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masood umer
masood.umer@aku.edu

Yasir J Sepah
Aga Khan University

Sharjeel Asif
Aga Khan University

Iqbal Azam Syed
Aga Khan University, iqbal.azam@aku.edu

Muhammad Umar Jawad
Aga Khan University

Acetabular morphometry and prevalence of hip dysplasia in the South Asian population

Masood Umer,[1] Yasir J. Sepah,[1] Sharjeel Asif,[3] Iqbal Azam,[2] Muhammad Umar Jawad[4]

[1]Department of Orthopaedic Surgery, The Aga Khan University, Karachi, Pakistan; [2]Department of Biostatistics and Community Health Sciences, The Aga Khan University, Karachi, Pakistan; [3]Institute of Orthopaedic Surgery, Karachi; [4]Department of Orthopaedic Surgery, University of Miami, FL, USA

Abstract

We carried out a cross-sectional study to measure the association of the seven acetabular parameters with pelvic morphometry and prevalence of hip dysplasia in our population. Convenience sampling was carried out and 250 consecutive patients who came to AKUH for intravenous pyelogram and had no complaints in the region of the hip joint were enrolled in the study. Post-micturition standardized plain antero-posterior pelvic radiographs of 250 asymptomatic adults (500 hip joints) was studied. There were 136 males (54.4%) and 114 females (45.6%). Mean age of our study population was 38 years (15-78 years). The average center edge angle was 35.5±6.6° standard deviation (SD), acetabular angle was 37.76±4.37°, depth to width ratio was 0.31±4.6°, roof obliquity was 10.6±6.2°, extrusion index was 0.1±5.8, lateral subluxation 8.9±2.7 mm, and peak to edge distance 17±3.98 mm. There was significant influence ($p<0.05$) of age in all angles except depth to width ratio. A total of seven hip joints (1.4%) were dysplastic with CE angle <25° while four of the seven hips were severely dysplastic with CE angle <20°. In the dysplastic group there was significant correlation ($p<0.05$) of CE angle with acetabular angle, depth to width ratio, extrusion index and peak to edge distance. Prevalence of hip dysplasia was found to be very low in our population. These results are consistent with the findings of studies carried out in other Asian countries.

Introduction

Osteoarthritis (OA) of the hip joint is an important cause of pain and disability, especially in the elderly.[1] Its prevalence appears to vary widely among different populations from an estimated 1-4% in adult black Africans to 7-24% in the white population.[2] Epidemiological studies suggest that OA of the hip joint is multifactorial in etiology and several risk factors have been identified.[3] These include increasing age, obesity, trauma and occupational physical activity.[4] In addition, clinical studies of patients with hip OA suggested that structural abnormalities of the hip that are present at birth or develop in children may result in an accelerated or premature joint degeneration. Examples of these include congenital hip subluxation/dislocation, slipped capital femoral epiphysis, and Legg-Calve-Perthe's disease. A more common structural abnormality that may predispose to hip OA is acetabular dysplasia. Based on case series of patients with hip OA, Murray and Harris estimated that between 25 to 40% of hip OA may be caused by sub-clinical acetabular dysplasia.[5,6]

Previous studies have reported that Southern Chinese, South African black and East Indian populations have a much lower incidence of osteoarthritis of the hip joint than European or American white populations.[7-10] Primary osteoarthritis of the hip joint is very rare in Asians. Most people have secondary hip OA caused by a number of affections, mainly acetabular dysplasia.[7] Various population based studies have found a high incidence of dysplasia in the Japanese and Chinese populations. Similar studies carried out in the West have revealed a low incidence of acetabular dysplasia in the Caucasian population.[8,9,11]

The pelvic anteroposterior (AP) radiograph plays an important role in the assessment of the dysplastic hip.[12,13] Acetabular dysplasia is defined in two separate ways; a center-edge angle (CEA) of 25° or less, or an acetabular angle of 43° or more.[14,15] Acetabular dysplasia is considered to be severe, if the CEA is 20° or less. The methods of measuring anatomical morphology of the acetabulum from plain radiographs of the hip joint include the following: CEA of Wiberg, acetabular angle of Sharp, acetabular index of depth to width described by Heyman and Herndon, acetabular roof obliquity of Massie and Howorth, femoral head extrusion index, lateral subluxation and peak to edge distance.[7,13,14,16] By applying these parameters, we can evaluate the morphology of the acetabulum and the degree of acetabular dysplasia.

There has been no study of acetabular morphometry in South Asia. We measured seven different parameters of acetabulum in the local hospital based asymptomatic population. Our aim was to find out the prevalence of acetabular dysplasia in our population. We also tried to assess the individual strength of correlation of these seven parameters in identifying acetabular dysplasia.

Correspondence: Masood Umer,
Associate Professor of Orthopaedics, Department of Orthopaedic Surgery, The Aga Khan University Stadium Road, Karachi-74800, Pakistan
E-mail: masood.umer@aku.edu

Key words: center edge angle, acetabular angle, depth to width ratio, roof obliquity, extrusion index, peak to edge distance, lateral subluxation.

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Materials and Methods

A cross-sectional, hospital based study was conducted in the Orthopaedic Division, Department of Surgery, at the Aga Khan University Hospital, Karachi from November 2006 to May 2007. All patients who came for intravenous pyelogram with no complaint around the hip region were included in the study. An informed written consent was taken from all the volunteers who participated in the study. Since no surgical intervention was to be carried out, an approval from an ethical review committee was not obtained. Patients with radiological evidence of surgery around the hip joint, tumors around the hip joint, and old fractures of the pelvis, acetabulum or proximal femur were all excluded from the study. Convenience sampling was carried out and the first 250 patients who came to our radiology department for an intravenous pyelogram were registered for the study. AP radiograph was used to measure the seven parameters of acetabulum. The post-micturition pelvic AP radiographs of 250 adults (500 hip joints) were studied. To obtain a constant pelvic radiography, the distance between the X-ray tube and the film was set at 40 inches, and the beam was projected 5 cm proximal to the symphysis pubis. There were

136 (54.4%) males and 114 (45.6%) females. The mean age of the study population was 38 years (range, 15-78 years). Radiographs were measured by the same person who had previously measured radiographs for a similar study in the Singaporean population.[17] The morphology of acetabulum was assessed by measuring the center edge angle (CEA), acetabular angle, acetabular roof obliquity, acetabular depth to width ratio, femoral head extrusion index, lateral subluxation and peak to edge distance. A comparison of normal and dysplastic hip joint is shown (Figure 1). The acetabular angle is formed by the angle between a line connecting the left and right sides of the pelvic tear drop and a line joining the lateral edge of the acetabular roof and the inferior tip of the pelvic tear drop (Figure 2A). The CE angle is formed by the angle between a line connecting the center of the femoral head and lateral margin of the acetabular roof and a perpendicular line joining the center of the femoral head (Figure 2B). The center of the femoral head was determined with the aid of a transparent plastic sheet marked with concentric Moose circles. Peak to edge distance (Figure 2C) is a horizontal line parallel to the inter-tear drop line and is drawn across the sourcil. The horizontal distance from the highest point of the sourcil to the acetabular edge is then measured. Depth to width ratio is the ratio of distance between the deepest part of acetabulum to distance from the upper and lower margin of acetabulum (Figure 2D). Femoral head extrusion index is a percentage that is calculated by dividing the horizontal distance of the part of the femoral head that is lateral to the edge of acetabulum (A) by the total horizontal width of femoral head (A+B) and multiplying by 100 ([A/(A+B)] x 100) (Figure 2E). Lateral subluxation is measured from the lateral edge of the teardrop to the most medial portion of the femoral head (Figure 2F). The acetabular roof obliquity is defined as the angle between a line connecting the lateral edge of the acetabular roof and the inferior edge of sourcil and a line parallel to both the pelvic tear drops (Figure 2G). The data was analyzed using the SPSS version 10 program. The study population was divided into 7 subgroups, according to their age. The minimum age was 15 years and the maximum was 78 years. We compared our measurement in both sexes by applying Student's t-test. The relationship between the individual measurements was evaluated by Pearson correlation coefficient. A sample of 239 hips achieves 80% power with anticipated correlation coefficient of 0.18 or more with a level of significance of 0.05 with a two-sided hypothesis. Maximum sample size to achieve both the objectives of our study was calculated to be 239. Moreover post-hoc power was determined and was found to be more than 80% for all except subluxation vs. CE angle (26.2%).

Results

The mean center edge angle was 35.5° (SD±6.6°), mean acetabular angle was 37.8° (SD±4.37°), mean depth to width ratio was 0.3(SD±0.05), mean roof obliquity was 10.6° (SD±6.2°), mean extrusion index was 0.13 (SD±0.05), mean lateral subluxation was 8.9 mm (SD±2.7 mm) and mean peak to edge distance was 17 mm (SD±4 mm). Gender comparison showed a significant difference ($p<0.05$) in all measurements (Table 1). There was significant influence ($p<0.05$) of age on center edge angle, extrusion index, roof obliquity, lateral subluxation, acetabular angle and peak to edge distance. There was significant correlation ($p<0.05$) of CE angle with all other angles except lateral subluxation (Table 2). The critical values for the diagnosis of acetabular dysplasia were defined as a CE angle of 25° or less or an acetabular angle of 43° or more. There were 7 hip joints (1.4%) out of the total 500 hip joints which were dysplastic. All 7 were females. Correlation of CE angle with all other measurements in dysplastic group is shown in Table 3. There was significant correlation ($p<0.05$) of CEA in the dysplastic group with acetabular angle and peak to edge distance.

Association between age and center edge, acetabular angle, root obliquity, extrusion index, lateral subluxation, depth to width ratio, peak to edge distance was observed. A very strong negative association was observed between age and acetabular angle (r=-0.825), similarly, strong positive association with center edge (r=0.608), strong negative association with depth to width ratio (r=-0.748), moderate negative association with extrusion index (r=-0.498), weak negative association of age with root obliquity (r=-0.221) and lateral subluxation (r=0.384) and finally very weak negative association with peak to edge distance (r=-0.011).

Figure 1. Comparative X-rays of a normal (A) and a dysplastic hip (B).

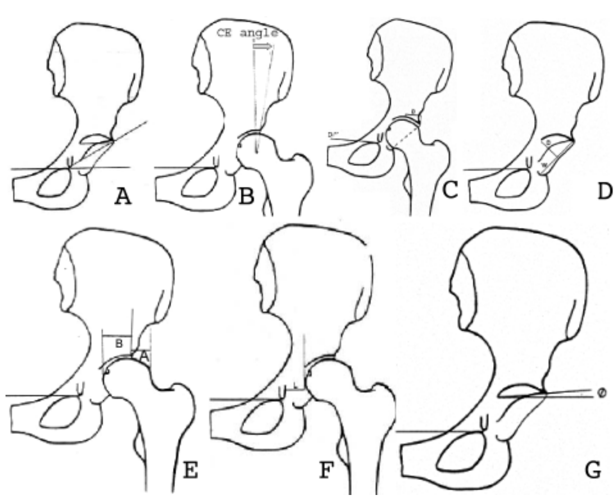

Figure 2. Schematic drawing of the hip joint showing Sharp's acetabular angle (A), center-edge angle (B), peak to edge distance (C), depth by width ratio (D), extrusion index; A/A+B (E), lateral subluxation (F) and roof oliquity (G).

Discussion

Osteoarthritis of the hip joint has been generally divided into primary osteoarthritis with no pre-existing cause and secondary osteoarthritis which usually follows a pre-existing condition. The concept of idiopathic osteoarthritis of the hip is based on the premise that this condition, which develops in adult life, results from an undetermined abnormality of the cartilage or the subchondral bone, which is abnormally superimposed on grossly normal growth and development of the hip. There is now substantial evidence from different areas of the world that there is no disease that warrants the designation of primary osteoarthritis of the hip or, if it does exist, it is quite uncommon.[5,6]

Several investigators have reported that primary osteoarthritis is a rare occurrence among Orientals.[18] The first study on the occurrence of hip osteoarthritis in Asia was conducted by Hoaglund *et al.* in 1973.[19] In this study, 500 males and females outpatients in Hong Kong had pelvic radiographs for study purposes. Five (1%) people in the sample had radiographic evidence of Kellgren and Lawrence grade 3 or 4 hip osteoarthritis. The author compared their results in the 55-64 years old age group with the figures from a similar survey in Britain and found a lower incidence of hip osteoarthritis in Hong Kong compared to Britain. These results were confirmed by a recent large scale study conducted by Lau *et al.* in Hong Kong.[2] Again the prevalence of 3 or more radiographic features of hip osteoarthritis was low (0.3% as compared to the British population (1.5%).[20] Harris compiled roentgen graphic measurements of normal hip joints of Caucasians and formulated diagnostic criteria to differentiate a normal hip from a dysplastic hip.[5] They selected four criteria as the most valuable: center-edge (CE) angle; acetabular angle, roof obliquity, acetabular depth. Their study showed that average CE angle of a normal hip was 37° for men and 35° for women, and that the average acetabular angle was 33° for men and 35° for women. Developmental dysplasia of the hip joint is one of the most a common causes of osteoarthritis of the hip joint.[5] Acetabular dysplasia is the underdevelopment of the acetabular roof; consequently, the surface available for weight bearing is smaller than normal. During walking, this small weight-bearing surface, receives a much larger pressure per unit area resulting in early degeneration. It has been suggested by several studies that acetabular morphometry may show geographical differences. Center edge angle, acetabular angle, roof obliquity, depth to width ratio, extrusion index lateral subluxation and peak to edge distance were used in most studies to evaluate the acetabular morphometry.[7,14,15] These parameters also help to assess the degree of acetabular dysplasia.[7,14]

Table 1. Gender comparison.

	Male		Female		p	Total (n=500)	
	Mean	SD	Mean	SD		Mean	SD
Roof obliquity	11.68	6.0	9.19	6.24	<0.001	10.55	6.23
Extrusion index	0.13	0.05	0.11	0.06	<0.001	0.13	0.05
Lateral subluxation	9.48	2.82	8.14	2.45	<0.001	8.87	2.74
Peak to edge distance	17.92	3.76	15.82	3.94	<0.001	16.97	3.98
CE angle	36.28	6.44	34.57	6.78	0.004	35.50	6.65
Depth to width ratio	0.319	0.04	0.309	0.04	0.018	0.31	0.04
Acetabular angle	37.31	4.27	38.28	4.43	0.013	37.76	4.37

Table 2. Correlation of CEA with other angles.

	Acetabular angle	Roof obliquity	Extrusion index	Depth to width ratio	Peak to edge distance	Lateral Subluxation
CEA Mean = 35.5 SD = 6.6						
Mean	37.76	10.55	0.13	0.31	16.97	8.87
SD	4.37	6.23	0.05	0.04	3.98	2.74
Correlation R^2	0.393	0.259	0.482	0.128	0.358	0.007
p	<0.001	<0.001	<0.001	<0.001	<0.001	0.066

Table 3. Correlation of CEA in dysplastic group with other angles.

	Acetabular angle	Depth to width ratio	Lateral subluxation	Roof obliquity	Extrusion index	Peak to edge distance
CE angle < 20						
Mean	46.50	0.24	7.25	6.75	0.28	8.25
SD	1.91	0.04	3.77	4.57	0.04	6.07
Correlation r^2	0.18	0.18	0.29	0.39	0.40	0.45
p	0.01	0.57	0.45	0.37	0.36	0.01

The most commonly used parameter, CE angle was first described by Wiberg in 1939. Values greater than 25° were considered normal where as values less than 25° were considered abnormal, and values below 20° were associated with acetabular dysplasia.[21] The average CE angle reported by Wiberg was 36°.[22] Massie and Howarth[23] in a study performed on US population, reported 35°.[22] Nakamura in Japanese population, reported 32.2±6.4° SD.[24] Yoshimura and Croft in a study performed on British people, reported 36.2±6.9° SD.[15] Hoaglund,[8] in a Hong Kong population, reported 35.9±6.5° SD. Fredensborg in a study performed on Swedish people, reported 35°±6.6° SD.[21] Fuji in a study performed on a Japanese population, reported 30±6.2° SD.[25] Han and associates in their study performed on a Korean population, reported 32.6±5.7° SD.[14] In our study, the average CE angle was 35.5°± 6.6° (36.3±6.4° in males, 34.6±6.8° in females). The CE angle of our population is greater than the CE angle values reported in the Japanese and Korean population by Nakamura, Fuji and Han whereas CE angle of our population is close to the CE angle reported by Massie and Howarth for a US population, Yoshimura and Croft for a British population and Fredensborg for a Swedish population. The acetabular angle described by Sharp is also a common radiographic parameter used to assess acetabular dysplasia.[26] Average acetabular angles reported by Nakamura in a Japanese population was 38±3.6° SD. Stulberg and Harris, in white people, reported 32°.[5,27] Han, in a Korean population, reported 37±3.7° SD.[14] In our study, the average acetabular angle was 37.8±4.4° SD (37.3±4.3° in males, 38.3±4.4° in females). When compared with published data, our acetabular angle value is close to that measured in Asian countries. The prevalence of acetabular dysplasia reported in different studies were 3.3% in Nigerian men by Gombe and colleagues,[28] 3.4% in white females in Britain by Lane and associates,[11] 4.5% in Chinese men by Lau and co-worker,[2] 3.8% in

Table 4. Correlation of age and parameters of hip morphometry.

	Age edge angle	Center angle	Acetabular obliquity	Root index	Extrusion subluxation	Lateral to width	Depth distance	Peak to edge
Age								
Pearson correlation	1	0.608	-0.825	-0.221	-0.498	-0.384	-0.748	-0.011
Sig. (2-tailed)	-	0.147	0.022	0.634	0.255	0.395	0.053	0.981
N	7	7	7	7	7	7	7	7
Centre edge angle								
Pearson correlation	0.608	1	-0.784	0.591	-0.935	-0.09	0.022	0.684
Sig. (2-tailed)	0.147	-	0.037	0.162	0.002	0.848	0.962	0.09
N	7	7	7	7	7	7	7	7
Acetabular angle								
Pearson correlation	-0.825(*)	-0.784	1	-0.277	0.677	0.415	0.505	-0.146
Sig. (2-tailed)	0.022	0.037	-	0.548	0.095	0.355	0.248	0.755
N	7	7	7	7	7	7	7	7
Root obliquity								
Pearson correlation	-0.221	0.591	-0.277	1	-0.649	0.014	0.647	0.653
Sig. (2-tailed)	0.634	0.162	0.548	-	0.115	0.977	0.116	0.112
N	7	7	7	7	7	7	7	7
Extrusion index								
Pearson correlation	-0.498	-0.935	0.677	-0.649	1	0.26	-0.099	-0.591
Sig. (2-tailed)	0.255	0.002	0.095	0.115	-	0.574	0.833	0.162
N	7	7	7	7	7	7	7	7
Lateral subluxation								
Pearson correlation	-0.384	-0.09	0.415	0.014	0.26	1	0.447	0.464
Sig. (2-tailed)	0.395	0.848	0.355	0.977	0.574	-	0.314	0.294
N	7	7	7	7	7	7	7	7
Depth to width ratio								
Pearson correlation	-0.748	0.022	0.505	0.647	-0.099	0.447	1	0.646
Sig. (2-tailed)	0.053	0.962	0.248	0.116	0.833	0.314	-	0.117
N	7	7	7	7	7	7	7	7
Peak to edge distance								
Pearson correlation	-0.011	0.684	-0.146	0.653	-0.591	0.464	0.646	1
Sig. (2-tailed)	0.981	0.09	0.755	0.112	0.162	0.294	0.117	-
N.	7	7	7	7	7	7	7	7

Britain by Croft and co-worker,[20] 8.6% by Strinovic and associate,[29] 1.8% in a Korean population by Han,[14] 2.4% in a Turkish population by Aktas[7] and 7.2% in a Singaporean population by Umer *et al.*[17] The prevalence of acetabular dysplasia in our study group is 1.4%. When we compare our data with other studies, the prevalence of acetabular dysplasia is lower in our study group compared to Korean, Chinese, Singaporean and Turkish populations.

We also studied the correlation of CE angle with other angles in all patients and in a dysplastic group. In the dysplastic group, CE angle was significantly correlated ($p<0.05$) with acetabular angle and peak to edge distance. These provide the rationale to consider these parameters as complementary methods to diagnose acetabular dysplasia.

This is the first study of its kind in South Asia that has looked at the acetabular morphometry in detail. Our results confirmed the general perception of a low incidence of hip dysplasia and hip osteoarthritis in our region.

Our results can now be used in designing better press fit sockets for the acetabular component of total hip replacement. The existing design and sizes of press fit sockets have been derived from Caucasian data. These adjustments in the shape and sizes of the press fit sockets will ensure better longevity and survival of these implants.

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