

Predictive Factors in Children with Hip Dysplasia at Bone Maturity: A Longitudinal Study with an Average Follow-up of 12 Years

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INTRODUCTION:

Acetabular dysplasia (AD) significantly increases the risk of developing osteoarthritis of the hip. Salter-innominate osteotomy (SIO) is commonly performed as a preventive surgical intervention. Standard indications for SIO around age 5 include an acetabular index (AI) of $\geq 30^\circ$ or a centeredge (CE) angle of $< 5^\circ$. However, we sometimes encounter cases in which AD persists despite not meeting these criteria. The purpose of this study was to identify risk factors for AD at skeletal maturity and establish cutoff values of relevant radiographic parameters assessed at age 5.

METHODS:

Patients diagnosed with developmental dysplasia of the hip (DDH) who underwent closed reduction since 1995 and were followed without corrective surgery until skeletal maturity were analyzed. AD at maturity was defined as having a CE $< 20^\circ$ or an acetabular roof obliquity (ARO) $> 15^\circ$. The factors evaluated included age at initial consultation, sex, affected side, family history, and radiographic parameters (CE angle, AI, modified lateralization distance (LD), and the presence of Os acetabuli). Differences between patients with DDH and control were assessed using t tests, and logistic regression analysis were conducted to identify risk factors.

RESULTS:

A total of 250 hips were included. Of these, 51 hips (20%) had residual AD at skeletal maturity. Significant risk factors for residual AD were left side involvement, absence of Os acetabuli, lower CE angle, and increased modified LD. Optimal cutoff values at age 5 were a CE angle $\leq 8.0^\circ$ and a modified LD ≥ 7.4 mm. Combining the parameters (CE $\leq 8^\circ$ and modified LD ≥ 7.4 mm) yielded the highest positive predictive value (PPV), of 65.5%. In contrast, the PPV using traditional surgical indications at age 5 (CE $\leq 5^\circ$ or AI $\geq 30^\circ$) was only 36.3%.

DISCUSSION AND CONCLUSION:

Risk factors for AD after skeletal maturity included left-sided, absence of Os acetabuli, a lower CE angle ($\leq 8.0^\circ$), and a high modified LD (≥ 7.4 mm). Given the limited predictive value of radiographic measurements, surgical decision should be made cautiously. Magnetic resonance imaging may enhance decision making regarding interventions, such as Salter osteotomy.

Table 1. A comparison of patient characteristics and 5-year parameters between two groups

Parameter	AD (n=51)	Control (n=199)
Age at initial consultation (years)	1.2	1.1
Sex (male/female)	25/26	103/96
Affected side (left/right)	28/23	112/87
Family history (yes/no)	12/39	58/141
Os acetabuli (present/absent)	38/13	181/18
CE angle ($^\circ$)	10.5	12.5
AI ($^\circ$)	28.5	28.5
Modified LD (mm)	7.8	7.5

Table 2. Multivariate analysis for predicting acetabular dysplasia at skeletal maturity

Parameter	OR	95% CI	P-value
Affected side (left)	2.1	1.1-4.0	0.02
Absence of Os acetabuli	3.5	1.8-6.9	<0.001
Lower CE angle ($\leq 8^\circ$)	2.8	1.5-5.2	0.001
Higher modified LD (≥ 7.4 mm)	2.2	1.2-4.0	0.008
AI $\geq 30^\circ$	1.1	0.6-1.8	0.70
Family history	1.0	0.6-1.6	0.95
Age at initial consultation	1.0	0.9-1.1	0.35
Sex	1.0	0.7-1.4	0.80
Constant	-2.5	-3.5 to -1.5	<0.001

Table 3. The cutoff value of risk factor for acetabular dysplasia at skeletal maturity

Parameter	Cutoff value	AI	CE	Modified LD
AI $\geq 30^\circ$	30	30	5	7.4
CE $\leq 5^\circ$	5	5	5	7.4
Modified LD ≥ 7.4 mm	7.4	7.4	7.4	7.4
AI $\geq 30^\circ$ or CE $\leq 5^\circ$	30	30	5	7.4
CE $\leq 8^\circ$ or Modified LD ≥ 7.4 mm	8	8	8	7.4

Table 4. Positive and Negative predictive values at 5 years old

Parameter	Acetabular Dysplasia (11 hips)		Normal (189 hips)	
	Positive	Negative	Positive	Negative
AI $\geq 30^\circ$ or CE $\leq 5^\circ$	11 hips (36.3%)	23 hips	80 hips (42.3%)	109 hips (57.7%)
CE $\leq 8^\circ$ or Modified LD ≥ 7.4 mm	23 hips (65.5%)	23 hips	80 hips (42.3%)	109 hips (57.7%)

Table 5. Inter- and intra-observer reliability

Parameter	CE	AI	ARO	Sharp
Inter-observer reliability	0.87-0.94	0.70-0.91	0.70-0.88	0.61-0.88
Intra-observer reliability	0.73-0.93	0.56-0.83	0.70-0.88	0.70-0.91