BMJ Paediatrics Open

Risk factors for misdiagnosis in children with developmental dysplasia of the hip: a retrospective single centre study

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To cite: Fan Z-Z, Yan Y-B, Sha J, *et al*. Risk factors for misdiagnosis in children with developmental dysplasia of the hip: a retrospective single centre study. *BMJ Paediatrics Open* 2023;**7**:e001909. doi:10.1136/bmjpo-2023-001909

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Received 11 February 2023
Accepted 1 May 2023

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ABSTRACT

Objective To investigate risk factors of misdiagnosis at the first visit of children with developmental dysplasia of the hip (DDH) who did not participate in hip ultrasound screening.

Methods A retrospective review was conducted on children with DDH admitted to a tertiary hospital in northwestern China between January 2010 and June 2021. We divided the patients into the diagnosis and misdiagnosis groups according to whether they were diagnosed at the first visit. The basic information, treatment process and medical information of the children were investigated. We made a line chart of the annual misdiagnosis rate to observe the trend in the annual misdiagnosis rate. Univariate and multivariate logistic regression analyses were used to identify significant risk factors for missed diagnosis.

Results A total of 351 patients met the inclusion criteria, including 256 (72.9%) patients in the diagnosis group and 95 (27.1%) patients in the misdiagnosis group. The line chart of the annual rate of misdiagnoses among children with DDH from 2010 to 2020 showed no significant change trend. Multiple logistic regression analysis showed that the paediatrics department (*v* the paediatric orthopaedics department: OR 0.21, p<0.001), the general orthopaedics department (*v* the paediatric orthopaedics department: OR 0.39, p=0.006) and the senior physician (*v* the junior physician: OR 2.47, p=0.006) on the misdiagnosis at the first visit of children were statistically significant.

Conclusion Children with DDH without hip ultrasound screening are prone to be misdiagnosed at their first visit. The annual misdiagnosis rate has not been significantly reduced in recent years. The department and title of the physician are independent risk factors for misdiagnosis.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Early treatment is the key to improving the prognosis of developmental dysplasia of the hip (DDH) in children. Children with DDH often lack typical clinical manifestations. Additionally, some are asymptomatic and can only be detected by hip screening. Even children with an early hip physical examination may be easily missed.

WHAT THIS STUDY ADDS

⇒ One in four children with DDH without hip ultrasound screening was misdiagnosed at their first visit. The annual misdiagnosis rate has not improved significantly in recent years. The department and title of the physician are independent risk factors for misdiagnosis.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Areas, where conditions are available, should add elective or all children's hip ultrasound screening programmes to the infant physical examination programme as much as possible. It is necessary to strengthen the training of physicians in related departments to diagnose DDH in areas where hip ultrasound screening is not performed. In addition, the physical examination should pay more attention to the screening of the hip so that it can play a role in diagnosing DDH.

INTRODUCTION

Developmental dysplasia of the hip (DDH) is one of the common congenital disorders in paediatric orthopaedics. It ranges from mild acetabular dysplasia to complete hip dislocation.[1] The incidence of DDH varies in different countries and regions, ranging from 1‰ to 34‰.[2]

Early treatment is the key to improving the prognosis of DDH in children. Delayed treatment will not only complicate the treatment, but lead to poor prognosis and early occurrence of degenerative hip disease.[3 4] DDH diagnosed late after the age of 8 years tends to perform poorly at open reduction of the hip, so it remains highly controversial whether to perform the reduction in these patients.[5 6]

Children with DDH often lack typical clinical manifestations. Additionally, some are asymptomatic and can only be detected by hip screening.[7 8] Even children with an early hip physical examination may be easily missed. Ziegler *et al* found that compared with hip ultrasound screening, the rate of false negative results of neonatal hip physical examination was 55.6%.[9] Since the level of public health development in China still

has a particular gap compared with developed countries. Many regions have not established a good screening system for DDH. Therefore, children with DDH who do not participate in hip ultrasound screening will inevitably have some misdiagnoses during hospital visits. In clinical work, we have also encountered many children who were misdiagnosed at the first visit, which caused some children to miss the best treatment time. This study aimed to examine the risk factors of misdiagnosis at the first visit in children with DDH who did not participate in hip ultrasound screening. To provide a scientific basis for reducing the misdiagnosis rate and promoting early diagnosis of children with DDH.

METHODS

Study design

After obtaining ethics committee approval, we retrospectively studied patients diagnosed with DDH at a tertiary hospital in northwestern China between January 2010 and June 2021. The first visit was defined as the children's initial visit to the hospital after DDH-related symptoms were found by parents or physical screening. Patients were divided into the diagnosis and misdiagnosis groups according to whether they were diagnosed at the first visit. Collected data were reviewed to investigate potential risk factors for misdiagnosis of DDH in the study cohort.

Inclusion and exclusion criteria

For the purpose of this study, we enrolled only children with DDH younger than 7 years of age. To analyse annual changes in misdiagnoses, we selected only patients with their first visit between 2010 and 2020. All children diagnosed within 6 months had hip ultrasounds reported, while those diagnosed after 6 months had hip radiographs reported. They all had at least one hip diagnosed as DDH: (1) ultrasound showing IIb or worse grade as Graf's classification or (2) abnormal acetabular angle or femoral head coverage for age and sex of the infant in an anteroposterior radiograph of the hips in a neutral position.

Children with other causes of hip deformity and those diagnosed by routine participation in hip ultrasound screening were excluded. In addition, children with DDH accompanied by other congenital diseases that may affect the diagnosis, such as clubfoot, cerebral palsy and congenital heart disease, were also eliminated from the study.

Data collection

All study subjects were contacted via telephone or face-to-face with their guardians after being informed of the study's purpose. Electronic questionnaires were collected via a WeChat platform or onsite after informed consent. To ensure the quality of the questionnaire, we retrieved the patients' previous medical records to help them recall their previous visits. Information on the investigation included: sex, age at the first visit, birthplace, first main symptom, time of the first visit, hospital level at the first visit, department at the first visit, title of the physician at the first visit, side of the affected hip, Graf ultrasonic classification of the hip joint, Tönnis radiographic classification, participating in the infant physical examination or not, birth parity, fetal presentation and family history.

Statistical analyses

The line chart of the annual misdiagnosis rate was drawn to observe the trend in the annual misdiagnosis rate. Non-normally distributed continuous variables were present as median and IQRs and compared by the Mann-Whitney U test. Categorical variables tested using the χ^2 tests, Fisher exact tests and logistic regression analysis were used to examine possible significant predictors at the univariable level. All variables with a p value of <0.1 in univariate analysis and variables shown to be strongly related to diagnosis of DDH reported in previous studies (main symptom, participation in the infant physical examination or not, family history and severity of DDH) were included in a non-automatic multivariable logistic regression model. The differences were statistically significant at a p value of <0.05. Statistical analysis was performed using the software SPSS V.26.0 (IBM).

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

A total of 530 children diagnosed with DDH from January 2010 to June 2021 were potentially eligible for inclusion in this study (figure 1). Among them, 22 patients were unwilling to cooperate after the child guardian understood the research purpose, and 65 patients could not be contacted due to the change of contact information. A total of 443 questionnaires were collected, and the overall loss to follow-up rate was 16.4% (87 of 530 patients). In the questionnaire, 92 patients were excluded because they did not meet the inclusion and exclusion criteria. Finally, 351 patients met the criteria. There were 256 patients (72.9%) in the diagnosis group and 95 patients (27.1%) in the misdiagnosis group, including 55 men (15.7%) and 296 women (84.3%). Seventy-two patients (20.5%) were diagnosed by ultrasound within 6 months of age, and 279 patients (79.5%) were diagnosed by X-ray after 6 months of age.

The line chart of the annual misdiagnosis rate at the first visit showed no significant change trend from 2010 to 2020 (figure 2). From 2010 to 2020, the minimum number of patients collected was 20 (5.7%) in 2010, and the maximum number of patients collected was 46 (13.1%) in 2018. The highest annual misdiagnosis rate was 32.3% in 2016, and the lowest annual misdiagnosis rate was 18.2% in 2012.

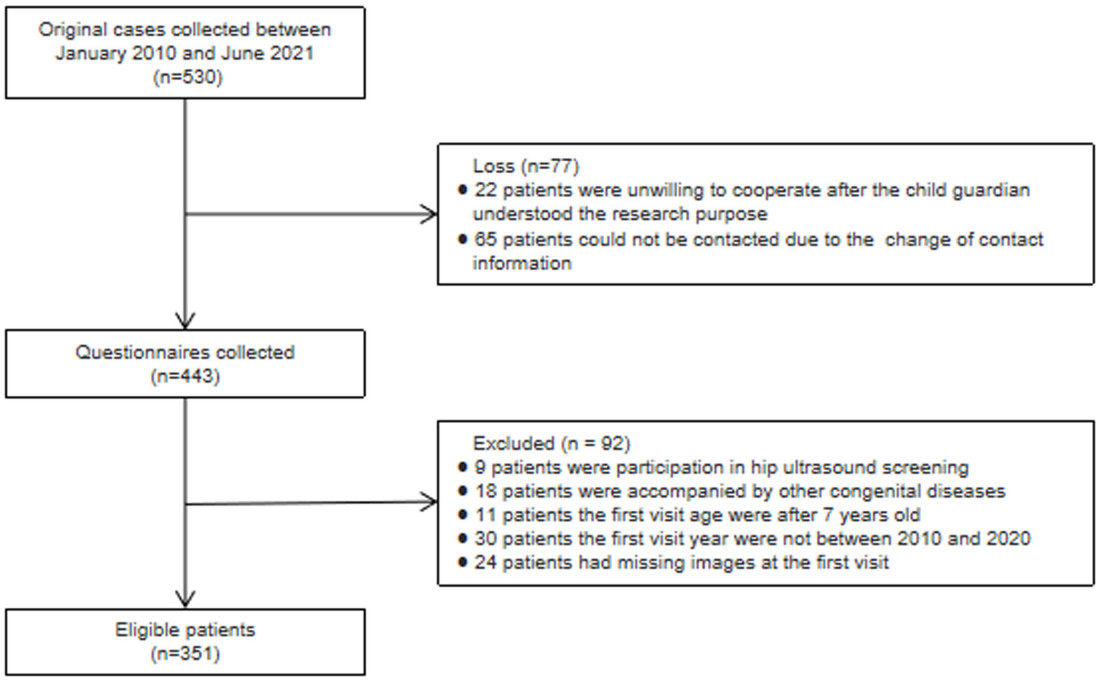

Figure 1 A flowchart of the study population.

The results of the univariate analysis showed that the tertiary hospital (*v* the primary hospital, OR 2.98, p=0.001), the surgery department (*v* the paediatric orthopaedics department: OR 0.17, p=0.001), the paediatrics department (*v* the paediatric orthopaedics department: OR 0.19, p<0.001), the general orthopaedics department (*v* the paediatric orthopaedics department: OR 0.32, p<0.001), the intermediate physician (*v* the junior physician: OR 1.95, p=0.040) and the senior physician (*v* the junior physician: OR 3.23, p=0.001) had statistically significant effects on the misdiagnosis of DDH (table 1). There was no significant correlation between the misdiagnosis of DDH and the patient's sex, age, birthplace, main symptom, year, side of the affected hip, participation in the infant physical examination or not, birth parity, fetal presentation, family history and severity of DDH (all p>0.05).

In the multivariate analysis (table 2), the paediatrics department (*v* the paediatric orthopaedics department: OR 0.21, p<0.001), the general orthopaedics department (*v* the paediatric orthopaedics department: OR 0.39, p=0.006) and the senior physician (*v* the junior physician: OR 2.47, p=0.006) remained independently associated with the risk of misdiagnosis.

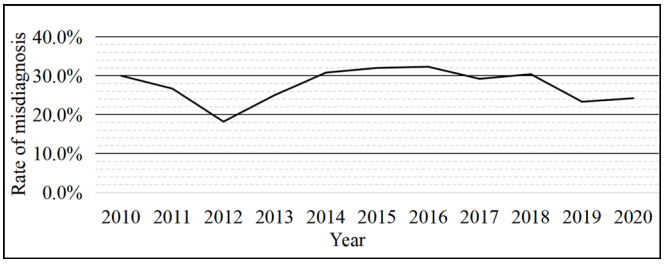

Figure 2 Line chart of misdiagnosis rate in children with DDH from 2010 to 2020. DDH, developmental dysplasia of the hip.

DISCUSSION

The treatment principles for DDH vary depending on the initial age of the treatment. The younger the treatment age, the simpler the treatment method, and the more likely to obtain a good prognosis.[1] To make an early diagnosis of DDH in children, some European countries have implemented nationwide hip ultrasound screening in infants.[10] Some scholars even consider children with DDH diagnosed after 3 months as a delayed diagnosis because they believe that starting treatment after 3 months increases the risk of a poor prognosis.[4] Numerous studies have shown that hip ultrasound screening is a major contributing factor in the early diagnosis of children with DDH.[11 12] However, many regions do not yet have a well-established hip screening system. In this study, only 20.5% (72 of 351) of patients were diagnosed before 6 months. It indicated that the delayed diagnosis of children with DDH without hip ultrasound screening was still severe. Establishing a well-established system for hip screening requires substantial financial investment from government sectors.[13 14] This was a gradual process of improvement. Until the screening system is not well established, we still need to make efforts to reduce the occurrence of misdiagnoses. Misdiagnosis is bound to delay the following treatment, preventing children from obtaining the best treatment. Some of these children may irreversibly progress to hip arthritis and even lower extremity disability or severe limitations in physical function.[15 16]

The results of the present study showed that the overall missed rate of children with DDH without hip ultrasound

Table 1 Results of univariate analysis of misdiagnosis at the first visit

Characteristic	Diagnosis group (n=256)	Misdiagnosis group (n=95)	OR (95% CI)	P value
Sex, n (%)				
Male	43 (16.8)	12 (12.6)	Reference	
Female	213 (83.2)	83 (87.4)	0.72 (0.36 to 1.43)	0.342
Age (months), medians (25th percentile, 75th percentile)	16 (8.25–22.75)	15 (12–19)	0.99 (0.98 to 1.01)	0.299
Birthplace, n (%)				
Rural	139 (54.3)	53 (55.8)	Reference	
Urban	117 (45.7)	42 (44.2)	1.06 (0.66 to 1.71)	0.803
Main symptom, n (%)				
Lower limbs were asymmetrical	45 (17.6)	13 (13.7)	Reference	
Buttock lines are asymmetrical	47 (18.4)	14 (14.7)	0.97 (0.41 to 2.29)	0.944
Abnormal gait*	149 (58.2)	59 (62.1)	0.73 (0.37 to 1.45)	0.368
Abnormal hip*	15 (5.9)	9 (9.5)	0.48 (0.17 to 1.35)	0.165
Year, n (%)				
2010–2015	128 (50)	46 (36.8)	Reference	
2016–2020	128 (50)	49 (51.6)	0.94 (0.59 to 1.50)	0.793
Hospital level, n (%)				
Tertiary	186 (72.7)	49 (51.6)	Reference	
Secondary	56 (21.9)	35 (36.8)	0.42 (0.25 to 0.71)	0.001
Primary	14 (5.5)	11 (11.6)	0.34 (0.14 to 0.79)	0.012
Department, n (%)				
Paediatric orthopaedics	145 (56.6)	25 (26.3)	Reference	
Surgery	8 (3.1)	8 (8.4)	0.17 (0.06 to 0.50)	0.001
Paediatrics	18 (7.0)	16 (16.8)	0.19 (0.09 to 0.43)	<0.001
General orthopaedics	85 (33.2)	46 (48.4)	0.32 (0.18 to 0.56)	<0.001
Title of the physician, n (%)				
Junior	41 (16.0)	32 (33.7)	Reference	
Intermediate	70 (27.3)	28 (29.5)	1.95 (1.03 to 3.69)	0.040
Senior	145 (56.6)	35 (36.8)	3.23 (1.79 to 5.84)	<0.001
Affected hip, n (%)				
Left	99 (38.7)	41 (43.2)	Reference	
Right	73 (28.5)	26 (27.4)	1.16 (0.65 to 2.07)	0.608
Bilateral	84 (32.8)	28 (29.5)	1.24 (0.71 to 2.18)	0.449
Infant physical examination, n (%)				
Yes	67 (26.2)	23 (24.2)	Reference	
No	189 (73.8)	72 (75.8)	0.90 (0.52 to 1.56)	0.709
Parity, n (%)				
Firstborn	179 (69.9)	71 (74.7)	Reference	
Second child or more	77 (30.1)	24 (25.3)	1.27 (0.75 to 2.17)	0.377
Fetal presentation, n (%)				
Cephalic presentation	227 (88.7)	84 (88.4)	Reference	
Breech presentation	29 (11.3)	11 (11.6)	0.98 (0.47 to 2.04)	0.948
Family history, n (%)				
Yes	21 (8.2)	6 (6.3)	Reference	
No	235 (91.8)	89 (93.7)	0.75 (0.30 to 1.93)	0.557
Severity of DDH, n (%)				
Mild (Graf: IIb–IIc/Tönnis: 1–2)	133 (52.0)	47 (49.5)	Reference	
Severe (Graf: III–IV/Tönnis: 3–4)	123 (48.0)	48 (50.5)	0.91 (0.57 to 1.45)	0.680

*Abnormal gait (lameness, duck gait, delay in learning to walk, unstable gait). Abnormal hip (pain, limited joint movement, abnormal joint movement).
DDH, developmental dysplasia of the hip.

Table 2 Results of multivariate analysis of misdiagnosis at the first visit

	B	SE	Wald	OR	95% CI	P value
Main symptom						
Lower limbs were asymmetrical				Reference		
Buttock lines are asymmetrical	−0.23	0.49	0.22	0.80	0.31 to 2.07	0.638
Abnormal gait	−0.33	0.39	0.73	0.72	0.34 to 1.53	0.394
Abnormal hip	−0.80	0.57	2.01	0.45	0.15 to 1.36	0.156
Hospital level						
Tertiary				Reference		
Secondary	0.12	0.60	0.04	1.13	0.35 to 3.69	0.842
Primary	−0.03	0.60	0.00	0.97	0.30 to 3.16	0.959
Department						
Paediatric orthopaedics				Reference		
Surgery	−1.42	0.73	3.80	0.24	0.06 to 1.01	0.051
Paediatrics	−1.56	0.43	12.97	0.21	0.09 to 0.49	<0.001
General orthopaedics	−0.94	0.34	7.46	0.39	0.20 to 0.77	0.006
Title of the physician						
Junior				Reference		
Intermediate	0.43	0.35	1.48	1.53	0.77 to 3.04	0.223
Senior	0.91	0.33	7.45	2.47	1.29 to 4.73	0.006
Infant physical examination						
Yes				Reference		
No	0.20	0.32	0.39	1.23	0.65 to 2.31	0.532
Family history						
Yes				Reference		
No	−0.31	0.52	0.36	0.74	0.27 to 2.02	0.552
Severity of DDH						
Mild (Graf: IIb–IIc /Tönnis: 1–2)				Reference		
Severe (Graf: III–IV/Tönnis: 3–4)	0.15	0.27	0.30	1.16	0.68 to 1.97	0.585

DDH, developmental dysplasia of the hip.

screening at the first visit was 27.1%. On average, at least one out of every four children with DDH was misdiagnosed. The line chart of the annual misdiagnosis rate from 2010 to 2020 shows no improvement trend. There was also no significant difference in univariate analysis for misdiagnoses in 2016–2020 compared with 2010–2015. It also illustrates that the misdiagnoses of DDH have not significantly improved in recent years, and all remain at a high level. The results of multivariate logistic regression showed that the misdiagnosis of DDH at the first visit was only associated with the department and the title of the physician. That is to say, the experience and professional degree of physicians are very important for diagnosing DDH. However, even the paediatric orthopedists, which had the most apparent impact on misdiagnosis at the first visit, the misdiagnosis rate reached 14.7% (25 of 170 patients). It may suggest that there is still a long way to go for standardised training of paediatric orthopedists in China.

To reduce the occurrence of misdiagnosis, we should understand the risk factors and diagnostic methods for DDH. The occurrence of DDH is multifactorial. Previous studies revealed that the genetic, female, breech delivery, first birth, swaddling mode, birth weight and oligohydramnios are the main risk factors for DDH. In addition, factors such as delivery mode, multiple pregnancies and maternal hyperthyroidism in early pregnancy may also be related.[17–19] The early clinical manifestations of DDH lack specificity. According to our investigation results, most children visited the hospital with the main symptoms of gluteal lines asymmetry or lower limb asymmetry before learning to walk. In the stage after learning to walk, abnormal gait becomes the primary clinical manifestation. However, there may be some differences in children's development, and toddlers' gait is inherently unstable, so these symptoms are difficult to distinguish from normal conditions. Therefore, clinical symptoms had no significant effect on misdiagnosis. The Ortolani

and Barlow tests are the most commonly used physical examination methods for diagnosing DDH in infants. However, the sensitivity of the Ortolani and Barlow tests decreased significantly after 2–3 months. After that, the hip abduction test can be performed, and if the abduction is limited or asymmetric, it is positive. At the same time, the length and buttock line of the lower limbs can also be compared.[20] However, the sensitivity of hip physical examination is low. Because hip physical examination cost is low, it is more suitable for the initial screening of DDH.[21] In this study, the physical examination that children participated in did not play a significant role in diagnosing DDH. It suggests that we need to strengthen hip screening in physical examinations. The diagnosis of DDH mainly depends on imaging examination. Hip ultrasound is the primary examination method for diagnosing DDH within 4–6 months. The most commonly used hip ultrasound diagnostic standard is the Graf method.[22 23] In some countries and regions, hip ultrasound screening has been routinely performed for all infants to diagnose DDH early. The ossified nucleus of the femoral head has appeared in most children over 4–6 months. Therefore, the anteroposterior pelvic X-ray has become the first choice for diagnosing DDH in children over 4–6 months old. The diagnostic indicators include the acetabular index, center-edge angle, Perkin's quadrant and Shenton's line.[24] Anteroposterior pelvic X-ray can be taken in almost all hospitals. It has a low radiation dose, low cost and high diagnostic value. Therefore, we believe that it is necessary for physicians to perform an anteroposterior pelvic X-ray on children over 6 months who cannot completely exclude DDH. Considering that CT has a high dose of radiation to children and MRI often requires anaesthesia to complete, CT and MRI are rarely used in clinical practice to diagnose DDH.

Due to the relatively low incidence of DDH, it has not attracted enough attention from most physicians. In this study, the rate of misdiagnosis (27.1%) is high on the first visit. The risk factors of DDH, such as sex, family history, parity and fetal presentation, have no significant influence on the misdiagnosis of DDH. Clinical symptoms were also unreliable in the diagnosis of DDH. Therefore, clinicians should carefully ask about children's medical history when they visit to avoid misdiagnosis. For children with risk factors and related clinical symptoms for DDH, a hip ultrasound or a hip X-ray should be performed in addition to a careful physical examination. In addition, the routine infant physical examination has not played a due role in diagnosing DDH. Since the infant physical examination is mainly performed by community physicians, childcare physicians and general practitioners. Therefore, it is necessary to strengthen the training of these physicians in infant hip physical examination, to strengthen DDH screening in routine physical examinations. Of course, some studies have shown that physical examination alone may still lead to a high risk of misdiagnosis.[9] Therefore, selective or universal hip ultrasound screening should be added to the infant physical examination programme whenever possible in areas where it is available. In this way, more children with DDH can be diagnosed early and the incidence of misdiagnosis can be reduced.[25]

There are limitations to the present study. First, the study is single-centre, and most subjects come from northwest China. There is a certain bias in the selection of samples, which cannot represent the overall level of misdiagnosis of patients with DDH who did not participate in hip ultrasound screening at the first visit. In particular, there may be large differences compared with some regions where well-developed hip screening systems have been established. Second, this study is a retrospective study. Although the follow-up compliance of the children's family members is good, the follow-up time is up to 11 years, which could not avoid recall bias. Third, the follow-up loss rate was high (16.4%). If a prospective study could be carried out to collect detailed information on patients' first visit in time, the results would be more reliable.

In conclusion, children with DDH without hip ultrasound screening are prone to be misdiagnosed at their first visit. The annual misdiagnosis rate has not been significantly reduced in recent years. The department and title of the physician are independent risk factors for misdiagnosis. It is necessary to strengthen the training of physicians in related departments to diagnose DDH in areas where hip ultrasound screening is not performed. In addition, the physical examination should pay more attention to the screening of the hip so that it can play a role in diagnosing DDH. In this way, the misdiagnosis of children with DDH can be reduced.

Acknowledgements The authors gratefully acknowledge Ye Han, Department of Radiation Medicine, Xijing Hospital, for his help in the data collection.

Contributors Z-ZF takes the responibility for overall content as guarantor. Z-ZF, Y-BY, JS and L-YH designed the research. Z-ZF, Y-BY, H-FX, JS and Z-CL performed the data collection and analysis. H-FX, CL and JL reviewed the results. Z-ZF interpreted the data and drafted the manuscript. Y-BY, JS and L-YH revised the paper. All authors have read and approved the submitted manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Disclaimer The study was conducted in the Air Force Military Medical, Xijing Hospital, Department of Pediatric Orthopedics. In this retrospective case–control study, we investigated children with DDH who were visited between January 2010 and June 2021. A total of 351 children who met the criteria were included in this study.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants but the Ethical Committee of the First Affiliated Hospital of the Air Force Medical University (ky20224254-1) exempted this study. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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