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Original

Radiographic Parameters of Acetabular Dysplasia in a Healthy Japanese Population

― Data from the Katashina Study ―

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Abstract

Background & Aims: Normal values for Sharp's angle (SA) and the center-edge angle (CEA) in Japanese are unestablished. We examined these radiographic parameters to identify their correlation with gender, age and spino-pelvic alignment and particularly the prevalence of acetabular dysplasia in healthy adults (middle-aged or older) in Japan. **Methods:** In 639 members of the general population in a mountain village in Japan, the SA and CEA were measured. Correlations with gender, age and the sacro-femoral-pubic angle (SFPA) were investigated. **Results:** A total of 562 subjects (mean age 65.7 years; range, 40–90 years) met the study criteria. The mean SA and CEA on both sides in women were larger and smaller than in men, respectively. An association was found between the SA and age in both genders. Acetabular dysplasia, based on the SA and/or CEA, was more prevalent in women than in men and on the right side than on the left. The SFPA was associated with age and the SA in both genders but almost never with CEA. **Conclusions:** There were gender-associated and right-left differences in the prevalence of acetabular dysplasia. The degree of pelvic retroversion was associated with age but almost never with the CEA.

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Introduction

Osteoarthritis (OA) is a common chronic condition of the hip joint. The prevalence of radiographic hip OA was reported as 18.2% in men and 14.3% in women in Japan[1] Prior studies have identified several risk factors of OA, including obesity, occupations, sport activity, and developmental dysplasia of the hip joint.

Acetabular dysplasia, characterized by a shallow shape of the acetabulum, has long been considered the primary cause of hip OA in Japanese and is categorized as "preosteoarthritis" in Japan. On anterior-posterior radiograph, acetabular dysplasia is commonly defined as a Sharp's angle (SA)>45° [2,3] and/or a center-edge angle (CEA)<20°.[4,5] A study of 254 healthy Japanese volunteers found that the mean SA and CEA values were 38.0±3.6° and 32.2±6.4°, respectively.[6] However, normal values for these radiographic parameters in Japanese general population have not been established.

The aim of this study was to examine the radiographic parameters of acetabular dysplasia (SA and CEA) in our cohort based on the results of an annual medical checkup and particularly, to examine the prevalence of acetabular dysplasia in healthy adults (middle-aged or older) in Japan. We further sought to identify their correlation with gender, age and the spino-pelvic alignment.

Materials and Methods

Participants

An annual medical checkup has been conducted for residents of a mountain village (Katashina-mura) in Gunma prefecture since 2006, where agroforestry and tourism are the main industries.[7,8] In 2013, a total of 639 of the subjects underwent anteroposterior (AP) pelvic radiography in the standing position as a part of the medical checkup. We excluded participants ≦39 years of age (n=11). We also excluded the data of those with missing background (*i.e.* age, gender, height and weight) data (n=45), a history of surgery of the hip (n=11), collapse of the femoral head (n=2) and inadequate radiographs (n=8).

Radiographic measurements

Digital images were analyzed using the Advanced CasePlan Pre-Operative Planning digital template system (Stryker Japan, Tokyo, Japan). All images were measured by a single board-certified orthopedic surgeon (T.W.).

Two pelvic landmarks were confirmed prior to the analysis to perform standardized measurements. One is the radiographic teardrop; its medial surface consists of the cortical surface of the pelvis, and its lateral border consists of the cortical surface of the acetabular fossa. The inter-teardrop-line, connecting the inferior tip of both teardrops, was used as the transverse axis of the pelvis. The lateral acetabular edge is the other landmark seen on the AP view. Because the most lateral point of the bony acetabulum roof can be indefinite by pelvic tilt, the lateral edge of the "sourcil", defined as the weight-bearing bony area of the hip joint and seen as a hyper-dense arched line along the acetabular roof, was used as the lateral acetabular edge in the present study.

SA was originally described as the "angle of inclination of the acetabulum" by Sharp.[9] It describes the angle formed between the inter-teardrop-line and the line connecting the inferior tip of the teardrop to the lateral acetabular rim. In this study, SA was measured by the same method (Fig. 1a).

The CEA of Wiberg is one of the most commonly used parameters in the diagnosis of acetabular dysplasia.[10,11] This angle is formed by a vertical line to the transverse axis of the pelvis and a line joining the femoral head center with the lateral rim of the acetabulum. In this study, the lateral edge of the sourcil was used as described previously[12] (Fig. 1b).

The sacro-femoral-pubic angle (SFPA) is a coronal plane pelvic parameter which correlates closely with pelvic tilt.[13] This angle was formed between the midpoint of the upper sacral endplate (by drawing the midpoint between lateral borders of the L5-S1 facet joints), the centroid of one acetabulum and the upper midpoint of the pubic symphysis (Fig. 2).

Statistical analyses

We compared the difference in height between males and females by applying Student's t-test. Mann-Whitney's U test was used to compare the differences in age, weight, body mass index (BMI) and SFPA between males and females. The same test was also used to compare the side-based differences in SA and CEA between males and females. The Wilcoxon? signed-rank test was used to compare the gender-based differences in the SA and CEA for the right versus left hips of each subject. Spearman's ρ test was performed to investigate the correlation between age and SA, age

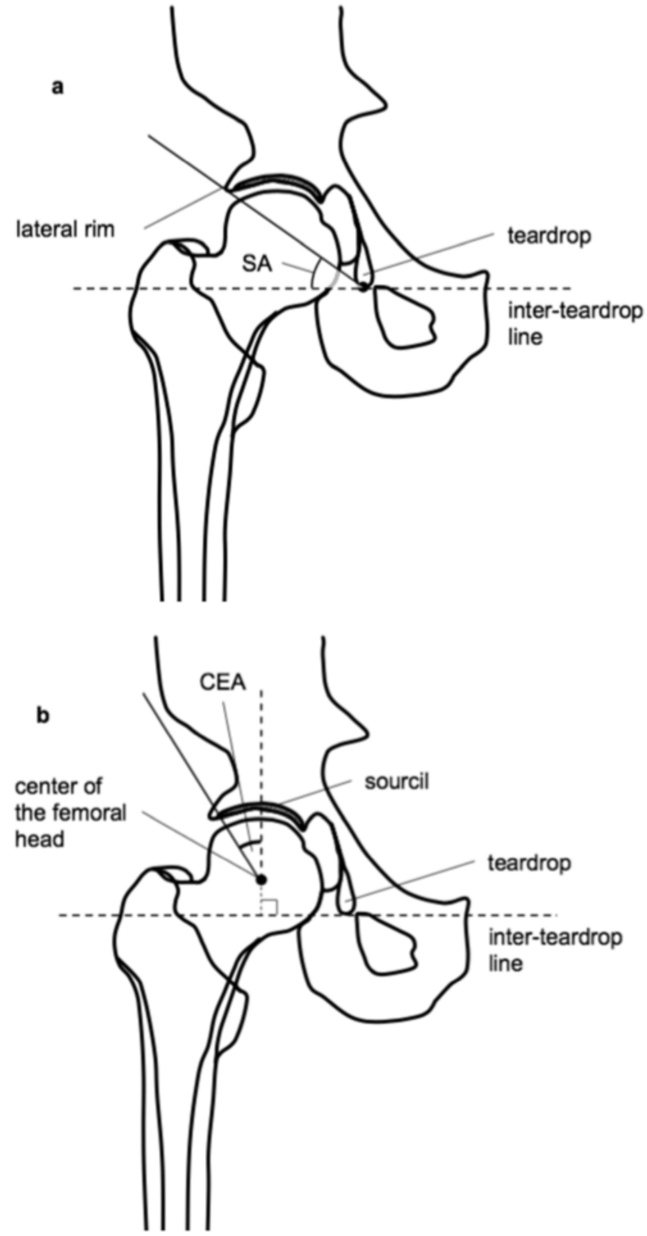

Fig. 1 a & b describe the morphology of the hip joint: Sharp's angle (SA) describes the angle formed between the inter-teardrop-line and the line connecting the inferior tip of the teardrop to the lateral acetabular rim (Fig. 1a). The center-edge angle (CEA) refined by Ogata is formed by a vertical line through the center of the femoral head and perpendicular to the transverse axis of the pelvis (inter-teardrop-line), and a line joining the head center with the lateral end of sourcil, *i.e.*, the weight-bearing area of the acetabulum (Fig. 1b).

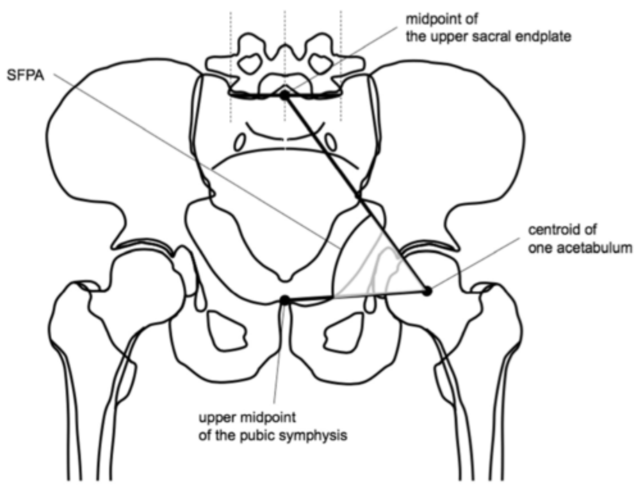

Fig. 2 The morphology of the pelvis is described: The sacro-femoral-pubic angle (SFPA) is defined as the angle between the midpoint of the upper sacral endplate (by drawing the midpoint between lateral borders of L5-S1 facet joints), the centroid of one acetabulum and the upper midpoint of the pubic symphysis.

and CEA, age and SFPA, SFPA and SA, and SFPA and CEA by gender.

Statistical significance was established at $p<0.05$. All statistical analyses were performed using the IBM SPSS Statistics Version 21 software package (IBM Japan, Tokyo, Japan).

Ethics

This study was approved by the Institutional Review Board of Gunma University (Approval No.23-31). Written informed consent was obtained from all subjects.

Results

A total of 562 subjects (≥ 40 years of age) met the study criteria (Table 1). There were 221 men and 341 women (mean age 65.7 years; range, 40-90 years). With regard to the measurement of the SFPA, the subjects included 209 men and 324 women (mean age 65.9 years; range, 40-90 years), because 29 radiographs (men, n=12; women, n=17) with intestinal barium after upper gastrointestinal series were inadequate (the midpoint of the upper sacral endplate was invisible) (Table 3).

Radiographic parameters of study subjects are shown in Table 2. The mean SA in men was 36.9° ± 4.0° on the right side and 36.2° ± 3.8° on the left (mean ± standard deviation). The mean SA in women was significantly larger (38.9° ± 4.6° on the right side and 38.3° ± 4.5° on the left, $p<0.01$) than in men. The SA on the right side was larger than on the left in both genders ($p<0.01$). When defined as SA>45°, acetabular dysplasia in male subjects was found in 1 hip (0.5%) on the right and 1 hip (0.5%) on the left. None had bilateral dysplasia. In women, acetabular dysplasia was found in 22 hips (6.5%) on the right and 14 hips (4.1%) on the left. Among them, 4 (1.2%) showed dysplasia bilaterally (Table 4).

The mean CEA in men was 31.7° ± 7.7° on the right side and 35.1° ± 7.4° on the left (mean ± standard deviation). The mean CEA in women was significantly smaller (26.8° ± 9.0° on the right side and 31.2° ± 9.0° on the left, $p<0.01$) than in men. The CEA on the right side was smaller than on the left in both genders ($p<0.01$). When defined as CEA<20°, acetabular dysplasia in male subjects was found in 14 hips (6.3%) on the right and 2 hips (0.9%) on the left. One had bilateral dysplasia. In women, acetabular dysplasia was found in 69 hips (20.2%) on the right and 32 hips (9.4%) on the left. Among them, 26 (7.6%) showed dysplasia bilaterally. In men, 1 hip (0.5%) on the right side and none on the left had both SA>45° and CEA<20°. In women, 6 hips (1.8%) on the right side and 4 hips (1.2%) on the left met both radiographic criteria. Two women showed dysplasia bilaterally (Table 4). A weak inverse association was found between the SA and age in men (right, $r=-0.281$, $p<0.01$; left, $r=-0.231$, $p<0.01$) and women (right, $r=-0.360$, $p<0.01$; left, $r=-0.320$, $p<0.01$). A relatively weak association was also found between the CEA of the

Table 1 The characteristics of the study population

	total	Men	Women	
	(n = 562)	(n = 221)	(n = 341)	P value
Age (years) (mean ± SD)	65.7 ± 11.6	66.6 ± 11.4	65.2 ± 11.7	0.184
Height (cm) (mean ± SD)	156.1 ± 9.1	163.3 ± 6.9	151.4 ± 7.0	<0.01
Weight (kg) (mean ± SD)	57.5 ± 10.4	64.1 ± 9.3	53.3 ± 8.7	<0.01
BMI (kg/m^2) (mean ± SD)	23.5 ± 3.2	24.0 ± 2.8	23.3 ± 3.5	<0.01

SD: standard deviation; BMI: body mass index

Table 2 The radiographic parameters of the study subjects

	Men (n = 221)		Women (n = 341)		P value Gender	P value Side
	RIght	Left	Right	Left		
SA (°) (mean ± SD)	36.9 ± 4.0	36.2 ± 3.8	38.9 ± 4.6	38.3 ± 4.5	<0.01	<0.01
CEA (°) (mean ± SD)	31.7 ± 7.7	35.1 ± 7.4	26.8 ± 8.9	31.2 ± 9.0	<0.01	<0.01

SD: standard deviation; SA: Sharp's angle; CEA: center-edge angle

Table 3 The characteristics of the study population for measurement of the SFPA

	total (n = 533)	Men (n = 209)	Women (n = 324)	P value
Age (years) (mean ± SD)	65.9 ± 11.6	66.6 ± 11.4	65.4 ± 11.7	0.214
Height (cm) (mean ± SD)	156.0 ± 9.1	163.3 ± 6.9	151.3 ± 6.9	<0.01
Weight (kg) (mean ± SD)	57.5 ± 10.4	64.1 ± 9.3	53.3 ± 8.8	<0.01
BMI (kg/m²) (mean ± SD)	23.6 ± 3.3	24.0 ± 2.8	23.3 ± 3.5	<0.01
SFPA (°) (median, range)	54.3 (1–78)	55.0 (23–72)	57.0 (1–78)	0.026

SD: standard deviation; BMI: body mass index; SFPA: sacro-femoral-pubic angle

Table 4 Number of hip joints with dysplasia and its prevalence

	Side	SA > 45° n (%)	CEA < 20° n (%)	SA > 45° and CEA < 20° n (%)
Men (n = 221)	Right	1 (0.5)	14 (6.3)	1 (0.5)
	Left	1 (0.5)	2 (0.9)	0 (0.0)
	Bilateral	0 (0.0)	1 (0.5)	0 (0.0)
Women (n = 341)	Right	22 (6.5)	69 (20.2)	6 (1.8)
	Left	14 (4.1)	32 (9.4)	4 (1.2)
	Bilateral	4 (1.2)	26 (7.6)	2 (0.6)

SA: Sharp's angle; CEA: center-edge angle

Table 5 The correlations between the SA or CEA and age or SFPA

	Gender	Side	Age		SFPA	
			Coefficient (r)	p value	Coefficient (r)	p value
SA	Men (n = 209)	Right	−0.281	<0.01	0.420	<0.01
		Left	−0.231	<0.01	0.291	<0.01
	Women (n = 324)	Right	−0.360	<0.01	0.375	<0.01
		Left	−0.320	<0.01	0.283	<0.01
CEA	Men (n = 209)	Right	0.040	0.564	−0.003	0.965
		Left	0.021	0.760	0.085	0.221
	Women (n = 324)	Right	0.112	0.043	0.093	0.095
		Left	0.079	0.154	0.177	0.001

SFPA: sacro-femoral-pubic angle; SA: Sharp's angle; CEA: center-edge angle

Table 6 The correlations between age and the SFPA

	Gender	SFPA	
		Coefficient (r)	p value
Age	Men (n = 209)	−0.441	<0.01
	Women (n = 324)	−0.657	<0.01

SFPA: sacro-femoral-pubic angle

right hip and age in women (right, r = 0.112, p = 0.043; left, r = 0.079, p = 0.154), although no association was found between the CEA and age in men (Table 5).

The median SFPA was 55.0° in men (range, 23°–72°) and 57.0° in women (range, 1°–78°) (Table 3). The SFPA was significantly associated with age in both genders (men, r = −0.441, p<0.01; women, r = −0.657, p<0.01) (Table 6) and also showed a modest association with the SA in both genders (men, right side, r = 0.420, p<0.01; left side, r = 0.291, p<0.01; women, right side, r = 0.375, p<0.01; left side, r = 0.283, p< 0.01). It was not associated with the CEA in men (right side, p = 0.965; left side, p = 0.221), whereas a weak association was found between the CEA of left hip and SFPA in women (right side, p = 0.095; left side, r = 0.117, p = 0.001) (Table 5).

Discussion

The present study is the largest yet to examine the prevalence of radiographic acetabular dysplasia in a general population in Japan. Our study had three main findings. First, there was a significant difference in the prevalence of acetabular dysplasia between genders. Women were more likely to have radiographic acetabular dysplasia than men. Second, our data showed that acetabular dysplasia was more likely to present in the right hip than in the left. Finally, the posterior inclination of the pelvis was modestly associated with the SA but almost never with the CEA.

In our study, acetabular dysplasia was found more often in women than in men. Our results are in line with those of previous studies reporting a female predominance.[4,14] We found that the prevalence of radiographic acetabular dysplasia in women, defined as SA>45° or CEA<20°, was 9.4% (32/341) and 22.0%

(75/341), respectively. In a smaller study containing 23 Japanese women, Mimura et al. reported a similar prevalence (SA>45°, 21.7%; CEA<20°, 13.0%).

We also found a significant right-left difference in the prevalence of acetabular dysplasia. In our study, the right hip was more likely to be dysplastic than the left. This right-left difference of acetabular dysplasia has been reported before[15]; however, its underlying mechanism has been unclear. In contrast to our finding, developmental dysplasia of the hip is reported to occur more frequently in the left side in infants, presumably due to the effect of the baby's position in the womb.

A weak inverse association was found between the SA and age in both genders, and a relatively weak association was also found between the CEA of the right hip and age in women. These findings might indicate that the bony support on the lateral edge of the acetabulum builds up with age and that further age-related alterations will occur in the sourcil.[16]

In line with prior studies, we found that posterior tilt of the pelvis, as assessed by the SFPA, significantly increased with age. Posterior tilt of the pelvis may result in under-coverage of the anterior acetabulum and potentially accelerate the progression of cartilage damage of the hip joint.[17] Although Saiwai et al. found in their study using reconstructed CT images that posterior tilt of the pelvis was associated with a decreased CEA,[18] we observed a similar but weak correlation between the SFPA and only the CEA of the left hip in women. However, we did detect a modest association between the SFPA and SA in both genders, which conflicted with the findings of previous reports. Our data indicate that posterior tilt of the pelvis is not necessarily associated with a reduction in acetabular coverage in the coronal plane. With the increase in the degree of pelvic retroversion with age, it might be easy to imagine that the SA would increase and the CEA would decrease. However, the pelvis might develop a posterior tilt with age through a change in the acetabular shape to prevent the loss of coverage of the femoral head, as mentioned previously. We hypothesized that the SA would decrease with age, and the CEA would be maintained. Furthermore, these results suggested that acetabular dysplasia does not necessarily lead to the failure of the hip joint.

Several limitations associated with the present study warrant mention. First, we analyzed radiographs of those who voluntarily participated in a medical checkup. As such, sampling bias may have occurred. Second, due to the limited number of young participants, we were unable to analyze the data of young adults. Third, we did not obtain detailed information on pain or the quality of life.

In the largest study of its kind to date, we examined the radiographic parameters of acetabular dysplasia in a general Japanese population. There were gender- and right-left differences in the prevalence of radiographic acetabular dysplasia. The degree of pelvic retroversion was associated with age but almost never with the CEA.

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