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Morphological Features of Pistol Grip Deformity

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Abstract

Purpose: The purpose of this study was to elucidate the morphological features of the pistol grip deformity (PGD) using radial computed tomography (CT) images.

Materials and Methods: Using multiplanar reformation, radial CT images of a total of 51 hips were reconstructed. The femoral neck was used as the axis of rotation and the images were generated at 10° intervals from anterior to posterior. The alpha angles of each plane were measured, and compared between the PGD and control (normal morphology) groups. We also compared the mean alpha angles between each plane within the PGD group.

Results: The mean maximum alpha angles were 61° in the 60° vector in the PGD group and 50° in the 40° and 50° vectors in the control group. The mean alpha angles in the PGD group was significantly greater than those in the control group in the 30° to 100° vectors ($P<0.05$). In the PGD group, the mean alpha angles at the anterosuperior position were significantly greater than those at the superior position ($P<0.05$).

Discussion: In this study, we found that PGD is a particular morphological abnormality from the anterosuperior to superior femoral head-neck junction. This finding contradicts the results that have previously been reported. We need to differentiate between PGD and pure cam-type deformity to understand the morphology for preoperative and intraoperative decision-making for femoroacetabular impingement by use of radial imaging.

Key words: Femoroacetabular impingement, Cam-type deformity, Pistol grip deformity, Radial imaging

Introduction

Femoroacetabular impingement (FAI) is the most common mechanism underlying the development of early cartilage and labral damage in the nondysplastic hip [1)-3)]. The most common femoral structural deformities involve loss of the femoral head-neck offset (cam-type deformities). Because there is evidence that incomplete correction of the femoral head-neck offset remains a leading cause of revision surgery for FAI [4)], a detailed preoperative understanding of the morphology is important for preoperative decision-making [5)].

A cam-type deformity can usually be detected on lateral radiographs of the hip. However, there is also a lesion that can be detected on anteroposterior (AP) radiographs of the hip, the so-called pistol grip deformity (PGD) [6)]. The two types of morphological features (PGD and cam-type deformity) have been assessed in the same cohorts to date (Fig. 1, 2). However, we believe that they should not be confused, because they have obviously different morphological features on AP radiographs.

The aim of this study was to elucidate the morphological features of PGD using radial computed tomography (CT) images. To our knowledge, this is the first study to focus on the morphological features of PGD.

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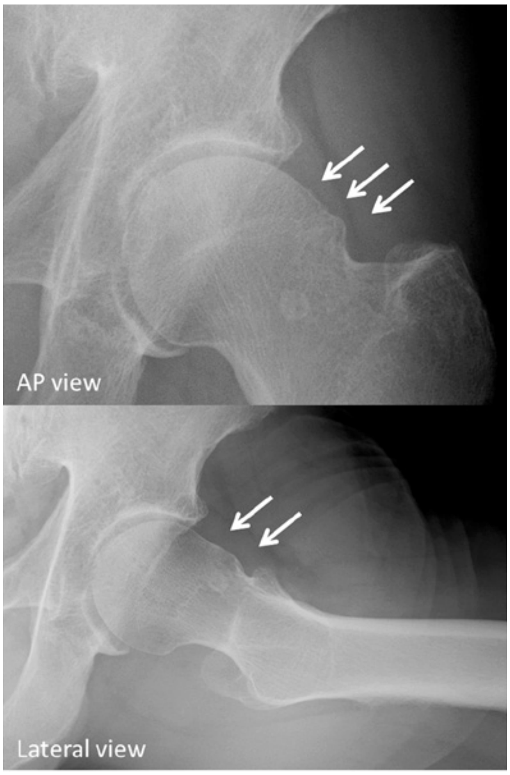

Fig. 1 AP and lateral radiographs of hips showing a typical case of PGD (Arrows indicate obvious presence of loss of femoral head-neck offset on AP and lateral radiographs).

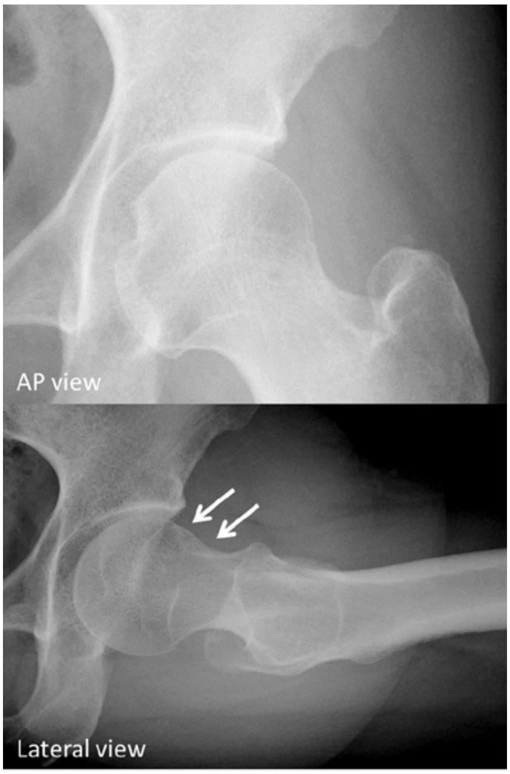

Fig. 2 AP and lateral radiographs of hips showing a typical case of pure cam-type deformity (Arrows indicate obvious presence of loss of femoral head-neck offset only lateral radiograph).

Materials and Methods

Fifty-one consecutive hips in 48 patients (31 men, 16 women; mean age, 63 years; age range, 30–96 years) who met our inclusion criteria were included after a retrospective review of the radiology information system and patient records. The inclusion criteria for the two groups were as follows. The PGD group was defined as obvious presence of loss of femoral head-neck offset on AP radiographs, triangular index [7] of ≥2 mm, and Tönnis grade [8] of ≤1. The control group (normal morphology) was defined as no history of ongoing hip or groin pain, no prior hip surgery, obvious absence of loss of femoral head-neck offset on AP radiographs, triangular index of <2 mm, lateral center-edge angle of ≥25°, alpha angle [9] on lateral radiographs of <50.5°, and Tönnis grade of ≤1. Patients who had not undergone CT imaging of the hip joint were excluded even if they met our inclusion criteria.

A supine AP digital radiograph of the pelvis was obtained. The tube-to-film distance was 120 cm, with the tube perpendicular to the table. The center beam was directed toward the midpoint between the upper border of the symphysis and a horizontal line connecting the bilateral AP iliac spines. The radiographic measurements were performed using a software program (Rapideye™ Hyper; Toshiba, Tochigi, Japan). The CT images were obtained with an Aquilion ONE ViSION Edition (Toshiba, Ootawara, Japan) , and multiplanar reformation was carried out with a ZIOSTATION (Ziosoft, Tokyo, Japan) . Radial CT images of each hip were reconstructed and generated at 10° intervals from anterior to posterior (0° to 180°) of the femoral head, using the femoral neck as the axis of rotation (Figs. 3, 4). The alpha angles of each plane were measured. A value of >50.5° was considered positive for cam-type morphology according to previous reports [9-14] . We defined the 50° and 60° vectors as anterosuperior positions and the 80° and 90° vectors as superior positions based on previous studies [10, 15-17].

For each group, the vector at which the mean maximum alpha angle measurement occurred and the percentage distribution of positive cam-type deformities at each plane were noted. The differences in the mean alpha angle values between the PGD group and the control group at each plane were determined using a two-sample *t*-test or Mann–Whitney U test depending on the normality of the distribution of the alpha angles evaluated by the Shapiro–Wilk test. Analysis of variance was used to evaluate the differences in the mean alpha angle values at each plane

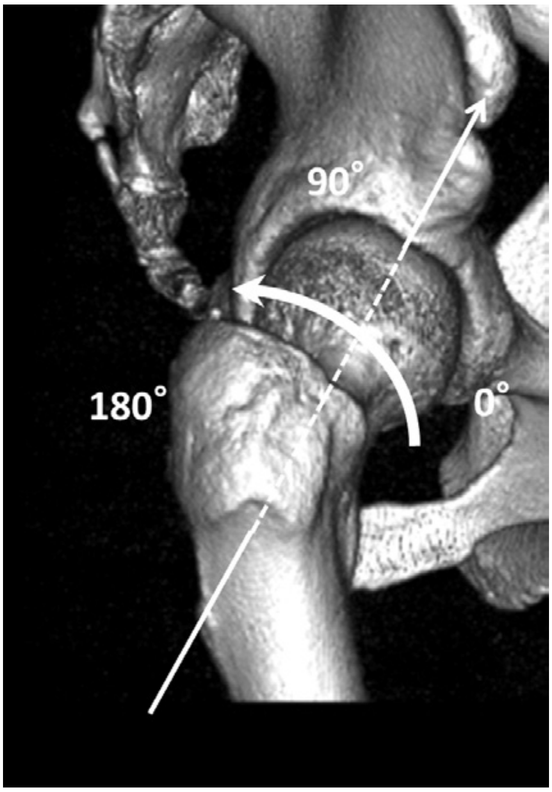

Fig. 3 The panel shows the process for reconstructing radial images from anterior (0°) to posterior (180°) of the femoral head at 10° intervals, using the femoral neck as the axis of rotation (Normal morphology case).

within the PGD group. Finally, the rates of positive cam-type morphology at each plane were compared between the two groups using the chi-square test. Values of P<0.05 were considered statistically significant.

The alpha angle measurements were performed by two of the authors, and the intraclass correlation coefficients (ICCs) were determined.

Results

In the PGD group, there were 31 hips in 8 female and 20 male patients with a mean age of 65 years. In the control group, there were 20 hips in 8 female and 12 male patients with a mean age of 60 years. The mean maximum alpha angles were 61° in the 60° vector in the PGD group and 50° in the 40° and 50° vectors in the control group. The mean alpha angles in the PGD group were significantly greater than those in the control group in the 30° to 100° vectors (Table 1). In the PGD group, the mean alpha angles in the 50° and 60° vectors (anterosuperior positions) were significantly greater than those in the 90° to 100° vectors (P<0.0001) and 80° to 100° vectors (superior positions) (P<0.05), respectively. In the PGD group, the rates of positive cam-type morphology were significantly higher than those in the normal group in the 30° to 90° vectors (Table 2).

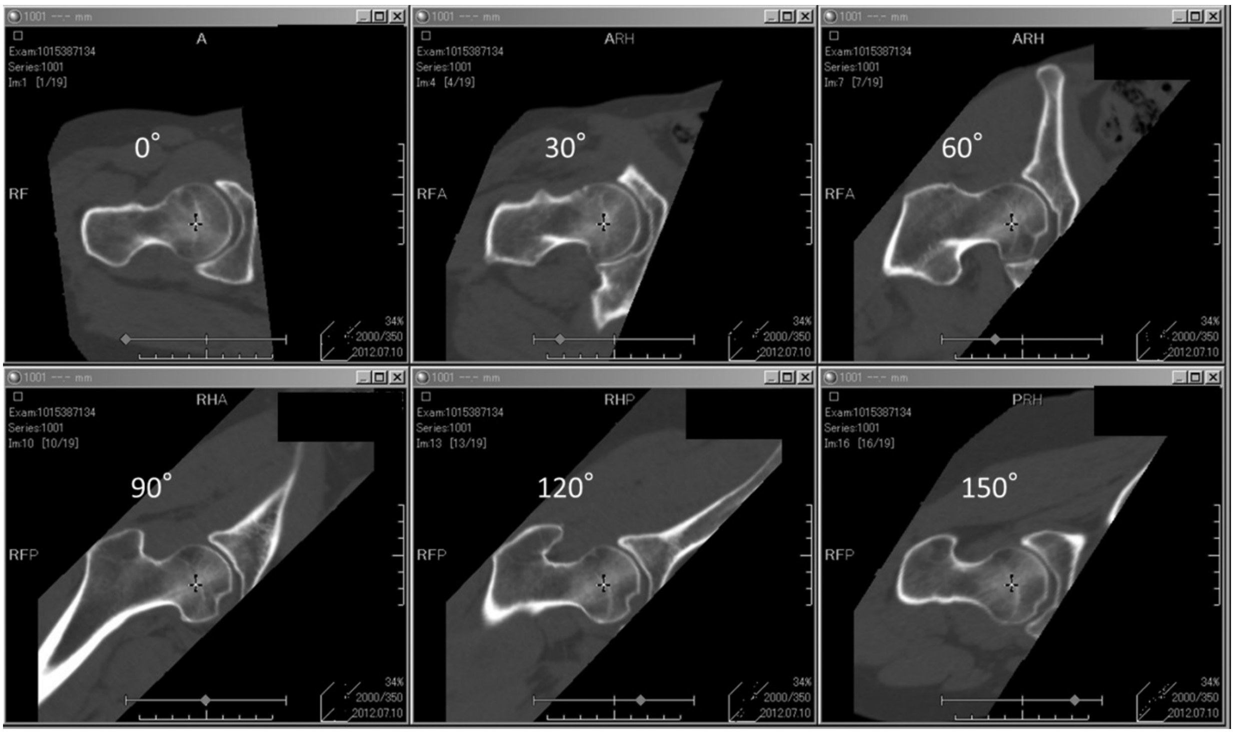

Fig. 4 Radial images at each vector (Normal morphology case).

Table 1. Comparison of the alpha angles of each plane between the two groups

Plane (°)		0*	10*	20*	30*	40*
PGD group	Alpha angle (°)					
	mean	40.5	43.6	47.3	52.7	57.8
	range	23.9-57.5	31.3-59.8	31.1-63.9	32.6-69.7	39.3-82.8
	standard deviation	8.1	8.1	8.4	9.3	9.9
Control group	Alpha angle (°)					
	mean	39.1	41.4	44.8	47.2	50.1
	range	32.2-47.3	33.8-49.8	35.3-54.9	37.8-57.7	39.7-60.0
	standard deviation	4.5	4.9	5.4	5.3	6.2
P value			n.s.		0.011	0.001

Plane (°)		Anterosuperior			Superior				
		50*	60*	70*	80*	90*	100**	110**	120**
PGD group	mean	59.6	60.6	56.2	53.3	48.3	42.9	40.1	37.5
	range	39.0-81.7	42.5-88.0	42.0-72.9	36.9-75.4	35.1-70.3	33.2-63.5	32.1-64.6	29.2-63.8
	standard deviation	9.0	9.4	8.6	9.1	8.8	7.2	6.5	6.4
Control group	mean	49.7	46.2	44.3	41.2	39.6	38	37.7	36.2
	range	42.7-60.3	39.3-53.3	39.0-51.7	35.9-45.1	37.0-44.8	33.3-43.8	32.1-49.7	30.4-49.7
	standard deviation	5.7	4.0	3.6	2.5	2.3	3.2	4.5	4.7
P value		<0.001	<0.001	<0.001	<0.001	<0.001	0.005	n.s.	

Plane (°)		130*	140*	150**	160**	170**	180**
PGD group	mean	35.8	34.1	33.5	32.3	31.5	31.3
	range	27.5-46.4	27.7-42.9	26.1-50.8	23.8-45.3	22.1-39.8	19.9-41.5
	standard deviation	4.5	3.4	4.4	4.4	4.6	5.5
Control group	mean	34.3	34.1	33.4	33.2	32.4	31.6
	range	28.7-48.1	28.9-41.1	26.8-40.1	26.6-46.6	27.7-48.6	26.4-47.4
	standard deviation	5.1	3.4	3.3	4.4	4.6	4.7
P value				n.s.			

n.s. = not significant, PGD = pistol grip deformity

* Two-sample t-test, ** Mann-Whitney U test

Table 2. Percentage distribution of cam-type morphology at each plane and the differences between the two groups

Plane (°)	No. of hips: PGD group	No. of hips: Control group	P value*
0	3 (10%)	0 (0%)	n.s.
10	6 (19%)	0 (0%)	n.s.
20	12 (39%)	2 (11%)	n.s.
30	21 (68%)	4 (22%)	0.002
40	24 (77%)	9 (50%)	0.048
50	28 (90%)	8 (44%)	0.001
60	28 (90%)	4 (22%)	<0.001
70	21 (68%)	1 (6%)	<0.001
80	19 (61%)	0 (0%)	<0.001
90	12 (39%)	0 (0%)	0.002
100	3 (10%)	0 (0%)	n.s.

n.s. = not significant, PGD = pistol grip deformity

* Chi-square test

The ICCs for measuring the alpha angles were 0.992 (95% confidence interval [CI], 0.991 to 0.993) for intraobserver reliability and 0.969 (95% CI, 0.964 to 0.972) for interobserver reliability.

Discussion

In cam-type deformities, there are two obviously different types of morphological abnormalities. These comprise abnormalities that can even be seen on AP radiographs (PGD) and only seen on lateral radiographs (pure cam-type deformity). Although PGD was originally described by Stulberg et al. [6] as a morphological feature that can be seen on AP radiographs, Eijer et al.[18] subsequently reported that it can be best identified on lateral radiographs. Since then, most studies evaluating cam-type deformities have assessed these two types of deformities in confusion. Because there is evidence that incomplete correction of the femoral head-neck offset remains the leading cause of revision surgery for FAI [4], a detailed preoperative understanding of the morphology is important for preoperative decision-making [5]. We believe that these two types of morphological features (PGD and pure cam-type deformity) should not be confused because they have obviously different morphological features on AP radiographs.

There are some studies that have addressed the morphological features of cam-type deformities using radial images. Siebenrock et al.[17] described that the FAI group showed a statistically significant decrease in the femoral head-neck offset in the anterosuperior quadrant compared with the control group. Phirmann et al.[16] reported that the alpha angle was significantly larger in patients with cam-type FAI at the anterior and anterosuperior positions. To the best of our knowledge, no studies have reported the morphological abnormalities in the superior femoral head-neck junction in FAI hips. In this study, we found that the mean alpha angles in the PGD group were significantly greater than those in the control group in the 30° to 100° vectors and that the rates of positive cam-type deformities were significantly higher in the PGD group than in the normal group in the 30° to 90° vectors. The PGD group was revealed to have cam-type deformities not only at the anterosuperior but also at the superior femoral head-neck junction. In FAI hips, Tamura et al.[19] described that a mode 1 labral tear, which may be a risk factor for the development of adjacent acetabular cartilage damage, was likely to occur at the anterior and anterosuperior zones. Our findings imply that the cartilage and labral damage in PGD hips may occur in a wider range of zones compared with hips with pure cam-type deformities, and that a wider range of resection of the femoral head-neck junction may be needed for PGD hips. Further investigations to evaluate the differences in the location and degree of cartilage or labral damage between hips with PGD and pure cam-type deformity will be needed.

In the PGD group, the mean maximum alpha angle was 61° in the 60° vector. This finding was similar to previous reports that have been published [15, 17]. In the PGD group, we also found that the mean alpha angles at the anterosuperior position were significantly greater than those at the superior position. The percentage distributions of positive cam-type morphology at the 50°, 60°, 80°, 90°, and 100° vectors were 90%, 90%, 61%, 39%, and 10%, respectively. Therefore, PGD hips had a high rate of cam-type deformities at anterosuperior positions. Meanwhile, they also had cam-type deformities at superior positions at lower rates. Rakhra et al.[15] reported that radial plane imaging should be considered to avoid underestimating or missing the morphological abnormalities of FAI hips. Our study supports their opinion. Because there is a possibility of overlooking cam-type deformities, especially at the superior position, in PGD hips without three-dimensional evaluations, we recommend radial imaging evaluation for preoperative decision-making for cam-type FAI.

There is a limitation to our study. The alpha angles of pure cam-type deformity should ideally be compared with those of PGD. However, it was difficult for us to collect a sufficiently large sample size for pure cam-type FAI because of the low incidence of pure FAI in Japan [20]. However, we feel that our study design is not inferior to those in previous reports evaluating the morphological features of cam-type FAI [15, 16].

In conclusion, we found that PGD is a particular morphological abnormality from the anterosuperior to superior femoral head-neck junction. This finding contradicts the results that have previously been reported[16, 17]. For preoperative and intraoperative decision-making for cam-type FAI we need to differentiate these two types of morphological features, and a radial imaging evaluation is recommended.

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