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Research Article

Frog-Leg Lateral Pelvic Radiographs are Reliable for the Measurement of Acetabular Index in Developmental Dysplasia of the Hip

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Abstract

Background: Acetabular index (AI) is the most commonly utilized radiographic measure for developmental dysplasia of the hip (DDH). However, there is variability in measurement of AI, thus impairing reproducibility. Frog-leg lateral (FL) positioning allows more consistent visualization of the acetabular sourcil compared with anteroposterior (AP). The purpose of this study is to determine if there is any difference in AI measurements on AP versus FL radiographs and if there is less measurement variability on FL than AP radiographs.

Methods: An IRB approved, retrospective study was performed on 274 hips that underwent screening AP and FL radiography for DDH. Radiographs were reviewed using a standard measurement technique. Interobserver measurement differences and the differences between measurements made on AP and FL radiographs were calculated.

Results: 233 (85%) were normal, and 41 (15%) had DDH. The average AI on AP vs FL was not significantly different (24.13 and 23.66 degrees, respectively; P = 0.147). There was a significant difference in measurement in variability for the interobserver difference for AI on AP (0.48 degrees; P = 0.001), whereas there was no significant difference for AI on the FL (0.18 degrees; P = 0.114).

Conclusion: AI had less variability on the FL view than the AP view, likely due to a more orthogonal projection of the sourcil creating a single sclerotic line with which to perform measurements. We recommend using the FL radiograph as a supplement to the AP radiograph for measuring AI for following up patients diagnosed with DDH.

Level of Evidence: Level III.

Keywords: *Developmental Dysplasia of the Hip (DDH); Acetabular Index; Frog Lateral*

Introduction

The current recommendations by the American Academy of Pediatrics (AAP) and American College of Radiology (ACR) for screening for developmental dysplasia of the hip (DDH) in patients older than four months of age is use of single view anterior-posterior (AP) pelvic radiograph [1-6]. If the AP view appears abnormal then the addition of a frog-leg lateral (FL) view is recommended [1-5,7,8]. Some studies,

however, recommend routine use of both AP and FL or von Rosen views [9-13]. The addition of the lateral view can demonstrate the reducibility of the hips and provide orthogonal views of the proximal femur which can both increase diagnostic ability and assist in pre-operative planning [14,15].

The most common radiographic measurement used in assessing pelvic radiographs for DDH is the acetabular index (AI) [16]. This is most commonly measured on the AP radiograph of the pelvis [6,17-22]. (Figure 1A). The AI is an angle formed by a line extending along the acetabular roof and a horizontal line connecting the bilateral triradiate cartilages [23]. A normal value at birth is less than 30 degrees, at six months less than 24 degrees, and less than 22 degrees at one years old or older [17]. Previous studies have shown the AI lacks reliability with interobserver variability around 3.66 degrees and has been found to be as high as 21.9 degrees [21,24-28]. Several studies have explained the inconsistent measurements of the acetabular indices to be secondary to improper patient positioning, pelvic rotation and tilt [27,29-31]. Another cause of variability in measuring the AI may be the difficulty of accurately identifying the lateral edge of the acetabulum (Figure 1B) [32]. When the sourcil is visible as a single clear sclerotic line, it is reproducible and easier to distinguish [32,33]. This tends to be more clearly seen on the frog lateral projection of the pelvis (Figure 1C). Previous studies have demonstrated that in the FL position, the lateral edge of the acetabulum and the sourcil appear to overlap and provide a consistent landmark for measurement [34]. Additionally, the FL positioning has been reported to provide more consistent pelvic position allowing for improved interobserver reliability for radiographic evaluation of other hip joint conditions such as femoroacetabular impingement [35].

Difficulty with identifying landmarks for measurement and measurement variability leads to the potential for inconsistent measurements and difficulty with accurate measurement of AI for both initial screening and long term follow up of DDH. Typical follow up of DDH is serial radiographs to establish and follow the trend of AI to determine either effectiveness of treatment or normal development of the growing hip joint. Variability of this measurement can make following this trend more difficult and less accurate leading to difficulty making treatment decisions and following outcomes.

To our knowledge, no study has yet evaluated whether there is any difference in AI measurements made on AP and FL radiographic views in patients with DDH and whether the improved landmark visibility on FL positioning improves the variability found in measurement of the AI. This study has two aims, first, to determine whether there is any significant difference between AI measurements made on AP and FL radiographs in patients with normal anatomy and acetabular dysplasia. Second, to determine whether the AI measured on FL radiographs is less variable and therefore more reliable for comparison than those made on AP radiographs. Our hypothesis is that the FL radiographs will have less variability and be a more reliable radiograph for measuring and trending AI.

Materials and Methods

Patient selection and demographics

This retrospective case-control study was approved by the hospital institutional review board with waiver of informed consent. All pelvic AP and FL radiographic images in patients less than three years old were reviewed from April 2010 to December 2010.

Imaging studies and the electronic medical record were reviewed for these inclusion criteria: (a) age less than three years, (b) indication for radiographs was screening for DDH or findings associated with DDH (c) no previous imaging or ultrasound performed, (d) no obvious skeletal deformities, (e) no major neurologic or medical conditions predisposing to hip instability (e.g. Down's Syndrome, Cerebral Palsy), (f) records of follow up of at least six months with pediatrician or a definitive evaluation by an orthopedic surgeon and (g) AP and FL radiographs with well visualized acetabulum bilaterally.

Consensus review of the electronic medical record was performed by a fellowship trained pediatric orthopaedic surgeon, an attending who had 28 years of experience to confirm a diagnosis of DDH. This reviewer was different from the primary orthopedic imaging reviewer.

From this review a total of 25 (9.1%) hips were re-categorized as either DDH or normal compared to the original diagnosis from chart review. Of the 274 hips evaluated in 137 patients, 233 (85%) were normal and 41 (15%) had DDH.

Image analysis

A CAQ-certified pediatric radiologist with additional subspecialty training in musculoskeletal radiology with eight years of experience and a fellowship trained pediatric orthopedist with 5 years of experience reviewed the radiographs by consensus without knowledge of clinical follow-up or diagnosis. The images were blinded and randomized on each review with the only information available to reviewers being the patient's age. The readers were unaware of the percentage of normal studies during review. Independently, both reviewers measured the AI on AP radiographs. At a later date, blinded to the AP radiograph measures, the same patients' FL AI were measured. A standard method for measurement of the AI was utilized by all reviewers. This was the angle formed by Hilgenreiner's line and the lateral edge of the acetabulum and was consistent with all descriptions of this measure (Figure 1A and 1C) [17,18,20].

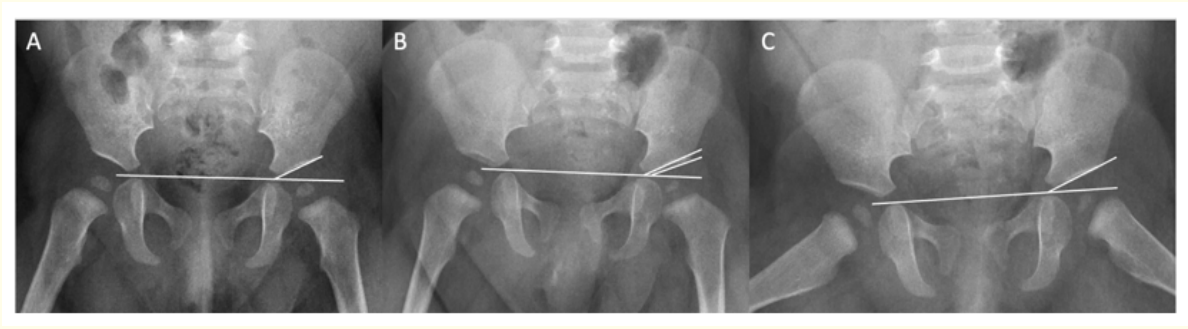

Figure 1: *Measuring acetabular index (AI) on anteroposterior (AP) and frog lateral (FL) radiographs. A: AI measurement on AP radiograph of pelvis B: AI measurement on AP with two sclerotic lines C: AI measurement on FL with single clear sclerotic line.*

Statistical analysis

Paired t-test was used to compare AP vs. FL radiographs utilizing the average of both readers' measurements. $P < 0.05$ was considered to indicate statistical significance. Paired t-test was used to determine the interobserver measurement differences between readers. This was calculated for AP and FL radiographs. The p-value and 95% CI was determined for these differences.

Results

A total of 622 individual patients were evaluated and 140 patients met the final inclusion criteria. Three additional patients were excluded during radiographic review, one due to skeletal deformities not noted in radiographic review and the other two for inability to evaluate the acetabulum due to the gonadal shield placement.

The final study population of 137 patients (274 hips) was generated with a mean age nine months (range 1 month to 2 years) with 67% of patients being female. Patient demographics and clinical indications for all hip screening is detailed in table 1.

Total Hips (n = 274)	Normal Hips (n = 233)	DDH (n = 41)
Sex		
Male	85 (36.5%)	5 (12.2%)
Female	148 (63.5%)	36 (87.8%)
Laterality		
Left Hips	114 (48.9%)	23 (56%)
Right Hips	119 (51.1%)	18 (43.9%)
Reason for Screening		
Evaluate for DDH	54 (23.2%)	18 (43.9%)
Gait Abnormality	34 (14.6%)	2 (4.9%)
Exam Abnormality	71 (30.5%)	7 (17.1%)
Click, Pop, or Clunk	33 (14.2%)	5 (12.2%)
Hip Pain	12 (5.2%)	4 (9.8%)
Abnormal ROM	8 (3.4%)	2 (4.9%)
Born Breech	21 (9.0%)	3 (7.3%)

Table 1: *Demographics and clinical indications for screening of study population.*
DDH = Developmental Dysplasia of the Hip; ROM = Range of Motion; n= Number; % = Percentage.

The average AI on AP radiographs was 24.13 degrees while the average AI for FL radiographs was 23.66 degrees. This demonstrates a 0.47 degree difference between AP and FL radiographs (p = 0.147). The AP radiographs were found to have a difference between reviewers of 0.48 degrees and this is statistically significant (p = 0.001, 95% CI [0.18 to 0.78]). The FL radiographs did not demonstrate statistical significance for interobserver variability between reviewers of 0.18 degrees (p = 0.114, 95% CI [-0.11 to 0.47]).

Discussion

Our results suggest that there is less variability in measuring the AI on the FL compared to the AP radiograph for screening for DDH. This may be due to difficulty in delineating the lateral edge of the acetabulum on the AP view and the variability between patients in their pelvic tilt [8,27,29-33]. With the FL view, the lateral acetabular edge is visualized more reliably [33-35]. Based on this, we hypothesized that measurement of AI would be less variable when made on FL than on AP radiographs. Our findings support these hypotheses. We found that the average AI measurement made on FL radiographs was not statistically different from that of the AP radiographs. However, measurements made on FL radiographs were significantly less variable than those made on AP radiographs.

These findings address the concern over variability in measurement of the AI. Currently, neither the AAP nor ACR, recommends the use of FL radiographs in primary screening for DDH [4,5]. In follow up of DDH, both AI and FL are often ordered every year to trend AI. Our results suggest that the FL position may improve the ability to make consistent measures of the AI. In DDH follow up, this is important as variation in measurements can lead to misleading longitudinal tracking of interval change that may negatively affect patient care. We believe that the reproducibility of FL AI measurements compared with AP AI measurements is due to decreased pelvic tilt resulting in the lateral acetabular edge becoming radiographically co-linear, or nearly co-linear, with the sourcil. This creates a more clear sclerotic line with which to measure the AI [31,33,34,36]. The same concept has previously been described for the measurement of the acetabular angle of Sharp [36].

A previous study by Hudak., *et al*. looked at AP and FL radiographs and the variation between them in pediatric patients when screening for DDH. Their findings were that there was little clinical difference in variability for AI on the AP and FL radiographs concluding that a

patient being screened did not require both views [37]. However, this was based on a smaller patient population of normal, non DDH hips. Further, the readers of radiographs were orthopedic surgery, general surgery and radiology residents and pediatric orthopedic fellows which potentially introduces learning error and variability to these measurements. The present study differs from that study in that we included measurements made on radiographs of patients with confirmed DDH and by an attending orthopaedic surgeon and pediatric musculoskeletal radiologist by consensus.

To our knowledge, no previous study has addressed the differences between AP and FL radiographs for measurement of the AI or the utility of FL positioning in patients with DDH. These are questions that merit answers given the frequent use of both images in evaluation for DDH. Many studies have recommended utilizing CT or MRI for evaluation of true hip positioning and have identified poor correlation between radiographs and 3-D images [35,38]. However, these studies are significantly more time intensive, expensive and pose greater risk to patients in terms of radiation exposure and need for anesthesia. Therefore, these imaging studies are not practical for initial screening or follow up with serial imaging. The use of these 3D imaging studies, however, has demonstrated that FL radiographs have high interobserver reliability which is consistent with the findings of our study [35].

Limitation of the Study

This study has several limitations. First, only two image reviewers were used. While we demonstrated interobserver reliability, this assertion would be strengthened by an increased number of reviewers. The population size we used for measurement of acetabular indices is another limitation as only 274 hips were measured. This however is significantly larger than other study populations previously used to determine the interobserver reliability of the AI [21,24-28,37] and we found very consistent values considering only two reviewers. In addition to this we used a standardized method for measurement of the AI which may have improved the reproducibility of measurements by our reviewers.

Conclusion

While this study does not conclude that FL radiographs should replace AP radiographs in evaluation of the AI for DDH, it does demonstrate strong evidence that FL radiographs are an important supplement to the AP radiograph. This becomes especially important in the long term longitudinal follow up of DDH patients when AI is being trended. FL radiographs assist in determining not only whether the hips are reducible but they also provide an image which allows for a more reproducible measure of the AI. This may result in decreased variability in the measurement of the AI therefore allowing for more consistent interpretation of screening and better ability to trend AI during follow up of DDH.

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None declared.

Statement of Conflicts of Interest

All authors declare no conflicts of copyright, financial, consultant, institutional or other resulting in bias. Each author certifies that his or her institution has approved the animal and human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research. No informed consent was required for this study.

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