frog leg	7	14	21	
Von Rosen	7	6	13	
Lateral	1	0	1	
False profile	0	2	2	
Total	52	57	109	
The most preferred radiographic parameters (multiple parameters can be chosen)				
Perkins line	13	12	25	.782 ^b
Hilgenreiner' line	6	7	13	
Acetabular index	33	35	68	
Ossified nucleus	9	10	19	
Shenton-Menard line	23	22	45	
Courcil	2	4	6	
Medial joint space	7	8	15	
Center edge angle	8	5	13	
Sharp angle	1	1	2	
Tear drop	1	3	4	
Collo-diaphysial angle	0	4	4	
Total	103	111	214	

^aPearson chi-square test.

^bFisher exact.



dysplasia after closed reduction.³¹ However, there is no consensus on the acetabular index upper limit.³² In our study, greater than 30° after the age of 1 was the most common answer for acetabular index upper limit.

In acetabular dysplasia, the femoral head is inside the acetabulum, but the acetabulum does not cover the femoral head. In the case of dislocation, the relationship between the femoral head and the acetabulum is impaired. In dysplastic hips, loading is greater at the acetabulum margin. With the osteotomy procedures to be performed, this load can be reduced by improving the moment arm and increasing the acetabulum contact area. The most preferred osteotomy type was pelvic osteotomy. Salter osteotomy was the most preferred among pelvic osteotomies. However, in some studies, Dega osteotomy was preferred over Salter osteotomy according to better acetabular improvement and the lack of secondary surgery necessity.^{33,34}

When the scenario of a patient with normal USG findings at 6 weeks of age and dysplasia findings of same patient radiographs at 6 months of age was asked to our participants, it was reported that treatment should be given according to the current x-ray. In some recent studies, it has been stated that even if the USG performed at 6 weeks of age is normal in breech

presentation babies, x-rays performed after 4-6 months may show dysplasia requiring treatment. In the light of this information, even if USG is normalized during follow-ups, radiography control is recommended at the sixth month in dysplastic hips. Follow-up of these patients up to the skeletal maturity would be beneficial^{35,36} (Figure 3).

Arthrography is a reliable method used in the decision of the surgeon to switch to open surgery in closed reduction of developmental hip treatment.³⁷ It was observed that the use of arthrography was higher for more experienced surgeons in this study ($P = .005$). In a study, it was observed that the risk of avascular necrosis was significantly higher when arthrography was not used.³⁸ There was no difference between groups in parameters other than these, and an alternative algorithm was created with this information.

Percentage of participants is one of the limitations of our study. The response rate of 56% may increase potential bias. Participants in the study were divided into 2 groups according to their experience in pediatric orthopedics. However, grouping according to the experience year in practice (i.e., more/less than 10 years) may not reflect the experience in DDH completely because the experienced surgeons may not be working in a high-volume center for DDH. Technically there is no

subspecialty for pediatric orthopedics in Turkey. Hip dysplasia can be treated by all orthopedists and its management is included in the core education curriculum of Orthopedics and Traumatology in our country. We chose members of the Turkish Pediatric Orthopedics Association in order to select orthopedists who were supposed to deal with pediatric orthopedics more. We do not have objective criteria for the evaluation of experience in DDH. We accept that not all members were masters, but it can be easily said that the participants had interest and experience in the management of hip dysplasia.

CONCLUSIONS

Universal screening is the most preferred method, and it is recommended to be performed with USG in the fourth week. In type 2a patients, USG control is preferred in the third month. The most favored radiographic method is an anteroposterior x-ray, which is recommended to be performed in the sixth month. The acetabular index is the most preferred radiographic measurement parameter.

Although there are some differences among physicians in the diagnosis, treatment, and follow-up approach to DDH, there was no significant difference according to the level of experience. For this reason, it can be considered that standardization has been achieved in the treatment of DDH.

Ethics Committee Approval: Ethics Committee approval was obtained from İstanbul University-Cerrahpaşa, Cerrahpaşa Medical Faculty Ethical Council with the number 20.11.2019-177968.

Informed Consent: N/A.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – Y.K., A.Ş.; Design – Y.K., A.Ş.; Supervision – Y.K., A.Ş., M.F.G., M.K.Ö., B.K.; Funding – Y.K., A.Ş.; Materials – Y.K., A.Ş., M.F.G., M.K.Ö., B.K., E.D.; Data Collection and/or Processing – Y.K., A.Ş., E.D.; Analysis and/or Interpretation – Y.K., A.Ş., M.F.G., M.K.Ö., B.K., E.D.; Literature Review – Y.K., A.Ş., M.F.G., B.K., E.D.; Writing – Y.K., A.Ş., M.F.G., B.K., E.D.; Critical Review – Y.K., A.Ş., M.F.G., M.K.Ö., B.K.

Declaration of Interests: The authors declare that they have no competing interest.

Funding: This study received no funding.

This study was presented at the 30th National Turkish Orthopedics and Traumatology Congress as an oral presentation.

REFERENCES

1. Akman A, Korkmaz A, Aksoy MC, Yazici M, Yurdakök M, Tekinalp G. Evaluation of risk factors in developmental dysplasia of the hip: results of infantile hip ultrasonography. *Turk J Pediatr*. 2007;49(3):290-294.
2. Çekiç B, Erdem-Toslak İ, Sertkaya Ö, et al. Incidence and follow-up outcomes of developmental hip dysplasia of newborns in the western Mediterranean region. *Turk J Pediatr*. 2015;57(4):353-358.
3. Tümer Y, Ömeroğlu H. Prevention of developmental hip dysplasia in Turkey. *Acta Orthop Traumatol Turc*. 1997;1:176-181.
4. Kural B, Devecioğlu Karapinar E, Yilmazbaş P, Eren T, Gökçay G. Risk factor assessment and a ten-year experience of DDH screening in a well-child population. *BioMed Res Int*. 2019;2019:7213681. [CrossRef]
5. Roposch A, Wright JG. Increased diagnostics information and understanding disease: uncertainty in the diagnosis of developmental hip dysplasia. *Radiology*. 2007;242(2):355-359. [CrossRef]
6. Roposch A, Liu LQ, Protapapa E. Variations in the use of diagnostic criteria for developmental dysplasia of the hip. *Clin Orthop Relat Res*. 2013;471(6):1946-1954. [CrossRef]
7. Feeley IH, Green CJ, Rowan FE, Moore DP. International variance in the treatment of developmental dysplasia of the hip. *J Child Orthop*. 2014;8(5):381-386. [CrossRef]
8. Al-Essa RS, Aljahdali FH, Alkhilaiwi RM, Philip W, Jawadi AH, Khoshhal KI. Diagnosis and treatment of developmental dysplasia of the hip: a current practice of paediatric orthopaedic surgeons. *J Orthop Surg (Hong Kong)*. 2017;25(2):2309499017717197. [CrossRef]
9. Terjesen T. Residual hip dysplasia as a risk factor for osteoarthritis in 45 years follow-up of late-detected hip dislocation. *J Child Orthop*. 2011;5(6):425-431. [CrossRef]
10. Jamal B, Pillai A. Developmental dysplasia of the hip. *Dysplasia Causes Types Treat Options*. 2012;2:35-48. [CrossRef]
11. Williams D, Protapapa E, Stohr K, Hunter JB, Roposch A. The most relevant diagnostic criteria for developmental dysplasia of the hip: a study of British specialists. *BMC Musculoskelet Disord*. 2016;17(1):38. [CrossRef]
12. Biedermann R, Eastwood DM. Universal or selective ultrasound screening for developmental dysplasia of the hip? A discussion of the key issues. *J Child Orthop*. 2018;12(4):296-301. [CrossRef]
13. Holen KJ, Tegnander A, Bredland T, et al. Universal or selective screening of the neonatal hip using ultrasound? *Journal of Bone and Joint Surgery*. 2002;84(6):886-890. [CrossRef]
14. Krikler SJ, Dwyer NSP. Comparison of results of two approaches to hip screening in infants. *J Bone Joint Surg Br*. 1992;74(5):701-703. [CrossRef]
15. Tönnis D, Storch K, Ulbrich H. Results of newborn screening for CDH with and without sonography and correlation of risk factors. *J Pediatr Orthop*. 1990;10(2):145-152. [CrossRef]
16. Mahan ST, Katz JN, Kim YJ. To screen or not to screen? A decision analysis of the utility of screening for developmental dysplasia of the hip. *J Bone Joint Surg Am*. 2009;91(7):1705-1719. [CrossRef]
17. Gokharman FD, Aydin S, Fatihoglu E, Ergun E, Kosar PN. Optimizing the time for developmental dysplasia of the hip screening: earlier or later? *Ultrasound Q*. 2019;35(2):130-135. [CrossRef]
18. Lussier EC, Sun YT, Chen HW, Chang TY, Chang CH. Ultrasound screening for developmental dysplasia of the hip after 4 weeks increases exam accuracy and decreases follow-up visits. *Pediatr Neonatol*. 2019;60(3):270-277. [CrossRef]
19. Tan SHS, Wong KL, Lim AKS, Hui JH. The earliest timing of ultrasound in screening for developmental dysplasia of the hips. *Ultrasonography*. 2019;38(4):321-326. [CrossRef]
20. Rosenberg N, Bialik V, Norman D, Blazer S. The importance of combined clinical and sonographic examination of instability of the neonatal hip. *Int Orthop*. 1998;22(3):185-188. [CrossRef]
21. Ömeroğlu H, Koparal S. The role of clinical examination and risk factors in the diagnosis of developmental dysplasia of the hip: a prospective study in 188 referred young infants. *Arch Orthop Trauma Surg*. 2001;121(1-2):7-11. [CrossRef]
22. Dogruel H, Atalar H, Yavuz OY, Sayli U. Clinical examination versus ultrasonography in detecting developmental dysplasia of the hip. *Int Orthop*. 2008;32(3):415-419. [CrossRef]
23. Şenaran H, Özdemir HM, Ögün TC, Kapıcıoğlu MIS. Value of limited hip abduction in developmental dysplasia of the hip. *Pediatr Int*. 2004;46(4):456-458. [CrossRef]
24. Terjesen T, Holen KJ, Tegnander A. Hip abnormalities detected by ultrasound in clinically normal newborn infants. *J Bone Joint Surg Br*. 1996;78(4):636-640. [CrossRef]
25. Jari S, Paton RW, Srinivasan MS. Unilateral limitation of abduction of the hip. A valuable clinical sign for DDH? *J Bone Joint Surg Br*. 2002;84(1):104-107. [CrossRef]

26. Kang MS, Han GW, Kam M, Park SS. Clinical significance of asymmetric skin folds in the medial thigh for the infantile screening of developmental dysplasia of the hip. *Pediatr Neonatol*. 2019;60(5):570-576. [\[CrossRef\]](#)
27. Bilgili F, Sağlam Y, Göksan SB, Hürmeşdan ÖM, Birişik F, Demirel M. Treatment of Graf type IIa hip dysplasia: a cut-off value for decision making. *Balk Med J*. 2018;35(6):427-430. [\[CrossRef\]](#)
28. Ömeroğlu H, Çaylak R, Inan U, Köse N. Ultrasonographic Graf type IIa hip needs more consideration in newborn girls. *J Child Orthop*. 2013;7(2):95-98. [\[CrossRef\]](#)
29. Kosar P, Ergun E, Gökharman FD, Turgut AT, Kosar U. Follow-up sonographic results for Graf type 2a hips: association with risk factors for developmental dysplasia of the hip and instability. *J Ultrasound Med*. 2011;30(5):677-683. [\[CrossRef\]](#)
30. Kitay A, Widmann RF, Doyle SM, Do HT, Green DW. Ultrasound is an alternative to X-ray for diagnosing developmental dysplasia of the hips in 6-month-old children. *HSS J*. 2019;15(2):153-158. [\[CrossRef\]](#)
31. Li YQ, Guo YM, Li M, et al. Acetabular index is the best predictor of late residual acetabular dysplasia after closed reduction in developmental dysplasia of the hip. *Int Orthop*. 2018;42(3):631-640. [\[CrossRef\]](#)
32. Ömeroğlu H, Ağuş H, Biçimoğlu A, Tümer Y. Evaluation of experienced surgeons' decisions regarding the need for secondary surgery in developmental dysplasia of the hip. *J Pediatr Orthop*. 2012;32(1):58-63. [\[CrossRef\]](#)
33. López-Carreno E, Carillo H, Gutiérrez M. Dega versus Salter osteotomy for the treatment of developmental dysplasia of the hip. *J Pediatr Orthop B*. 2008;17(5):213-221. [\[CrossRef\]](#)
34. El-Sayed M, Ahmed T, Fathy S, Zyton H. The effect of Dega acetabuloplasty and Salter innominate osteotomy on acetabular remodeling monitored by the acetabular index in walking DDH patients between 2 and 6 years of age: short- to middle-term follow-up. *J Child Orthop*. 2012;6(6):471-477. [\[CrossRef\]](#)
35. 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):551-555. [\[CrossRef\]](#)
36. Imrie M, Scott V, Stearns P, Bastrom T, Mubarak SJ. Is ultrasound screening for DDH in babies born breech sufficient? *J Child Orthop*. 2010;4(1):3-8. [\[CrossRef\]](#)
37. Ahmed AA, FadelMED. Role of intraoperative arthrogram in decision making of closed versus medial open reduction of developmental hip dysplasia. *Int J Res Orthop*. 2019;5(6):1037. [\[CrossRef\]](#)
38. Khoshhal KI, Kremli MK, Zamzam MM, Akod OM, Elofi OA. The role of arthrography-guided closed reduction in minimizing the incidence of avascular necrosis in developmental dysplasia of the hip. *J Pediatr Orthop B*. 2005;14(4):256-261. [\[CrossRef\]](#)