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Acetabular morphometry for determining hip dysplasia in the Singaporean population

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ABSTRACT

Purpose. To assess and evaluate the usefulness of 7 morphological measurements of the acetabulum in establishing the prevalence of acetabular dysplasia in the Singaporean population.

Methods. Standardised plain anteroposterior radiographs of 522 hip joints of 261 asymptomatic patients (mean age, 60 years; range, 16–99 years) were evaluated. The 7 morphological measurements were centre-edge angle, acetabular angle, depth-to-width ratio, roof obliquity, extrusion index, lateral subluxation, and peak-to-edge distance.

Results. 19 (7.3%) patients were acetabular dysplastic (centre-edge angle of <20 degrees). The mean centre-edge angle was 31.2 degrees (range, 5–52 degrees), acetabular angle 39.46 degrees (range, 10–58 degrees), depth-to-width ratio 0.32, roof obliquity 7.86 degrees, extrusion index 0.18, lateral subluxation 9.9 mm, and the peak-to-edge distance 15.65 mm.

Conclusion. Centre-edge angle was the most useful measurement and correlated significantly with acetabular angle, extrusion index, peak-to-edge distance, and roof obliquity. These preliminary results show a relatively higher rate (7.3%) of acetabular dysplasia in the Singaporean population, compared with other similar but larger Asian studies performed in Hong Kong (1.1%) and Korea (1.8%).

Key words: *acetabulum; osteoarthritis, hip; radiography; Singapore*

INTRODUCTION

Acetabular dysplasia is a condition wherein the acetabular roof is underdeveloped and remains vertically oriented and shallow, which results in a smaller surface available for weight-bearing. The weight-bearing surface therefore receives a much larger force per unit area during walking and may

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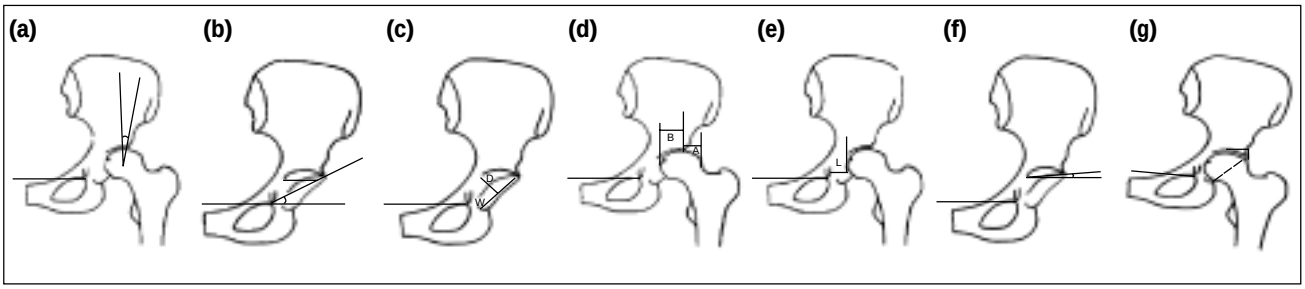

Figure The 7 morphological measurements for acetabular dysplasia are **(a)** centre-edge angle, **(b)** acetabular angle, **(c)** depth-to-width ratio, **(d)** extrusion index (A/A+B), **(e)** lateral subluxation, **(f)** roof obliquity, **(g)** peak-to-edge distance.

experience early degeneration. The criteria for determining a dysplastic hip have been defined previously.[1,2] In these studies, radiographic measurements of the centre-edge angle were used to formulate diagnostic criteria for differentiating a normal hip from a dysplastic hip.

The centre-edge angle was first described by Wiberg in 1939. It is formed by the intersection of a line drawn through the midpoint of the femoral head and a second line drawn from the centre of the femoral head to the upper outer margin of the acetabulum. Values of >25° were considered normal, whereas those of <20° were associated with acetabular dysplasia.[3] The mean centre-edge angle of a normal hip was 37° for men and 35° for women.[1,2]

Although the centre-edge angle is widely used to determine dysplasia, its measurement can sometimes be affected by the pathological condition of the femoral head, making it difficult to locate the centre. The angle becomes even more difficult to determine if the hip is subluxed.[4] Other measurements are thus worth considering: acetabular angle,[4] depth-to-width ratio, extrusion index, lateral subluxation, and peak-to-edge distance have been used to evaluate hip joint morphometry.[5–8] These measurements can help assess the degree of acetabular dysplasia.[5,7] Therefore, the pelvic anteroposterior radiograph plays an important role in the assessment of the dysplastic hip.[6,9] Acetabular dysplasia is defined by either a centre-edge angle of ≤25° (severe if ≤20°) or an acetabular depth of <9 mm.[7,10] Although many studies have been performed to determine the criteria for dysplasia using the centre-edge angle, very few have considered other radiographic measurements.

The present study aimed to measure and evaluate the morphological norms of the acetabulum of the Singaporean population in order to better understand the correlation between various morphological measurements and criteria for diagnosing hip dysplasia.

MATERIALS AND METHODS

From March to May 2000, 261 patients (mean age, 60 years; range, 16–99 years) received pelvic radiographic examinations in the National University Hospital in Singapore. Patients with hip pain on presentation were excluded. Most were trauma patients; some had displaced fractures of the femoral neck wherein the femoral head remained in its original position; and some had undisplaced intertrochanteric fractures or fractures of the pubic rami. This selection of patients was prospective but non-randomised.

Standardised pelvic radiograph was taken with the patient in a supine position. The X-ray beamed from a height of one meter and focused over the pubic symphysis. A transparent template with circles and scales was placed directly over the radiograph to correctly identify the centre of the femoral head and to facilitate and elucidate the various measurements and angles. This obviated the need to first make a tracing of the hip joint and then take a measurement—a practice prone to errors.

After identifying the centre of the femoral head, a vertical line was drawn through this point. The angle subtended by this line to the line joining the centre to the outermost edge of the acetabulum was the centre-edge angle (Fig. a). A measurement of <20° was considered dysplasia.[3] The angle subtended by the line joining the outermost ossified portion of the acetabulum to the pelvic teardrop was the Sharp's acetabular angle (Fig. b). A measurement of >43° was considered dysplasia.[4] Depth-to-width ratio was measured using Heyman's method.[8] Width was measured by a line joining the lateral edge of acetabulum to the pelvic teardrop. The depth was measured by another line perpendicular to this line at the point of the greatest acetabular depth (Fig. c). The extrusion index was a ratio of 2 measurements: the horizontal distance between the vertical lines

Table 1
Mean and standard deviation (SD) of the 7 measurements in 522 hip joints

	Centre-edge angle	Acetabular angle	Depth-to-width ratio	Roof obliquity	Extrusion index	Lateral Subluxation (mm)	Peak-to-edge distance (mm)
Mean	31.25º	39.46º	0.32	7.86º	0.18	9.99	15.65
SD	7.98º	6.04º	0.06	6.55º	0.08	2.71	3.04

Table 2
Comparison of the 7 measurements between sexes

	Centre-edge angle	Acetabular angle	Depth-to-width ratio	Roof obliquity	Extrusion index	Lateral Subluxation (mm)	Peak-to-edge distance (mm)
Male							
Mean	30.63º	39.85º	0.32	7.79º	0.20	10.15	15.58
SD	8.19º	6.00º	0.06	6.46º	0.08	2.84	3.18
Female							
Mean	33.54º	38.25º	0.31	7.78º	0.14	9.48	15.95
SD	7.14º	5.98º	0.06	6.81º	0.07	2.23	2.59
Total							
Mean	31.25º	39.46º	0.32	7.86º	0.18	9.99	15.65
SD	7.98º	6.04º	0.06	6.55º	0.08	2.71	3.04
p value	**0.01**	**0.06**	**0.32**	**0.99**	**0.00**	**0.08**	**0.39**

drawn through the medial and lateral edge of the femoral head, and the distance between the lateral edge and outer edge of the acetabulum (Fig. d). Lateral subluxation was the distance between the teardrop and the medial-most edge of the femoral head (Fig. e). Roof obliquity was the angle subtended by the line connecting the inferior-most edge of the roof of the acetabulum to the lateral-most edge of the acetabulum with a parallel horizontal line (Fig. f). A measurement of <20º was considered dysplasia.[11] Peak-to-edge distance was the horizontal distance between the lateral edge of the acetabulum and the most vertical point of the sourcil (Fig. g).

All values were recorded on a Microsoft Excel spreadsheet. Analysis of variance between age and sex was performed, and Pearson's correlation coefficient was used to measure the relationship between various measurements using Statistical Package for the Social Sciences (Windows 2000; SPSS version 13, Chicago [IL], US). A p value of <0.05 is considered significant.

RESULTS

19 (7.3%) of the 261 patients with centre-edge angles of <20º were considered dysplastic. The mean and standard deviation of the 7 measurements are shown in Table 1. There was a significant difference between sexes in the centre-edge angle and the extrusion index ($p<0.05$, Table 2). Age was a significant contributing factor for the extrusion index and the acetabular angle ($p<0.05$), but not for the other measurements (Table 3). The centre-edge angle was correlated with other measurements in all patients and in the dysplastic group alone. Centre-edge angle correlated strongly with acetabular angle, roof obliquity, extrusion index, and peak-to-edge distance in the dysplastic group ($p<0.01$, Table 4).

DISCUSSION

The prevalence of acetabular dysplasia has been reported as 3.3% in Nigerian men,[12] 3.4% in white females in Britain,[13] 4.5% in Chinese men,[14] 3.8% in another British population,[15] 1.8% in the Korean population,[7] and 2.4% in the Turkish population.[5] The prevalence of acetabular dysplasia in the present Singaporean study was 7.3%, which was much higher than the Korean, Chinese, and Turkish populations. This suggests that hip joint morphometry may show geographical differences.

The mean centre-edge angle reported by Wiberg was 36º in a Swedish population, 35º in a United States population,[11] and 36.2º (standard deviation [SD], 6.9º) in a British population.[10] Fredensborg[3]

Table 3
Influence of age on the 7 measurements

Age (Years)	Centre-edge angle	Acetabular angle	Depth-to-width ratio	Roof obliquity	Extrusion index	Lateral Subluxation (mm)	Peak-to-edge distance (mm)
10–19							
Mean	28.00º	41.89º	0.31	8.89º	0.22	11.33	15.33
SD	5.52º	3.44º	0.03	4.59º	0.05	2.14	2.78
20–29							
Mean	28.76º	41.40º	0.32	6.88º	0.23	10.50	15.44
SD	5.74º	3.62º	0.03	5.70º	0.06	3.12	2.86
30–39							
Mean	30.05º	41.43º	0.34	6.81º	0.20	9.64	15.56
SD	8.70º	5.43º	0.05	6.65º	0.10	2.50	2.99
40–49							
Mean	32.67º	38.28º	0.31	7.12º	0.20	9.79	17.03
SD	6.54º	6.64º	0.05	5.60º	0.09	2.55	3.43
50–59							
Mean	31.79º	36.00º	0.35	7.50º	0.19	11.18	16.21
SD	12.10º	11.43º	0.12	8.75º	0.10	3.90	4.17
60–69							
Mean	32.04º	38.78º	0.31	8.96º	0.21	9.21	14.67
SD	8.95º	5.61º	0.04	7.96º	0.08	2.67	3.07
70–79							
Mean	32.15º	39.67º	0.31	7.47º	0.16	9.99	15.91
SD	8.18º	4.74º	0.05	6.95º	0.07	2.87	2.91
80–89							
Mean	32.34º	38.23º	0.32	8.14º	0.16	9.72	15.82
SD	7.31º	6.49º	0.08	6.02º	0.06	2.28	2.83
90–99							
Mean	28.91º	39.55º	0.28	12.64º	0.17	10.86	13.73
SD	7.15º	4.50º	0.03	4.78º	0.08	2.62	2.78
p value	**0.382**	**0.03**	**0.054**	**0.352**	**0.003**	**0.259**	**0.168**

Table 4
Correlation of centre-edge angle with other measurements among dysplastic patients

Patients with centre-edge angle of <20º, n=19	Acetabular angle	Depth-to-width ratio	Roof obliquity	Extrusion index	Lateral Subluxation (mm)	Peak-to-edge distance (mm)
Mean	47.58º	0.29	19.47º	0.31	11.05	10.55
SD	4.85º	0.08	4.77º	0.06	2.00	2.21
Correlation (r^2)	-0.61	0.06	-0.50	-0.86	0.01	0.57
p value	**0.0089**	**0.013**	**0.0095**	**0.0054**	**0.018**	**0.0032**

measured another Swedish population and reported a mean angle of 35º (SD, 6.6º). Among the Japanese population, the mean centre-edge angle has been reported at various notably lower measurements: 32.2º (SD, 6.4º)[16] and 30º (SD, 6.2º).[17] The Korean population were reported to have centre-edge angles of 32.6º (SD, 5.7º).[7]

The acetabular angle described by Sharp[4] is one of the most common radiographic measurements used to assess acetabular dysplasia. Nakamura et al.[16] reported a mean acetabular angle of 38.0º (SD, 3.6º) [males, 37.3º (SD, 3.7º); females, 38.6º (SD, 3.4º)] among the Japanese population. Stulberg and Harris.[1] reported the mean acetabular angle of 32.2º in white males, whereas Harris[2] reported 32.1º in white females. Han et al.[7] reported the mean acetabular angle among Koreans to be 37.0º (SD, 3.7º) [males, 36.5º (SD, 3.5º); females, 37.5º (SD, 3.8º)]. In the present Singaporean study, the mean acetabular angle was 39.46º (SD, 6.04º) [males, 39.85º (SD, 6.00º); females, 38.25º (SD, 5.98º)]. This is greater than that of other Asian populations previously published.

There was a significant association among the dysplastic patients between the centre-edge angle

and acetabular index, extrusion index, peak-to-edge distance, and roof obliquity ($p<0.01$). Although the number of dyplastic hip is small (n=19), this provides a rationale for considering these measurements as complementary methods in the diagnosis of acetabular dysplasia.

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