CLINICAL STUDY

Predictive Radiographic Factors in DDH Management

Khalid I. Khoshhal[1] FRCS Ed and Ahmed S. Al Khelaifi[2] ABOS

Department of Orthopedic Surgery, College of Medicine, Taibah University
Al Madinah Al Munawwarah[1], King Abdulaziz Medical City, Riyadh[2], Kingdom of Saudi Arabia

Abstract

Objectives

This study aims to assess the value of certain radiographic features of the pelvis associated with developmental dysplasia of the hip (DDH), in predicting the method of treatment; whether conservative or operative, in patients between 12 and 24 months of age where both options are valid.

Methods

A retrospective review of the radiographs and the clinical files of children diagnosed with DDH during their second year of life (mean age 18.2 months), including only children who had a follow up of clinically and radiologically for a minimum of 5 years. The initial plain AP pelvic radiograph before commencing any treatment was used to measure 12 different measurements and 2 ratios. Each radiograph was studied individually and blindly, without knowing to which group of patients it belonged.

Results

A total of 72 dislocated hips in 54 patients were studied. The mean, standard deviation and P. values of age and radiographic measurements were calculated. Patients were divided into 2 groups according to the treatment modality used whether conservative or operative then they were compared. The measurement of the width of the femoral head ossific nucleus was significantly higher in the conservative group. The measurements of lateralization, superior migration of the femoral head and the acetabular angle were found to be significantly higher in the operative group.

Conclusion

Study results suggest the possibility of using specific radiographic measurements in patients with DDH during the second year of life to determine the most feasible way of management.

Key words: DDH, Radiographic predictors, Width of the femoral ossific nucleus, Acetabular angle, Lateralization, Superior migration.

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Correspondence to:
Dr. Khalid Khoshhal
Associate Professor, Consultant Pediatric Orthopedic Surgery
College of Medicine, Taibah University ✉ 879
Al Madinah Al Munawwarah, Kingdom of Saudi Arabia
☎+966 4 8460006
🖷 +966 4 8461407
kkhoshhal@hotmail.com

Introduction

Early diagnosis and treatment of developmental dysplasia of the hip (DDH) is important for normal hip development. DDH is a spectrum of abnormalities that can range from a very mild disturbance to a very severe process that is incapacitating later in life[1]. It is a common pediatric orthopedic problem in Saudi Arabia and many other parts of the world hence, it needs careful evaluation and management[2]. The management of DDH depends upon age at presentation, and type of pathology. In many of the developing countries patients with DDH still present after walking when treatment with Pavlik harness is not an option. The treatment options could be closed reduction (CR) and hip spica cast or open reduction with or without acetabular, femoral or both osteotomies. It is not uncommon to see patients who were treated conservatively to start with, needing operative treatment later on. This may result in wasting a valuable time and effort, prolonging patients' and families' suffering and may also affect the prognosis.

Diagnosis and assessment of patients with DDH is generally with the help of radiographs starting around the age of 4 months when bony development of the femoral head and acetabulum is more evident[3-5]. Various radiological measurements have been advocated to help in this assessment. Many studies of pelvic radiographs have been carried out, aiming at defining normal ranges at different ages or to define prognostic factors and outcome predictors[3,5-15]. This study intended, as many authors recommended to assess the value of certain radiographic measurements of pelvic radiographs in patients with DDH during their second year of life to develop an early and reliable radiological guide for the prediction of the method of treatment that should be used[8,16].

Materials and Methods

Fifty four patients diagnosed with DDH during their second year of life were randomly selected from the Pediatric Orthopedic Unit at King Khalid University Hospital where they were treated and followed up for at least 5 years. This age group was selected for this study since patients less than 12 months old are usually successfully treated conservatively, while patients older than 24 months old usually need operative intervention. Patients with neuromuscular disorders, arthrogryposis or other syndromes were excluded. The hip radiographic features were studied retrospectively, and patients without good quality initial radiograph before treatment (a standard anteroposterior pelvic radiograph with equal obturator foramina of good quality to see the landmarks for appropriate and accurate measurement) were excluded. Our retrospective study design, although normally a limitation, actually helps in minimizing bias. As we were unaware of this study when the surgeries were performed, it is unlikely that our decision to operate was influenced by anything other than the preoperative clinical and radiographic findings. The decision for open reduction in all cases was based on inability to get a concentric reduction by arthrography. The decision for pelvic osteotomy was based on clinical limping and radiographic evidence of a subluxation of an initially concentrically reduced hip with a wide acetabular angle or during open reduction in older patients (18 months or older) based on the stability of the reduction. The femoral osteotomy is usually decided intra-operatively after open reduction with or without pelvic osteotomy.

The initial plain anteroposterior, pelvic radiographs in neutral position before commencing any treatment were used. Each radiograph was studied individually and blindly, without knowing to which group of patients (conservative vs. operative) it belonged, **(Table 1)**. The operative group was subdivided into 3 subgroups according to the type of surgery performed **(Table 2)**. Ratios were used for radiological measurement when possible, to reduce the influence of radiological magnification in the old x-ray films as some of our measurements were done on the old

films before digitization[17]. The following 12 different measurements and 2 ratios were used, measurements were in millimeter (mm), and the angels in degrees **(Figure. 1)**.
First the midline (M) is drawn vertically through the sacrum and symphysis pubis then the Hilgenreiner's horizontal line (H) is drawn through the triradiate cartilage at the lowest point of the ilium. Perkin's line (P), is drawn perpendicular to the H-line at the margin of the bony acetabulum[18,19].

1. Distance from center of femoral head ossific nucleus to midline (X1).
2. Distance from center of femoral head ossific nucleus to P-line (negative value when lateral to P-line) (X2).
3. Distance from center of femoral head ossific nucleus to H-line (negative value when above H-line) (Y).
4. Width of femoral head ossific nucleus (D1)[20].
5. Height of femoral head ossific nucleus (D2)[20].
6. Distance from most medial proximal femoral metaphysis to midline (c)[9].
7. Distance from most superior proximal femoral metaphysis to H-line (negative value when above H-line) (h)[15,19].
8. Modified Head-Tear drop distance (HT)[8].
9. Distance from P-line to midline (b)[9].
10. Acetabular length (A1).
11. Acetabular depth (A2).
12. Acetabular angle (in degrees) (T)[8]. The angle between the H-line and the line which connects the lowest point of the ilium and the acetabular edge.
13. The ratio between the distance from the most medial femoral metaphysis to midline and from P-line to midline (Smith's c/b ratio for lateral or horizontal displacement)[8,9,12].
14. The ratio between the distance from the most superior femoral metaphysis to H-line and from P-line to midline (Smith's h/b ratio for superior or vertical migration)[8,9].

Because of possible variation in plain radiographs magnification, the distance between the most medial borders of iliac bones in both sides (A) was compared for all the old x-ray films and the difference was found to be negligible. With the new digital systems for radiographs this problem is solved and measurement of angles and distances has become easier and more accurate[21].
The mean values of all measurements were calculated. Unpaired ***t***. test was used to compare the mean values of conservative vs. operative groups. P. value was considered significant if < 0.05.

Results

A total of 72 dislocated hips were studied in 54 patients between the ages of 12 to 24 months (mean age 18.2 months) during the study period. Eight hips belonged to male patients and 64 hips to females. Out of the 72 hips 38 (52.8%) did not need any surgical intervention after CR and went on for normal development for at least the 5 years follow up period **(Table 1)**. The other 34 (47.2%) hips had one or more surgical procedures that were carried out simultaneously at different times after the initial CR **(Table 2)**.
The mean, standard deviation and P. values of age and radiographic measurements for the conservative vs. operative groups are shown in Table 3. Among the measurements, the distance from most medial metaphysis to midline (c), modified Head-Tear drop distance (HT), and the Smith's c/b ratio were significantly different between the 2 groups (higher in the operative group) with P. values of <0.005. The age at the time of CR, the distance from most upper metaphysis to H-line (h), the distance from center of femoral head ossific nucleus to midline (X1), the Smith's h/b ratio, the distance from center of femoral head ossific nucleus to H-line (Y) and acetabular angle (T) were also found to be significantly higher in the operative group with P. values of <0.01.
The mean values for the measurements were analyzed for the operative subgroups; open reduction, pelvic osteotomy, femoral shortening osteotomy and any of their combinations. There was no significant difference between the values.

Table 1: Type of treatment for unilateral and bilateral dislocations.

Type of Treatment	Type of dislocation No. (%)			Total (Patients)	Total (hips)
	Unilateral	Bilateral			
		Patients	Hips		
Conservative	16 (44.4%)	11 (61.1%)	22 (61.1%)	27(50%)	38 (52.8%)
Operative	20 (55.6%)	7 (38.9%)	14 (38.9%)	27(50%)	34 (47.2%)
Total (hips)	36 (100%)	18 (100%)	36 (100%)	54(100%)	72 (100%)

Table 2: Types of operative treatment.

Type	No.
Pelvic osteotomy only	14 (41.2%)
Open reduction and pelvic osteotomy	17 (50%)
Open reduction, pelvic osteotomy and femoral osteotomy	3 (8.8%)
Total	34 (100%)

Table 3: Age and radiographic measurements among children with DDH according to the type of treatment.

Measurement (in millimeters)	Conservative		Operative		p-value
	Mean Value	Standard Deviation	Mean Value	Standard Deviation	
Age (months)	16.88	3.41	19.24	3.36	0.0012*
X1	57.65	6.57	60.94	4.26	0.0041*
X2	-7.45	6.09	-9.90	7.23	0.0864
Y	-2.76	5.13	-5.30	3.58	0.0058*
D1	7.53	2.58	6.37	2.28	0.0241*
D2	5.35	2.02	5.00	1.78	0.3755
c	48.60	5.88	52.30	3.69	0.0003*
h	0.38	5.71	-2.79	3.84	0.0018*
HT	21.19	4.03	23.87	2.69	0.0002*
b	49.84	4.64	49.40	3.73	0.6122
A1	18.28	3.82	17.93	2.83	0.6119
A2	0.50	0.88	0.25	0.51	0.0860
T (degrees)	40.60	7.48	44.28	5.80	0.0086*
c/b ratio	0.98	0.12	1.06	0.09	0.0003*
h/b ratio	0.006	0.118	-0.054	0.080	0.0040*

* Statistically significant results (t-test)

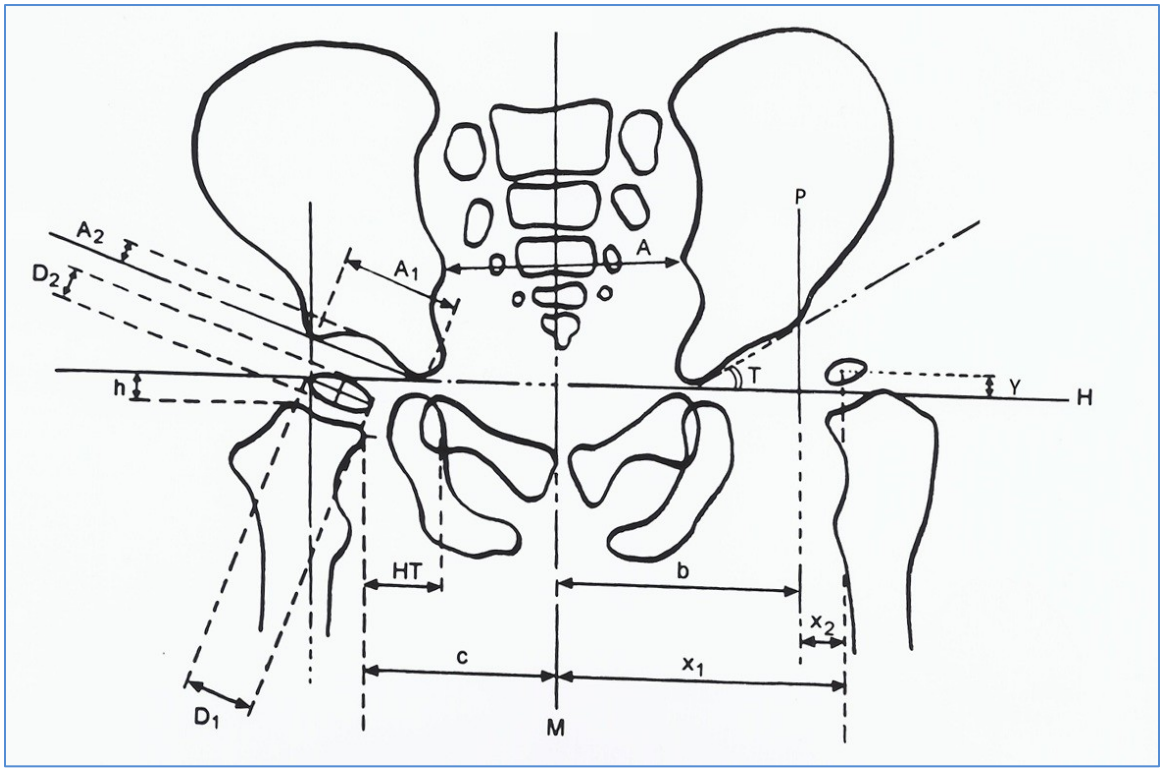

Figure 1: *A schematic diagram with the lines and angles drawn for measurements.*

Discussion

Radiological parameters are extremely useful in the diagnosis and management of DDH[17]. Various measurements have been used to help in the radiographic assessment of DDH. This study confirms that various radiographic measurements could be valuable in deciding the method of treatment in cases of DDH during the age between 12 and 24 months.

There is a significant difference in age between the 2 groups as expected since the older the age at the time of diagnosis the more likely there will be a need for operative management[15,16]. It is worthwhile noting that all measurements of lateralization (i.e. X_1, HT, c, and c/b ratio) and the superior migration measurements; (i.e. Y, h and h/b ratio), at the time of initial assessment were all significantly higher in the operative group (Table 3). This indicate that the further lateral and the further superior was the femoral head at the time of initial assessment the more likely the CR will fail and the hip will need operative intervention. This agrees with what was reported by Sankar et al[15], regarding the superior migration, and Smith et al[9], in regard to c/b and h/b ratios. The pre-reduction acetabular angle was significantly higher in the operative group which agrees with Kim et al[22].

Several studies were carried out to define prognostic factors or predictors of the outcome from assessing pelvic radiographs[3,5-12]. Most of these studies were carried out for diagnostic purposes before treatment or after CR to predict the possible final outcome[11,13,14] or during the assessment for the need of certain procedure like femoral shortening osteotomy[15]. This study was conducted trying to assess the value of certain radiographic measurements of pelvic radiographs of DDH patients to develop an early and reliable radiological guide for the prediction of the method of treatment that should be used; whether conservative or operative, in the age group (12 -24 months) when both options are valid. Having more than one radiological measurement is

important as many of these measurements can be difficult to measure on certain radiographs, because of positioning or unclear bony land marks which could introduce errors[22].

The current study suggests that it could be possible to use specific radiographic measurements in DDH cases to determine the most probable method of management will be needed; conservative versus operative. The measurement of the width of the femoral head ossific nucleus (D_1) was significantly higher in the conservative group; (P=0.0241). This could indicate that the larger the size of the femoral head ossific nucleus at the time of initial assessment, the more the chances of success of the CR will be in the same age group. The higher values of measurements from the pre-reduction radiograph for the femoral head lateralization; (X1, c, HT and c/b ratio), those that measure superior migration of the femoral head; (Y, h and h/b ratio) and followed by the acetabular angle (T), were found in this study to be the best indicators for the need for operative treatment after CR. Our data may be helpful for surgical planning, and counseling families before commencing any treatment. Although specific figures could not be reached at this stage, a planned prospective study using discriminant analysis or multivariable regression, for the measurements from this study to evaluate the outcome of CR, together with prediction of different types of surgical interventions could be more useful with larger sample size and a longer follow up.

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