RESEARCH ARTICLE

Assessment of Diagnostic Value of Single View Static & Dynamic Technique in Diagnosis of Developmental Dysplasia of Hip: A Comparison with Static and Dynamic Ultrasond Techniques

Seyed Ali Alamdaran, MD; Sahar Kazemi, MD; Ali Parsa, MD; Mohammad Hallaj Moghadam, MD; Ali Feyzi, MD; Reza Mardani, MD

Research performed at Dr. Sheikh Children Hospital, Mashhad, Iran

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Abstract

Background: Developmental dysplasia of hip (DDH) is a common childhood disorder, and ultrasonography examination is routinely used for screening purposes. In this study, we aimed to evaluate a modified combined static and dynamic ultrasound technique for the detection of DDH and to compare with the results of static and dynamic ultrasound techniques.

Methods: In this cross-sectional study, during 2013- 2015, 300 high-risk infants were evaluated by ultrasound for DDH. Both hips were examined with three techniques: static, dynamic and single view static and dynamic technique. Statistical analysis was performed using SPSS version 11.5.

Results: Patients aged 9 days to 83 weeks. 75% of the patients were 1 to 3 months old. Among 600 hip joints, about 5% were immature in static sonography and almost all of them were unstable in dynamic techniques. 0.3% of morphologically normal hips were unstable in dynamic sonography and 9% of unstable hips had normal morphology. The mean β angle differences in coronal view before and after stress maneuver was 14.43±5.47° in unstable hips. Single view static and dynamic technique revealed that all cases with acetabular dysplasia, instability and dislocation, except two dislocations, were detected by dynamic transverse view. For two cases, Ortolani maneuver showed femoral head reversibility in dislocated hips. Using single view static and dynamic technique was indicative and applicable for detection of more than 99% of cases.

Conclusion: Single view static and dynamic technique not only is a fast and easy technique, but also it is of high diagnostic value in assessment of DDH.

Keywords: α and β angles Graf method, Bone Diseases, Developmental Ultrasonography, Hip Dislocation

Introduction

The Developmental dysplasia of the hip (DDH) is one of the most prevalent musculoskeletal disorders in childhood with incidence of 0.1 - 2 cases in every 1000 births. DDH is referred to a wide range of disorders including hip immaturity, slight and full dysplasia of acetabulum , and luxation (dislocation) of hip (1). The wide range of disorders beside racial differences has been led to diversity in diagnostic methods and screening strategies.

Although clinical examination is trustworthy and sensitive by a deft examiner in finding the hip instability, it can lead to over-treatment or lack of treatment for some DDH cases. In many studies, it has been reported that the role of ultrasound screening is more efficient than clinical examination, especially for treatment planning and management (2, 3).

Following sonography's inclusion into DDH screening field in the late 20 years, two different diagnostic approaches were formed: static method, mostly based on acetabulum

Corresponding Author: Ali Feyzi, Department of Radiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran
Email: FeyziLA@mums.ac.ir

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morphology analysis, and dynamic method for analyzing the joint stability (4). Several studies have compared efficiency of these methods in the diagnosis of DDH which their results are controversial in some cases (1).

Static technique of hip ultrasound assesses the shape and evolution of acetabulum and also measures α and β angle. This is a mid-acetabular coronal view, which seems to be easier and faster to learn and to perform; but it may miss cases with joint instability. Dynamic technique which is more complex and time consuming, can truly analyze joint stability. Ortolani, Barlow or Pull and Push maneuvers are among dynamic techniques (5). Complexity of the latter technique, especially performed by not very skillful examiner is a general problem.

In this study, we used a combination of static Graf technique and dynamic technique in a more usual coronal/flexion view. We assessed the diagnostic value of single view static and dynamic technique compared to static and dynamic methods in the diagnosis of developmental dysplasia of hip.

Materials and Methods

This descriptive cross-sectional study was performed at Dr. Sheikh Children Hospital during 2011-2015 after being approved by the Institutional Review Board of Mashhad University of Medical Sciences, Iran. In this study, 300 infants (600 hips) with hip ultrasound indications, referred to the radiology department, were evaluated and entered to the study after obtaining consent from their parents. Hip ultrasound indications were as follows: abnormal or equivocal findings on physical or imaging examination of the hip, any family history of DDH, breech presentation on delivery, oligohydramniosis, and neuromuscular conditions especially in foot. Exclusion criteria of the study were age over 2 years and recognized DDH.

An expert pediatric radiologist performed ultrasonographic examinations. Gray-scale ultrasonography was performed using sonographic devices (Myla 50, Esaote, Italy and 7.5-12 MHz linear probes).

Following terms were used to define conditions in this study: 1) Luxation: abnormal movement within acetabulum with stress; 2) Subluxation: head positioned laterally, while it was in contact with the acetabular cavity and partly covered by acetabulum; 3) Subluxable: head displace laterally with stress, but contact the acetabulum or partially covered; 4) Dislocated: head has no contact or coverage by the acetabulum; 5) Dislocatable: head pushed out of the joint with stress; 6) Stability: motion of femoral head by stress (laxation, subluxate and subluxable); 7) Irreversible: dislocated hip which cannot be reduced; 8) Pull and Push maneuvers: Ortolani-like maneuver (knee pulling in flexed foot abduction) and Barlow-like maneuver (with kid's flexed foot adduction and slight pressure to back); 9) Acetabular Dysplasia: hips were stratified into four classes based on α degree and shape of acetabulum based on summarized Graf classification (normal: $\alpha > 60$, immature: $50 \leq \alpha < 60$, slight dysplasia: $43 \leq \alpha < 50$, severe dysplasia: $\alpha < 43$ (10) . Single view static and dynamic technique: ultrasound hip examination in coronal/flexion view with and without stress (1).

Both hips were scanned with three techniques including static technique, single view static and dynamic technique, and dynamic (multi-view) technique.

Static Technique

Both hips were scanned in the supine or some semi-oblique position in coronal neutral (extension) view (standard Graf technique) and obtained data were evaluated and documented for the following characters: femoral head position (normal, subluxate and dislocate), the relative shape of the acetabular bony roof (sharp-rounded), femoral head coverage (percentage of the femoral head inside the acetabulum), labrum echogenicity and its shape. In objective assessment of acetabular morphology based on α angle, patients were categorized in four groups (modified Graf classification).

Single view static and dynamic technique:

Hips were scanned in the supine or semi-oblique position in coronal/flexion view with and without Pull and Push stress (we named it "Single view static and dynamic technique"). In this coronal/flexion view (without stress), following observations were evaluated and documented including femoral head position, relative shape of the acetabulum top, femoral head, labrum shape and measurements of acetabular and labral angles (α and β angles).

Then in the same view, flexion and brief adduction were exerted to hip joint by doing the stimulating maneuver of Pull and Push (Ortolani and Barlow-like maneuver) trying to move the femoral head from the acetabulum cup. Femoral head position (normal, subluxate and dislocate) was checked during maneuver execution and the examiner classified the hips subjectively into three groups of stable, unstable (subluxate and subluxable) and dislocate or dislocatable based on the changes in β angle and the femoral head displacement rate. In unstable and dislocated joints, the reversibility of femoral head movement into the cup was also analyzed using pulling maneuver.

Dynamic technique

All hip joints were examined by dynamic technique in other views (coronal flexion view in posterior lip plan, transverse/flexion view and transverse/neutral view). Also, in unstable and dislocated joints, the reversibility femoral head movement into the cup was analyzed using other maneuvers (Ortolani and Barlow). This technique and results of patients follow up were considered as the gold standard.

During examination, cine loops from hip dynamic analyses were recorded to determine maximum changes in β angle. Stimulating maneuver was repeated to record the best examination. In addition, results from hip subjective examinations were recorded in the checklist.

Therapeutic approach was adopted based on clinical examinations and subjective sonography results. At first visit, all examinations were done for all kids. In suspected cases with normal hips but unstable morphology or with type 2a hips of Graf (lack of physiologic maturity), sonographic examinations were repeated with one-month

Table 1. Distribution of modified Graf classification and instability and dislocatiblity with three Static technique, Dynamic technique and Single view static and dynamic technique in our patient (N (P): number (percent)

Modified Graf Classification	Static technique		Dynamic technique			Single view static and dynamic technique		
	α angle	N (P)	Stable N (P)	Unstable N (P)	Dislocatable N (P)	Stable N (P)	Unstable N (P)	Dislocatable N (P)
Normal (Group A)	>60	538 (90)	534 (99)	3 (1)	0	534 (99)	3 (1)	0
Immature (Group B)	50-59	30 (5)	7 (23)	19 (64)	4 (13)	9 (30)	17 (57)	4 (13)
Mild dysplastic (Group C)	43-49	20 (3)	1 (5)	10 (50)	9 (45)	1 (5)	12 (60)	7 (35)
Sever dysplastic (Group D)	<43	12 (2)	0	1 (8)	11 (92)	0	1 (8)	11 (92)
Total		600	542	34	24	544	34	22

intervals.

Data were matched to the relevant checklists and classified for statistical analyses. Statistical analyses were performed using SPSS 11.5. The statistical significance level was considered as 0.05.

Results

Among 300 infants (600 hips) enrolled in our study, 155 were females and 145 were males. Minimum of age was 9 days with a maximum of 83 weeks. 35 infants (11% of patients) were less than 4 weeks old, 223 (74% of patients) had 1 to 3 months age and 32 (15% of patients) were more than 3 months old.

The first three columns of Table 1 show the distribution of modified Graf classification among our patients. There was no significant difference in α and β angles between coronal/neutral view and non-stress coronal/flexion view. The second three columns of Table 1 show statistical analysis of the results from coronal/flexion view with Pull and Push stress and dynamic technique in patients classified with modified Graf classification. A significant statistical difference was observed between the mean of changes in β angle in non-stress coronal/flexion view and stress coronal/flexion view ($P = 0.004$). In dynamic sonography, 0.3% of normal hip morphology was unstable and 9% of unstable hips had normal morphology. About 5% of hips were immature in static sonography which most of them were unstable in dynamic techniques. Almost all the patients with dysplastic hip had unstable hip in dynamic techniques.

Single view static & dynamic technique revealed acetabular dysplasia, instability and dislocation in all patients except in two dislocatable cases that were diagnosed in dynamic transverse view (conversion normal U shape acetabulum to abnormal V shape acetabulum with stress). Pull and Push maneuver was enough for stability assessment in all patients except in two patients that Ortolani maneuver showed femoral head movement reversibility to acetabular cap in dislocated hips. Single view static and dynamic technique was applicable for diagnostic purposes in more than 99% of patients.

Changes in β angle were measured in maneuvers with and without stress as an objective index of hip stability [Figure 1]. Mean of changes in β angle was 14.43 ± 5.47° (4 - 28°) in unstable hips. Significant statistical relation was observed between mean of changes in β angle and results of dynamic ultrasonography ($P = 0.004$). In many unstable and dislocatable hips, with increasing instability, the first measurement of β angle (β_0: before stress maneuver) was also increased. So, the change was not always related to the degree of joint stability. In dislocatable hips, the changes in β angle were nearly with equal distribution.

In our study, in 30 infants, the α angle was between 50° to 59° (type 2 modified Graf classification). 21 infants (3% of patients) were type 2a (physiological delay of ossification before 3 months) according to the Graf classification and needed follow up. At dynamic ultrasonography of these groups, 17 cases were stable and 4 cases had unstable hips. After a 3-month follow up, all infants had normal morphology and none of them worsened so much to require pediatric orthopedics.

Discussion

Since professor Reinhard Graf, first introduced US examination of the hip in 1980, various sonography methods have been introduced for diagnosis of DDH (5, 6). Graf method measures the angles of both cartilaginous

Figure 1. The changes of β angle for without and with stress maneuver in unstable hip; A) β angle in coronal neutral view; B) β angle in coronal neutral view; and C) in coronal neutral view with stress push maneuver. β angle in A and B are almost similar (60°) while for stress view is increased (85°).

and osseous parts of acetabulum in coronal/neutral view. Based on the measurement of α and β angles and acetabular morphology, hip joints are categorized into 4 groups (7). In another dynamic method which was initially described by Harcke, at least two orthogonal plan (transverse and coronal) are obtained at rest and in stress (7, 8). After these two methods, several sonographic approaches have been described and selection of the best method for screening DDH remains a subject of continuing controversy.

Coronal/flexion view, anatomically, is similar to coronal/neutral view. This view can easily reveal anatomic landmarks and accurately measure the angles. This view is the most common one in dynamic techniques. Considering advantages and disadvantages of previous protocols, in this study, we applied coronal/flexion view with and without dynamic maneuver for diagnosis of developmental dysplasia of hip.

Prevalence of DDH in our study was fewer than relevant article. 5% of hips were immature in the coronal/neutral view and 9% of hips were unstable in dynamic sonography, while in Kosar's study, 20% of hips were immature in Graf sonography and 10% were unstable in dynamic sonography (8). The lower incidence of immaturity may be due to lower incidence of DDH or lower rate of ultrasound requests in our area.

In our research, 100% of hips with dysplastic morphology (mild and severe) were unstable in dynamic analysis and 9% of unstable hips had normal morphology in static evaluation (see table 1). In Rosendahl study, 91% of infantile hips with dysplastic morphology were unstable and 49% of unstable hips had normal morphology (9). The lower incidence of instability in normal morphology may be due to our patients' age (all our patients were more than 1 week old).

Identifying Graf type 2a is an important issue; because this category is in great risk of dysplasia and in few cases, hip maturation does not complete until four months (developed cases should be considered as type 2b that need more aggressive treatment) (10, 11, 12). In our study, the type 2a frequency was 3%, which in 1.3% of cases, they developed to type 2b. In another study, the frequency of type 2a was 11.8% which 1.78% of them developed to type 2b (13). In Kosar study, hip maturation was not occurred in 2.63% of type 2a, which these cases were considered as type 2b (8). In Rosendahl's study, this rate was 3.3% (14). The diversity among the reported rate of type 2a may be due to differences in the period of time for sonographic analyses and their genetic background (10).

In our study, all unstable hips with normal morphology were stabilized with simple treatment using hip abduction position on follow up ultrasound in the next month. In Kosar study, 1.7% of such hips were late DDH; but this was 0% in our work (8). In Kosar research, among hips with pathological report in sonography at the first to third days of life, regardless of their type, just 10% of them remained abnormal during the first six weeks of life. This actually indicates that the dysplasia can develop in hips that initially seem to be normal. Hence, it is necessary to perform follow up sonographies and consider its optimal period of time (10).

In Rosendahl's research, the bilateral femoral head movement in mid coronal view was used as a quantitative standard for estimation of hip joint instability (14). In this study, we measured the changes of β angle as a standard objective for hip stability studies. The mean changes of β angle in unstable hips was 14.43±5.47°. Few studies have worked through this standard and it is suggested to conduct more researches in this field. The changes in β angle show importance of applying stress in dynamic techniques.

The changes in β angle, which are measured in hip stability, can be considered as a quantitative criterion for more precise diagnosis of DDH intensity and therapy management.

Our study demonstrated that the combined method (static and dynamic) is preferred for evaluation of hip because mature hip may be unstable and stable hip may have immature or dysplastic morphology. The single view static and dynamic technique with simple pull and push maneuver diagnoses acetabular dysplasia, instability and dislocatiblity in almost all our patients (> 99%). Stress transverse view and Ortolani maneuver had little additional diagnostic information in few patients.

Moderate sample size was one of our study limitations and more valid results will be obtained in future studies with larger sample size. Definite differentiation pathological instability and elasticity or laxity (according to Graf) was not mentioned. Considering operator-dependency of sonographic procedures, future studies with multi-centric and inter-observer structures will produce more assured results.

Single view static and dynamic technique with its static and dynamic nature provides a high diagnostic value for the assessment of DDH. It is an easy and fast method, which can be learned and performed with no specific complexity. This method is very appropriate for less experienced examiners.

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Seyed Ali Alamdaran MD
Surgical Oncology Research Center, Faculty of Medicine, Imam Reza Hospital, Mashhad University of Medical Sciences, Mashhad, Iran
Department of Radiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

Sahar Kazemi MD
Ali Feyzi MD
Reza Mardani MD
Department of Radiology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

Ali Parsa MD
Mohammad Hallaj Moghadam MD
Orthopedic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

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