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Morphometric Study of the Acetabular in Malay Population Normal Hips and its Clinical Applications

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The morphology study of acetabular is vital in clinical applications particularly through planning before acetabulum surgery and for determining the dysplastic hip. Several studies show that the acetabular morphology varies between populations; which lead to the difficulty to align the implant by following western standard. This prospective, cross sectional study focused on Malay population by providing essential information regarding normal value of acetabular which will enhance knowledge of the anatomical aspects and eventually aiding the acetabular cup placement during Total hip arthroplasty (THA). The acetabular images were obtained using computed tomography scanner and the measurement has been taken from 120 hips. We excluded from the study: pregnant woman, experienced hips injury, wearing implant or prosthesis. Our data were compared using Kolmogorov-Smirnov method and t-test. The findings for the acetabular as follows: center edge angle (CE) 31.69±5.48°; acetabular index angle (AA) 4.27±4.03°; acetabular angle of Sharp 42.35±3.24°; acetabular version (AcetAV) 14.99±5.05°; acetabular depth (AD) 15.49±1.70 mm; joint space width (JSW) 5.84±0.80 mm; anterior acetabular sector angle (AASA) 61.19±6.72°; posterior acetabular sector angle (PASA) 92.80±6.27°. This study documents for the first time the acetabular morphometric value on Malay population which will improve data, aiding the orthopedic surgeons during acetabular placements in THA and designing better implant.

Key words: Acetabular, acetabular angle, center edge angle, morphology

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INTRODUCTION

The morphology of the acetabular is essential particularly in acetabular osteotomy including the total hip arthroplasty (THA) acetabular placement (Stem *et al*., 2006). The acetabular images aid the surgeon to determine the correct size of the acetabular cup during THA and to realign the acetabular back to the normal position (Hozack *et al*., 2010; Wagner, 1978; Ninomiya and Tagawa, 1984; Ganz *et al*., 1988; Naito *et al*., 2005; Eppright, 1975). No study has been documented providing the normal value of the acetabular especially for Malay population which can be found largely at South East Asian region.

Several studies had been done regarding the parameters variation in acetabular especially the relationship between this value with the dysplasia, osteoarthritis, fracture and other diseases associated (Murray, 1965; Wiberg, 1939; Faulkner *et al*., 1993; Loder *et al*., 2003). Common used of x-ray alone is not sufficient enough, this lead to the usage of computed tomography images which provide more reliable measurement of bone morphology and are used in the diagnosis of osteoarthritic patients (Saikia *et al*., 2008; Tallroth and Lepisto, 2006). This normal value of acetabular will aid the surgeon on identifying the early stage of osteoarthritis that happened to the patient (Lequesne *et al*., 2004; Tonnis, 1976). The interesting fact that relates dysplasia to the osteoarthritis instead of the hip axis length (HAL), body mass index (BMI) and bone density has widened the study regarding acetabular (Wiberg, 1939).

This study focused on the normal acetabular morphometric measurements specifically on Malay population in Malaysia, which will improve data, determining dysplastic and osteoarthritic hip, aiding the orthopedic surgeons during acetabular placements in THA and designing better implant.

MATERIALS AND METHODS

This prospective, cross sectional study was performed at Hospital Tengku Ampuan Afzan, Malaysia. Sixty subjects were recruited after receiving approval from hospital ethics committee and the National Medical Research Register (NMRR). Period of the study was from January 2009 until Disember 2009. The exclusion criteria for this study included pregnant women, those who experienced previous femoral injury, wearing implant or prosthesis. Gonad shields were used and no contrast media was administered.

Acetabular images were acquired using CT scanner (Somatom, Volume Zoom, Siemens) at 3.0 mm thickness and 12.0 mm table feed per rotation. The four row multi slices CT scanner was conducted using 120 kV and 90 mAs with recon increment was set to 1.5 and 1.25 mm collimation. Subjects were asked to lay down at supine position with their feet stabilized using the specially designed wood jig to standardize the position of feet during image acquisition.

The following data were collected before the study: patient's age, gender, weight and height. The parameters involved were center edge angle (CE), acetabular index angle (AA), acetabular angle of Sharp, acetabular version (AcetAV), acetabular depth (AD), joint space width (JSW), anterior acetabular sector angle (AASA) and posterior acetabular sector angle (PASA). The definition used in this study as shown below:

- Center edge angle (CE)-the angle between line from the center femoral head to the lateral margin of acetabulum and the vertical line from center femoral head as shown in Fig. 1 (Wiberg, 1939)
- Acetabular index angle (AA)-the angle between pelvic horizontal line and line from lateral margin to superior fovea as shown in Fig. 1 (Tonnis, 1987; Tallroth and Lepisto, 2006)
- Acetabular angle of Sharp-the angle between the line from the tip of pelvic tear drop to the lateral margin of acetabulum and the horizontal line through the tip of pelvic tear drop as shown in Fig. 1 (Sharp, 1961; Saikia *et al*., 2008)
- Acetabular depth (AD)-the distance from line linking both lateral margin of acetabulum to the center line connecting the acetabular dome (AB) as shown in Fig. 2 (Murray, 1965; Lane *et al*., 1997; Chauhan *et al*., 2002)
- Joint space width (JSW)-consists of 3 measurements at hip joint which are; the superior (GH), fovea (EF) and inferior acetabulum (CD) as shown in Fig. 2 (Lequesne *et al*., 2004)
- Acetabular version (AcetAV) - the angle between the line perpendicular that linking posterior ischium and the line connecting anterior and posterior margin of acetabulum as shown in Fig. 3 (Kim *et al*., 1999; Visser *et al*., 1982)
- Anterior acetabular sector angle (AASA)- the angle between center line of both femoral heads and line from center towards the anterior margin of acetabular as shown in Fig. 3 (Anda *et al*., 1986)
- Posterior acetabular sector angle (PASA)-the angle between center line of both femoral heads and line from center towards the posterior margin of acetabular as shown in Fig. 3 (Anda *et al*., 1986)

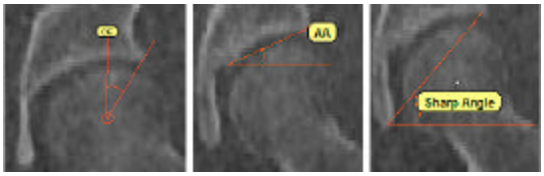

Fig. 1: Center edge angle (left), acetabular angle (center) and Sharp angle (right)

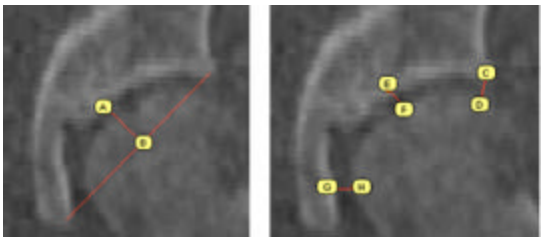

Fig. 2: Acetabular depth (left) and joint space width (right)

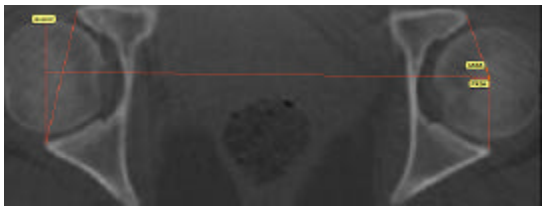

Fig. 3: Acetabular version angle (AcetAV), anterior acetabular sector angle (AASA) and posterior acetabular sector angle (PASA)

The measurements data were statistically analyzed with the SAS software. Several steps were taken to compare between genders and acetabular sides in this study. The goodness-of-fit test (Kolmogorov-Smirnov method) was used to verify the normality assumption for each group of data. If the data was normally distributed then Folded F method will be used to examine the equality of data variances. The probability was then checked using t-test either by Pooled method or Satterthwaite method, according to the equality of the variance. If the data was not normally distributed, nonparametric one-way ANOVA was adopted using Wilcoxon scores. The probability value was then determined by Chi-Square values through Kruskal-Wallis test.

RESULTS

A total of 120 hips joint were measured in this study. The demographic parameters for recruited subjects are shown in Table 1. This sample population was divided by gender with mean, standard deviation and range value. The average weight for male was 69.47 kg and female 53.50 kg, the average height for male was 171.93 cm and female 157.47 cm, the average body mass index (BMI) for male was 23.52 kg m^{-2} and female 21.64 kg m^{-2}.

Table 1: Demographic parameters for Malay population

Parameters	Gender	Mean	Standard deviation	Minimum	Maximum
Age (years)	Male	25	5.18	19	38
	Female	21	1.35	19	26
Weight (kg)	Male	69.47	12.04	51.00	107.00
	Female	53.50	10.63	39.00	80.00
Height (cm)	Male	171.93	6.52	153.00	185.00
	Female	157.47	6.14	142.00	170.00
BMI (kg m^{-2})	Male	23.52	3.99	16.05	35.75
	Female	21.64	4.81	16.88	38.68

The morphometric measurements for the acetabular region taken from computed tomography images according to the gender divided between right and left hip joints a re shown in Table 2. Statistical analysis showed that all parameters were not significant ($p>0.05$) between right and left hip joints. The measurements of center edge (CE), acetabular angle (AA) and Sharp angle (SA) were important for the orthopaedic surgeon especially during planning prior to osteotomy. There CE value ranged from 22.40-48.16° for male and 21.24-40.93° for female. The difference for AA and SA means value between right and left hips joint also showing small difference. The Acetabular Depth (AD) and Joint Space Width (JSW) could be used as a precursor for dysplastic and osteoarthritic joint. The AD mean value for male was acetabular sector angle (PASA) could be used to determined dysplasia patient. The normal value for AcetAV, AASA and PASA varies with populations and this value is important especially during acetabular cup placement while performing THA.

These normal values will be the reference for the clinical practitioners to determine the dysplastic and osteoarthritic hip joint and planning for the surgery (Table 3). The mean for CE angle was 31.69±5.48°, AA 4.27±4.03°, SA 42.35±3.24°, AcetAV 14.99±5.05°, AD 15.49±1.70 mm, JSW 5.84±0.80 mm, AASA 61.19±6.72° and PASA 92.80±6.27° (Table 4).

DISCUSSION

The anatomical feature of the hip joint is essential since the development of dysplasia is closely related with the secondary osteoarthritis (Harris, 1986; Wiberg, 1939). Generally, the acetabulum for dysplastic hip is shoal, quite lateralized and scarce anteriorly and posteriorly (Sanchez-Sotelo *et al*., 2002). This study hopefully will provide the normal value of acetabular for Malay populations that can be used by clinical practices

Table 2: Acetabular morphometric measurement across sample population

Parameters	Gender	Division	Measurement	Range	p-value
CE (°)	Male	Right	32.71±5.26	25.19–48.16	0.9478
		Left	32.64±5.72	22.40–43.63	
	Female	Right	29.32 ±5.60	21.24–40.93	0.1028
		Left	32.10±4.84	23.57–40.65	
AA (°)	Male	Right	9.42±3.69	-1.35–17.51	0.1095
		Left	10.64±4.76	4.03–19.79	
	Female	Right	9.56 ±3.58	3.26–17.89	0.4079
		Left	10.19±4.10	1.87–21.41	
SA (°)	Male	Right	42.05±3.4	35.1–48.28	0.4847
		Left	41.52±3.08	35.73–47.21	
	Female	Right	42.96±3.37	34.76–49.36	0.8901
		Left	42.87±3.05	37.38–49.25	
AcetAV (°)	Male	Right	15.90 ±5.73	4.20–26.26	0.0584
		Left	13.73±5.02	4.07–23.18	
	Female	Right	15.29±5.04	6.70–24.88	0.7411
		Left	15.06±4.35	5.80–24.17	
AD (mm)	Male	Right	16.05±1.75	11.31–20.43	0.3741
		Left	16.29±1.24	12.86–18.19	
	Female	Right	14.63±1.63	11.75–17.67	0.2076
		Left	14.99±1.62	12.79–18.51	
JSW (mm)	Male	Right	5.99±0.76	4.38–7.65	0.5939
		Left	5.93±0.95	4.23–8.10	
	Female	Right	5.81±0.72	4.36–7.34	0.1989
		Left	5.64±0.76	3.87–6.73	
AASA (°)	Male	Right	63.02 ±6.11	46.22–71.45	0.1962
		Left	61.58±9.55	51.31–75.39	
	Female	Right	59.40±7.72	47.17–74.95	0.1696
		Left	60.75±5.62	50.20–70.12	
PASA (°)	Male	Right	92.75±6.58	74.65–107.10	0.9870
		Left	92.73±6.01	77.48–102.56	
	Female	Right	92.26±6.54	81.01–105.86	0.2265
		Left	93.46±6.19	78.96–107.54	

CE: Center edge angle, AA: Acetabular index angle, SA: Acetabular angle of Sharp, AcetAV: Acetabular version, AD: Acetabular depth, JSW: Joint space width, AASA: Anterior acetabular sector angle, PASA: Posterior acetabular sector angle

Table 3: Comparison of the acetabular morphology in different populations

Parameters	Gender	Malay	Finland	India	USA	Malawi	Korea	Singapore
CE (°)	Male	32.67±5.45	39.0±7.0	32.3±10.5	28.7±7.8	34.0±7.5	32.6±5.7	30.63±8.19
	Female	30.71±5.38	43.0±7.0	33.5±10.2	27.9±7.1	34.3±7.5	32.3±6.8	33.54±7.14
SA (°)	Male	41.79±3.23	-	39.0±5.6	38.9±3.2	36.9±4.0	36.5±3.5	39.85±6.00
	Female	42.92±3.19	-	39.4±3.2	39.3±4.7	38.6±4.9	37.5±3.8	38.25±5.98
AA (°)	Male	10.03±4.27	5.0±5.0	-	-6.9±7.1	-	-	-
	Female	9.87±3.83	1.0±4.0	-	-7.5±5.5	-	-	-
AcetAV (°)	Male	14.81±5.45	17.0±6.0	18.0±6.1	-	-	-	-
	Female	15.17±4.67	23.0±7.0	18.4±6.2	-	-	-	-
AD (mm)	Male	16.17±1.51	-	2.5±0.8	-	-	11.5±2.6	-
	Female	14.81±1.62	-	2.5±0.6	-	-	10.2±2.6	-
JSW (mm)	Male	5.96±0.85	-	4.6±2.0	5.7±0.8	-	-	-
	Female	5.72±0.74	-	4.4±2.1	5.2±0.8	-	-	-
AASA (°)	Male	62.30±6.57	67.0±13	-	-	-	-	-
	Female	60.07±6.74	63.0±11	-	-	-	-	-
PASA (°)	Male	92.74±6.24	103.0±11	-	-	-	-	-
	Female	92.86±6.34	104.0±25	-	-	-	-	-

CE: Center edge angle, AA: Acetabular index angle, SA: Acetabular angle of Sharp, AcetAV: Acetabular version, AD: Acetabular depth, JSW: Joint space width, AASA: Anterior acetabular sector angle, PASA: Posterior acetabular sector angle

especially while performing placing the acetabular cup during total hip replacement.

Several studies have been done which correlates the morphological study of the acetabular with dysplasia (Saikia *et al*., 2008; Tallroth and Lepisto, 2006; Genda *et al*., 2001; Ito *et al*., 2009; Han *et al*., 1998; Lavy *et al*., 2003; Umer *et al*., 2006). The center edge angle (CE), the acetabular angle of Sharp (SA) and the acetabular index angle (AA) are the parameters introduced to determine whether the hip is considered dysplasia. The CE was introduced by Wiberg (1939) and the measurement was taken from femoral head lateral on an anterior-posterior view of the pelvis. The normal value for CE is within 25-45°, less than 20° is considered as

Table 4: Overall results of acetabular measurements for Malay population

Parameters	Mean	Standard deviation	Minimum	Maximum
CE (°)	31.69	5.48	21.24	48.16
SA (°)	42.35	3.24	34.76	49.36
AA (°)	4.27	4.03	-1.35	21.41
AcetAV (°)	14.99	5.05	4.07	26.26
AD (mm)	15.49	1.70	11.31	20.43
JSW (mm)	5.48	0.80	3.87	8.10
AASA (°)	61.19	6.72	46.22	75.39
PASA (°)	92.80	6.27	74.65	107.54

CE: Center edge angle, AA: Acetabular index angle, SA: Acetabular angle of Sharp, AcetAV: Acetabular version, AD:Acetabular depth, JSW: Joint space width, AASA: Anterior acetabular sector angle, PASA: Posterior acetabular sector angle

dysplasia (Wiberg, 1939). Our study showed that the CE was 32.67° for male and 30.71° for female which were in accordance to previous study (Saikia *et al*., 2008; Umer *et al*., 2006; Han *et al*., 1998). The CE is well known because of its consistency between gender and age (Fredenborg, 1976). Despite of this advantages, Sharp (1961) had underlined three limitations of CE which were the center point position of the deformed femoral head, subluxation of joint space and lateral acetabulum margin which affected the CE value.

The acetabular index angle (AA) also known as acetabular cartilage angle (AC) and Tonnis angle measures the weight bearing surface from coronal view (Tallroth and Lepisto, 2006; Tonnis, 1976). The normal value for AA is about 0-15° (Tonnis, 1987). However, Lequesne *et al*. (2004) indicated that AA value which more than 12° regarded as dysplastic. The acetabular angle of Sharp (SA) is introduced in 1961 which measures the acetabular inclination (Sharp, 1961). Previous study by (Sharp, 1961) from 200 normal hip joints found that the normal value for acetabular angle was within range 33-38°, angles within range 39-42° were the upper limit of normality and above 47° was considered as hip with congenital subluxation. The SA value in this study shows 41.79° for male and 42.92° for female. This SA value is higher than Singaporean population which has the average SA 39.46° (Umer *et al*., 2006). The acetabular angle of Sharp is valuable especially for acetabulum cup inclination during Total Hip Arthroplasty (THA) to reduce mispositioning, incidence of dislocation and acetabular cup failure (Stem *et al*., 2006).

Dysplastic hip also correlates with the Acetabular Depth (AD) (Loder *et al*., 2003). The normal AD is 9 mm and less than that is regarded as dysplasia (Saikia *et al*., 2008; Murray, 1965). In this study, we found that AD for male is 16.17 and 14.81 mm for female. Saikia *et al*. (2008) found that the AD values between gender and pelvic diversion is similar which shows 25 mm. The acetabular depth is the complement of CE which indicates reliable information of joint incongruity and possibility to osteoarthritic change (Murray, 1965). On the other hands, the Joint Space Width (JSW) is correlated with the osteoarthritic hip joint, although exclusion should be given to the elder and obese person (Saikia *et al*., 2008; Lequesne *et al*., 2004; Lane *et al*., 1997). The normal value for JSW is reported as 4 mm (Nelitz *et al*., 1999). In this study, we found that the joint space width is 5.96 mm for male and 5.72 mm for female. The osteoarthritic features indicate the reduced of the joint space width and this value shows vital inference for the epidemiological study (Lequesne *et al*., 2004).

Another parameters used to determine dysplasia are the acetabular version angle (AcetAV), anterior acetabular sector angle (AASA) and posterior acetabular sector angle (PASA) which images taken from anterior-posterior (AP) computed tomography view. This method is introduced by Anda *et al*. (1986) to determine the dysplastic patient using the femoral head and rim images from AP view. The normal value for AcetAV, AASA and PASA is 19°, 64° and 102° for male and 22°, 63° and 105° for female (Anda *et al*., 1986). In another study, Anda *et al*. (1991) indicates that poor hip condition when AASA is below 50° and PASA is below 90°. Our study shows value for AcetAV, AASA and PASA is 14.99°, 60.83° and 92.80°. The acetabular version (AcetAV) is vital especially during acetabular cup placement during Total Hip Arthroplasty (THA) (Stem *et al*., 2006). It also determines success of acetabular cup anterversion during surgery and reduces the torsional instability. Two studies suggested different orientation of AcetAV during THA which is 0° (Charnley, 1970) and 5°-25° (Lewinnek *et al*., 1978). Murray (1993) stated the variation of AcetAV was due to the different selected spatial reference points.

The main problem for acetabular placement will be positioning the acetabular cup implant and acetabular inclination to the correct location according to its acetabular version and the acetabular depth (Ito *et al*., 2009). The information regarding dysplasia has been acquired by both conventional radiograph and computed tomography (Wiberg, 1939; Faulkner *et al*., 1993; Loder *et al*., 2003; Saikia *et al*., 2008; Tallroth and Lepisto, 2006; Lequesne *et al*., 2004; Tonnis, 1976; Sharp, 1961; Kim *et al*., 1999; Visser *et al*., 1982). This normal value of the acetabular can be used to determine the dysplastic patient, osteoarthritic joint, evaluation for surgical intervention and implant templating.

In conclusion, we would like to accentuate the importance of the morphometric study of the acetabular which is particularly difference from one population to another. This study is the first one pointed the acetabular value for Malay population and hopefully will benefit the orthopedic surgeon, implant's manufacturer and other clinical practices.

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