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Do we need to follow up an early normal ultrasound with a later plain radiograph in children with a family history of developmental dysplasia of the hip?

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Abstract

Background We routinely perform a pelvic radiograph between 6 and 12 months of age for children with a family history of developmental dysplasia of hip (DDH). We conducted this study to determine whether children with a family history of DDH and a normal hip ultrasound after birth require any further radiological follow-up.

Methods We identified all children referred to our hip-screening clinic in a 3-year period between August 2008 and August 2011 with a family history of DDH and a normal hip ultrasound after birth. A total of 119 patients with a normal hip ultrasound after birth had a pelvic radiograph at a median age of 6.6 months.

Results Six patients had residual dysplasia (acetabular index $>30^\circ$) on the initial radiograph; five of these had resolved spontaneously by age 12 months, and the remaining patient had a normal radiograph at 21 months of age and was discharged.

Conclusion We have found no cases of residual hip dysplasia requiring treatment in children with a family history of DDH and a normal hip ultrasound after birth. We have therefore changed our practice accordingly and no longer routinely followed up such cases.

Level of evidence Diagnostic study, Level II.

Keywords Developmental dysplasia hip · Family history · Ultrasound · Radiograph

Introduction

Screening for developmental dysplasia of the hip (DDH) in the UK has been used for over 40 years. Initially, this consisted of clinical examination alone to detect instability using the tests described by Ortolani [1] and Barlow [2], but the sensitivity of such tests is reported as only 60 % [3]. These tests for clinical instability are also highly dependent on clinical experience for improved sensitivity [4]. Ultrasound was added in 1986 and has been shown to have improved sensitivity for detecting DDH [5]. Currently in the UK, selective screening is recommended with ultrasound examination for patients with specific risk factors including first-degree family history, breech presentation at delivery or breech position at any period after 36 weeks of pregnancy. All patients with an abnormal clinical examination using the Ortolani and Barlow tests are also referred for an ultrasound scan of the hips [6].

Patients with a family history of DDH, particularly a first-degree relative who has been treated for DDH, are felt to be at increased risk of developing DDH. In such cases, it has been the policy of our unit to obtain an ultrasound of the hips at around 6 weeks of age and if normal to follow this with a pelvic radiograph at 6–12 months of age. Before the introduction of widespread ultrasound screening for DDH, studies reported that the incidence of late DDH was much more likely in children who had a positive family history of DDH [7]. With the introduction of selective screening using ultrasound, late cases of DDH still occur with a reported incidence of 0.4–0.68 per 1000, but these cases usually have no risk factors [8, 9]. The current study aims to determine whether children with a positive family history of DDH develop late dysplasia requiring treatment and whether we can justify the need for a further radiograph despite a normal ultrasound at 6 weeks of age.

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The Ionising Radiation (Medical Exposure) Regulations (IRMER) were introduced in the year 2000 to make referrers justify a particular exposure to ionising radiation and eliminate unnecessary exposure to ionising radiation [20].

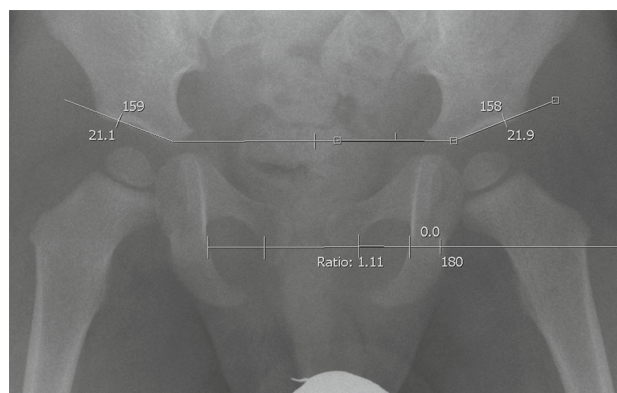
Methods

We retrospectively reviewed all patients referred to our hip-screening clinic with a family history of DDH over a 3-year period between August 2008 and August 2011. We identified 159 consecutive patients who had a positive family history of DDH and a normal hip ultrasound. We defined family history as any relative that had received treatment for DDH. These children were then reviewed again in clinic at 6 months of age with a pelvic radiograph to determine whether there was any residual dysplasia. If the initial radiograph suggested residual dysplasia, then repeat radiographs were obtained at age 12 months. During this time period, we performed repeat ultrasound instead of a radiograph in 20 patients at 6 months of age to determine whether this could be used as an alternative method to detect late dysplasia without the risk of ionising radiation.

The radiographs of all patients were initially reviewed by one author (ST) to determine the acetabular index (AI) of each hip. As the acetabular index is subject to measurement error, the senior author also measured the AI on 12 radiographs chosen at random. Intraclass correlation coefficients (ICC) were then calculated to determine the level of interobserver reliability. If the ICC was >0.8 , this indicated perfect agreement between the raters. Due to the variation in measuring the AI, we defined dysplasia as an AI >30 . The AI is also affected by pelvic rotation; therefore, the obturator index as described by Tonnis [15] was used to determine whether the radiograph was excessively rotated. This value is determined by drawing a line parallel to Hilgenreiner's line and bisecting the midpoint of the obturator foramen (see Fig. 1). The ratio of the width of the right obturator foramen compared to the left is then expressed as the obturator index (normal value 0.56–1.8).

Hip-screening clinic

We run a weekly hip-screening clinic during which all patients referred for possible DDH are seen. The clinic is led by a paediatric orthopaedic consultant with an experienced ultrasonographer performing the ultrasound. We obtain both static [16] and dynamic [17, 18] ultrasound images of the hips to determine whether any dysplasia or instability is present. Dynamic images of the hip are obtained by applying a posteriorly directed force to the hip whilst it is flexed and adducted to ensure there is no



$$OI = \frac{\text{Diameter of right obturator foramen (14.8mm)}}{\text{Diameter of left obturator foramen (13.3mm)}} = 1.11$$

Fig. 1 Radiograph showing measurement of AI and OI

movement of the femoral head out of the acetabulum (similar to the Barlow clinical test for instability [2]). A normal hip ultrasound is defined as a stable hip with normal morphology (good femoral head coverage $>50\%$ and alpha angle $>60^\circ$).

Results

The initial ultrasound scan was performed at a median age of 5.6 weeks (range 1.7–14 weeks). This identified 159 children with a positive family history and a normal initial ultrasound scan. Three patients (2 %) were also breech presentations, which were included in the final analysis. Twenty patients (12.6 %) did not attend for follow-up so 139 patients were included in the final analysis. The mean values for the acetabular index and the reference values of Tonnis are shown in Table 1. A total of 119 patients had a pelvic radiograph at a median age of 6.6 months (range 4.9–28.9 months). The obturator index was within the acceptable range, and hence, the radiograph was not significantly rotated in 91 % of cases (see Fig. 2). On further analysis of the 11 cases where the OI fell outside of the acceptable range of Tonnis, we found no significant difference in the AI between the right and left hips and no significant dysplasia in any of these cases (see Table 2). Six patients had an AI ≥ 30 on the initial radiograph. These had repeat radiographs at 12 months of age at which stage five had resolved. The remaining patient had a third radiograph at 21 months which was normal, and hence, the patient was discharged (see Fig. 3). Twenty patients had a repeat ultrasound scan instead of a radiograph at a median age of 6.3 months (range of 4.7–8.7 months); all demonstrated no instability or dysplasia and were discharged from clinic.

The intraclass correlation coefficient in 12 randomly chosen patients for the AI was 0.92–0.98, indicating

Table 1 Mean values for AI for girls and boys in our study with mean reference values (within 1 SD) provided by Tonnis

Age group (months)	5–6		7–9		10–12		13–15	
	R	L	R	L	R	L	R	L
Girls current study	24.5	24.8	23.1	23.0	19.8	21.1	21.3	23.0
Tonnis	27.3	29.3	25.3	26.6	24.7	27.1	24.6	26.9
Boys current study	20.6	21.3	21.4	22.2	22.3	22.4	20.6	21.3
Tonnis	24.2	26.8	24.6	25.4	23.2	25.2	23.1	24.0

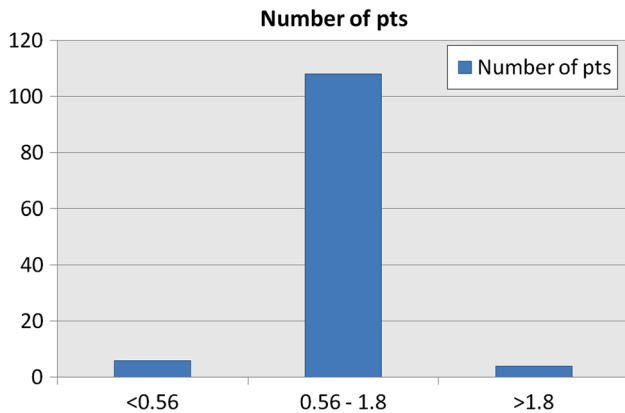


Fig. 2 Pelvic radiograph rotation as measured by the obturator index for all patients

Table 2 Cases where the obturator index (OI) was outside the acceptable range with their respective acetabular index (AI) for right and left hips

Case number	OI	AI right hip	AI left hip
1	0.46	20.1	23.1
2	0.43	17.7	21.1
3	2.28	19.3	20.3
4	0.43	16.7	17.1
5	2.11	16.2	14
6	0.55	19.2	19.7
7	0.46	19.6	22
8	2.13	22	21.8
9	0.55	12.1	12.5
10	2.08	24.1	22.9

excellent agreement between the raters for the measured AI values (Fig. 3).

Discussion

Family history is considered to be one of the strongest risk factors for DDH with Bache et al. [10] reporting a greater than threefold increase in the rate of ultrasound abnormality in children with a family history of DDH (133.5/1000 vs. 39.9/1000 for the whole population studied).

Clinical examination alone has been shown to be too insensitive to detect all cases of DDH. With the addition of ultrasound, the sensitivity has improved, but what has been less clear is the risk of late DDH in children with a normal clinical examination and hip ultrasound scan after birth.

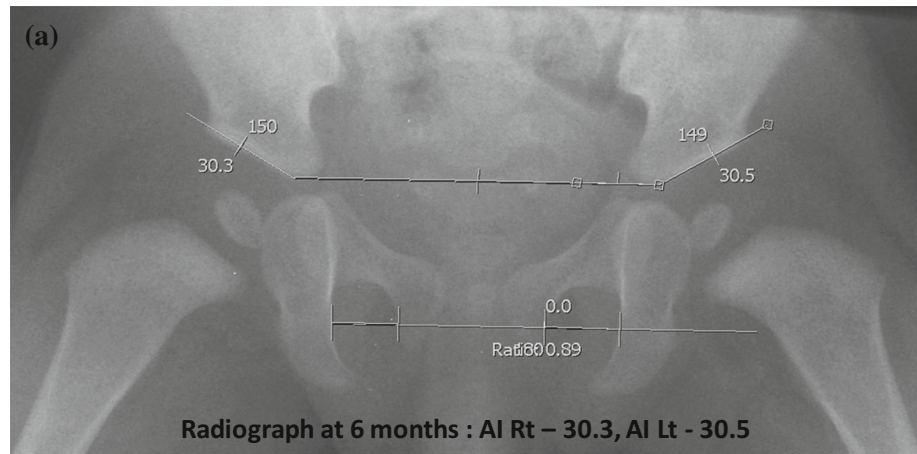
A number of studies have looked into the genetic link between family history and DDH with Wynne-Davies [11] reporting this to be a significant causal relationship. Along with this, Garvey et al. [7] using clinical examination alone reported late dysplasia occurring in 18 % of children with a family history of DDH. This has formed the basis of performing a radiograph at 6–12 months of age to ensure no late cases of DDH are missed. Despite current selective screening guidelines in the UK, late cases of DDH still occur with one study [8] reporting a rate of 0.4 per 1000 live births despite selective screening with ultrasound for “at risk” factors. This study found that the late cases had no identifiable risk factors.

The use of a pelvic radiograph in addition to ultrasound screening was assessed in the study by Price et al. [12], who performed radiographs of all patients discharged on the basis of a normal static hip ultrasound after birth. They found an abnormal radiograph at 5 months of age in 0.5 % of 11,000 patients cleared by a normal ultrasound. However, only eight patients required treatment for DDH. They concluded that a radiograph is not required in all patients, but in only those with an alpha angle <60° or femoral head cover (FHC) <50 % at 6–10 weeks, and they have also subsequently changed their policy of screening hips with static images measuring alpha angle and FHC alone to also include dynamic assessment to look at hip instability. We have been using this method for assessment of all patients referred to the hip-screening clinic for DDH.

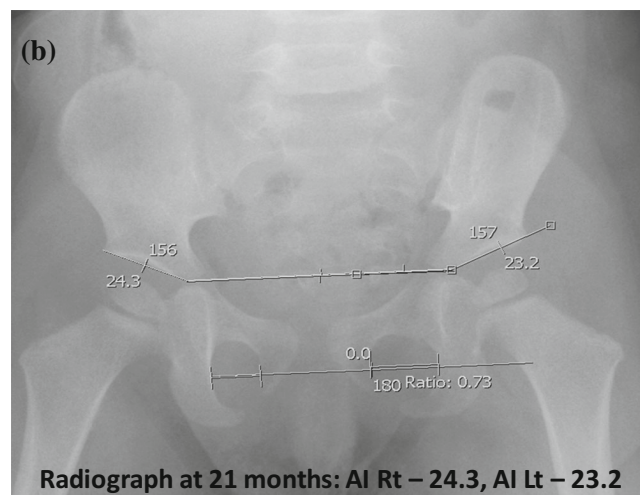
A further study by Jellicoe et al. [21] looked at whether all scanned hips needed to be followed up. Selective screening for known risk factors was performed, and all referred patients had an ultrasound scan at 6 weeks of age. They found that all patients with a normal hip ultrasound (94 hips) defined as a stable hip with normal coverage had a normal pelvic radiograph at 12 months of age. This led to a change in practice in this unit with all children with a normal hip ultrasound being discharged.

Our practice of obtaining a radiograph at 6–12 months of age in children who have a family history of DDH and a

Fig. 3 a Radiograph of a child who had a raised AI age 6 months, which improved without treatment by 21 months. **b** Radiograph of same child at 21 months showing improvement in AI without treatment



$$OI = \frac{10.0\text{mm}}{11.2\text{mm}} = 0.89$$



$$OI = \frac{14.0\text{mm}}{19.1\text{mm}} = 0.73$$

normal ultrasound has also been practiced by several other centres in the UK. The question was discussed amongst members of the British Society for Children's Orthopaedic Surgery with 35 % of surgeons indicating they would obtain a radiograph in patients with a normal ultrasound scan [14].

Two other studies in the literature have investigated the use of a radiograph at 6–12 months of age, and both have found no cases of significant residual dysplasia in children with a family history of DDH and a normal hip ultrasound after birth. The study by Osarumwense et al. [13] found two cases of acetabular dysplasia (1.1 %) in 181 children who had a radiograph at 9–12 months of age, but both these cases resolved spontaneously by 2.5 years of age. The study by Arumilli et al. [14] found no cases of residual acetabular dysplasia during the course of follow-up. Both these studies were retrospective and had some patients lost

to follow-up, 4.7–11 %, respectively. These studies reported the use of static ultrasound alone (Arumilli et al. [14]) and with dynamic assessment (Osarumwense et al. [13]). Our study reports the use of dynamic assessment of hip stability and static assessment of acetabular dysplasia being made at the time of ultrasound scanning.

A recent study by Gans et al. [19] looking at the treatment of residual acetabular dysplasia with rigid abduction bracing (mean AI in braced group of 34.5°; confidence interval 33.6–35.4) in children aged 6–12 months of age found faster resolution of the dysplasia in children treated with abduction bracing. Some of these patients had a family history of DDH and no prior treatment, a cohort similar to our study. Our study included six patients with a family history of DDH who had residual dysplasia at 6 months of age, with five resolving spontaneously by

12 months of age and the remaining case resolving by 21 months of age. We feel that abduction bracing may represent over-treatment in such cases as the dysplasia in all our cases resolved spontaneously.

Our study has found no cases of residual dysplasia requiring treatment in children with a family history of DDH and a normal hip ultrasound after birth. We therefore feel there is no need to follow up these children with a later plain radiograph after a normal early ultrasound and have changed our practice accordingly.

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Compliance with Ethical Standards

Conflict of interest None.

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