*Original Article*

# Prevalence of Cam-Type Femoroacetabular Impingement Morphology in Hip Joint of Asymptomatic Thai Population

Anoma Sanpatchayapong MD[1], Varit Watcharaprechasakul MD[2], Mason Porramatikul MD[2], Kan Radeesri MD[1]

[1] Division of Diagnostic Radiology, Department of Radiology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand

[2] Division of Sports Medicine, Department of Orthopedics, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand

**Objective**: To determine the prevalence of cam-type femoroacetabular impingement (FAI) in the hip joints of asymptomatic Thai individuals using increased alpha angle of more than 55° on computed tomography (CT) images.

**Materials and Methods**: The prospective study was conducted between 2019 and 2021. CT images of the 226 hip joints with no history of hip pain within three months prior to CT, no history of congenital dysplasia, Perthes disease, slipped capital femoral epiphysis, hip fracture, hip surgery, and inflammatory arthropathy, negative anterior impingement test, and no CT findings of osteoarthritis were evaluated. Alpha angles were measured in the axial oblique and radial planes at 12 o'clock, 1 o'clock, 1:30 o'clock, 2 o'clock, and 3 o'clock. Alpha angles of more than 55° were considered cam-type FAI morphology.

**Results**: The prevalence rates of cam-type FAI morphology using increased alpha angles of more than 55° measured on axial oblique and radial plane images at 12 o'clock, 1 o'clock, 1:30 o'clock, 2 o'clock, and 3 o'clock were 0.4%, 0%, 4.9%, 8.4%, 8.0%, and 1.8% respectively. Cam-type morphology was common in the anterosuperior aspect of the femoral head-neck junction. The prevalence of cam-type morphology was significantly higher in men than in women.

**Conclusion**: The range of prevalence rates of cam-type FAI morphology are between 0 to 8.4%. The prevalence is different in each image plane and location of the femoral head-neck junction. The prevalence of cam-type morphology in the present study differed from those in the previous studies conducted in other countries, which may be caused from variations in race and ethnicity.

**Keywords**: Prevalence; Cam-type Femoroacetabular Impingement (FAI); Alpha angle; Computed tomography (CT)

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Femoroacetabular impingement (FAI) is an abnormality of the femur and acetabulum that caused abnormal impingement of the acetabular rim, labrum and cartilage, and femoral neck in normal range of motion, resulting in injury of the labrum and cartilage from repetitive trauma and leading to the development of osteoarthritis (OA)[1]. Patients with femoral impingement usually present with symptoms in their second or third decade of life[2]. They present with hip and groin pain and limited hip motion[3], which are exacerbated by athletic activities or prolonged walking or sitting[4]. There are two types of femoral acetabular impingement, cam-type and pincer type[4]. Cam-type impingement is characterized by loss of sphericity of the femoral head or loss of femoral neck offset[1,5].

Presently, imaging has a key role in the diagnosis of FAI and evaluation of patients before surgical treatment. For years, studies reported on the use of alpha angle measurement in computed tomography (CT) and magnetic resonance imaging (MRI) to help evaluate abnormal femoral head and neck junction and found increased alpha angle on the femoral head-neck junction of symptomatic patients[5-9]. Nötzli et al found that all 39 patients with clinical and physical examination were consistent with FAI in their study, which has increased alpha angle of 55 to 95 degrees as compared with the control asymptomatic group, which has alpha angle of 33 to 48 degrees[6]. These increased alpha angle findings in the patient, which are clinically compatible with FAI, lead to the

**Correspondence to:**

Sanpatchayapong A,

Division of Diagnostic Radiology, Department of radiology, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok 10300, Thailand.

**Phone**: +66-2-2443000 ext. 3245

**Email**: anoma@nmu.ac.th

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diagnosis of cam-type FAI.

Two techniques of imaging of the femoral head-neck junction for alpha angle measurement are used. The first technique, which was introduced by Nötzli et al[6], is called the axial oblique plane. This plane is parallel to the long axis of the femoral neck and passes through the center of the femoral neck, representing only the anterior contour of the femoral head-neck junction. The second technique was proposed by Pfirrmann et al[10]. They used the radially reformatted images to evaluate the whole contour of the femoral head-neck junction.

Previous studies focused on alpha angle measurement with CT in the asymptomatic population using one of these two techniques or both and obtained various results of femoral cam-type deformity among asymptomatic patients[11-19].

The present study aimed to determine the prevalence of cam-type FAI morphology among the asymptomatic population using an alpha angle of more than 55°[11-23] on axial and radial plane images for further understanding of FAI in the hip joint of Thai individuals.

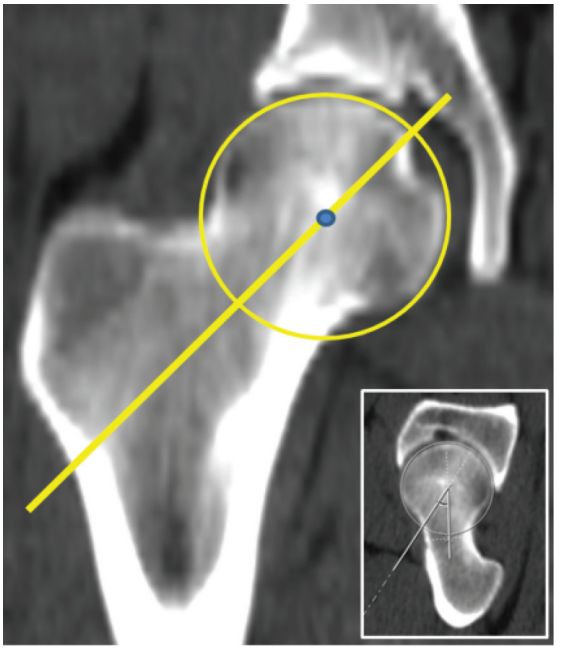

**Figure 1.** Coronal reformatted CT image showing the reference plane (yellow line) that forms axial oblique plane image (small picture on the bottom right). The reference plane is parallel to the femoral neck axis and passes directly through the center of the circle that fits to the femoral head.

## Materials and Methods

The present study was approved by the Institutional Review Board Office, Research Affairs, Navamindradhiraj University (IRB No. 140/61). All subjects provided written informed consents. The present study was a prospective descriptive study. Thai patients who were aged 18 to 45 years, that underwent CT, including the bilateral hip regions, between 2019 and 2021, and had no history of hip pain within three months prior to CT and no history of congenital dysplasia, Perthes disease, slipped capital femoral epiphysis, hip fracture, hip surgery, and any inflammatory arthropathy, and with negative anterior impingement test and no CT findings of OA were included in the study. According to a previous study[15] the prevalence is 0.18, thus, the estimated study number of hip joints was 226.

CT was performed with 128-detector row CT scanners (Brilliance; Philips Medical Systems, Amsterdam, the Netherlands). The axial 3-mm reconstruction images were reformatted to the coronal and sagittal planes on the workstation (IntelliSpace Portal 9, Phillip healthcare). Two types of the plane images for alpha angle measurement were used, axial oblique plane image and radial plane image. For the axial oblique plane image, first, the authors placed the plane parallel to the femoral neck axis on axial and sagittal planes to obtain the coronal reformatted image. Then, the coronal reformatted image was used to create the axial oblique plane image by placing the plane parallel to the femoral neck axis and to pass directly through the center of the femoral head as described by Nötzli et al[6] (Figure 1). For the radial plane image[10], the images were obtained through the mid-femoral neck axis, using the center of the femoral neck as the axis of rotation and five radial images were obtained at 12 o'clock (superior position), 1 o'clock, 1:30 o'clock, 2 o'clock (anterosuperior position), and 3 o'clock (anterior position) (Figure 2, 3). The alpha angle was defined as the angle between the line drawn from the center of the femoral neck at the narrowest point to the center of the femoral head and the line that was drawn from the center to the femoral head to a point where the femoral head protruded in a circle that best fit around the femoral head[6] (Figure 4). An alpha angle of more than 55° degree was considered indicative of cam-type morphology of FAI[11-23].

The alpha angle was measured in six images in each joint by one radiologist. The radiologist measured the alpha angles in the first 30 joints, two times with 1-month interval without knowing the result of the first alpha angle measurement to determine the intra-rater reliability using the intraclass

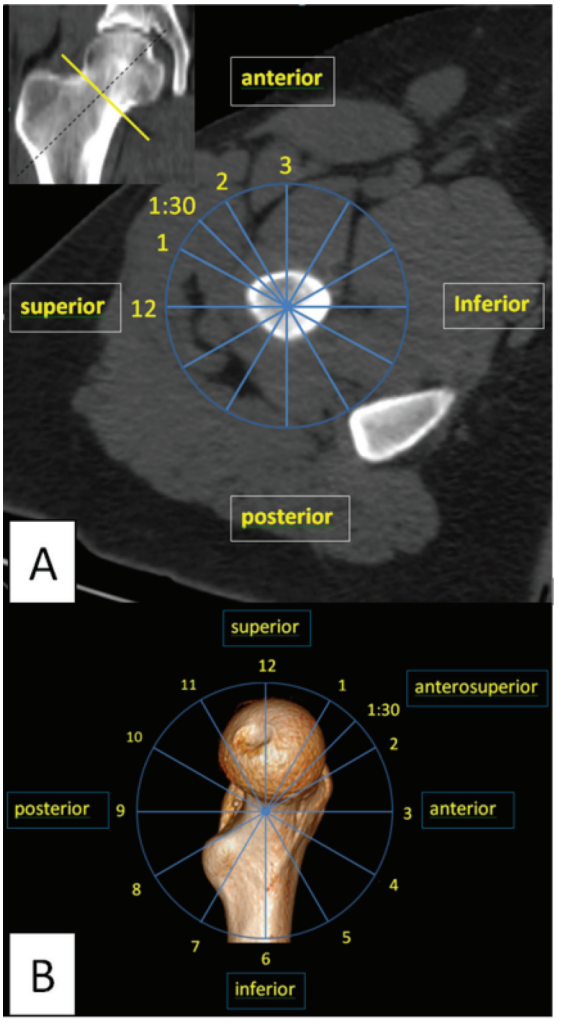


**Figure 2.** (A) Coronal reformatted CT image (small image on the upper left) shows the reference plane (yellow line) for obtaining the sagittal oblique image (large image). The reference plane passes through the femoral neck and is perpendicular to the long axis of the femoral neck. The sagittal oblique image shows superimposed redial reference lines (clock face) at 15° and 30° interval for radial plane images: 12 o'clock (0°), 1 o'clock (30°), 1:30 o'clock (45°), 2 o'clock (60°), and 3 o'clock (90°). These lines are used for reconstruction of the radial plane images on each position. The superior position of the femoral neck at 12 o'clock; anterosuperior position of femoral neck at 1 o'clock, 1:30 o'clock, and 2 o'clock; and anterior position of the femoral neck at 3 o'clock. (B) The clock face using the same radial reference lines on (A) was shown on the 3D reconstruction image of the femoral neck.

correlation coefficient (ICC). Data were expressed as prevalence of increased alpha angle of more than 55°, which were presented as numbers with percentage, mean ± standard deviation, and range. The chi-square test and Cochran's Q test with Bonferroni correction were used to analyze the difference in prevalence of cam-type FAI between genders and plane images. The independent sample t-test and repeated measures analysis of variance with Bonferroni correction were used to examine the difference in mean alpha angle between genders and plane images. Statistical significance was considered at a p-value less than 0.05. All analyses were performed using PASW Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA).

**Table 1.** Prevalence of cam-type FAI on each image plane

| Image planes | Total (n=226); n (%) | Male (n=109); n (%) | Female (n=117); n (%) | p-value |
|---|---|---|---|---|
| Axial oblique | 1 (0.4) | 0 (0.0) | 1 (0.9) | 1.000 |
| Radial 12 o'clock | 0 (0.0) | 0 (0.0) | 0 (0.0) | N/A |
| Radial 1 o'clock | 11 (4.9) | 11 (10.1) | 0 (0.0) | <0.001* |
| Radial 1.30 o'clock | 19 (8.4) | 14 (12.8) | 5 (4.3) | 0.029* |
| Radial 2 o'clock | 18 (8.0) | 16 (14.7) | 2 (1.7) | <0.001* |
| Radial 3 o'clock | 4 (1.8) | 3 (2.8) | 1 (0.9) | 0.355 |

N/A=not applicable

* Statistically significance; Comparison prevalence of cam-type femoro-acetabular impingement between gender by chi-square test

## Results

The alpha angles were obtained from 226 hip joints in 117 patients that included 56 men and 61 women. Bilateral hip joints were examined in 109 patients that included 53 men and 56 women, and one hip joint in eight patients that included three men and five women. The age of 117 patients ranged between 18 and 45 years. The mean age was 35.9 years.

In 226 hip joints, the prevalence rates of cam-type femoral impingement morphology of axial oblique and radial plane images at 12 o'clock, 1 o'clock, 1:30 o'clock, 2 o'clock, and 3 o'clock were 0.4%, 0%, 4.9%, 8.4%, 8.0%, and 1.8%, respectively (Table 1). The prevalence of cam-type FAI was significantly higher in the hip joint of men than that in the hip joint of women on radial plane images at 1 o'clock, 1:30 o'clock, and 2 o'clock. No significant differences were noted in the cam-type FAI prevalence between the left and right hip joints. The plane images that show the highest prevalence and the second highest prevalence were radial plane images at 1:30 o'clock and 2 o'clock, respectively, which represent the anterosuperior position of the femoral head-neck junction. The prevalence of FAI of radial plane images at 1:30 o'clock and 2 o'clock were significantly higher than that of the oblique axial and radial plane images at 3 o'clock and 12 o'clock (Table 2).

The mean alpha angle of the hip joints on axial

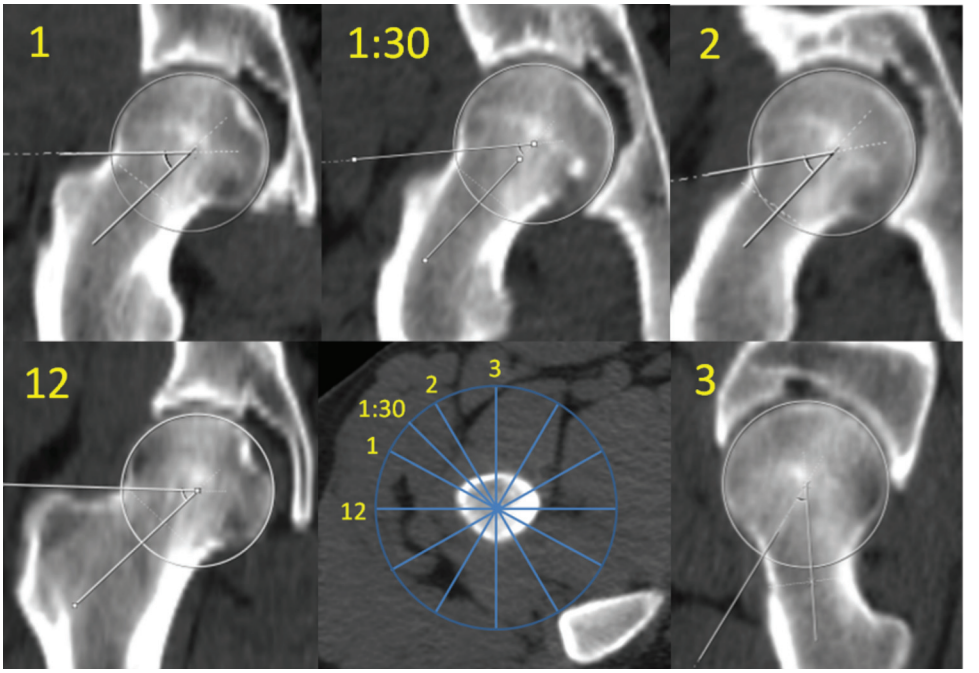


**Figure 3.** Radial plane images are reconstructed from the sagittal oblique image at 12 o'clock, 1 o'clock, 1:30 o'clock, 2 o'clock, and 3 o'clock with alpha angle measurement.

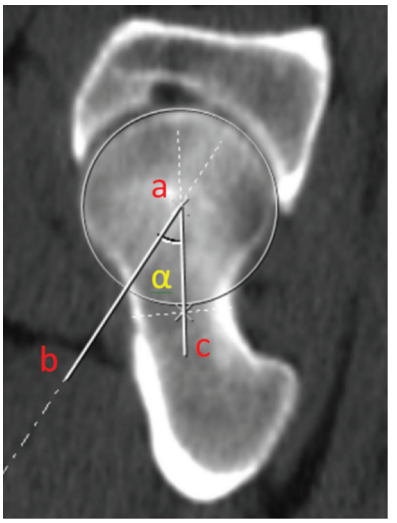


**Figure 4.** Measurement of the alpha angle. The alpha angle (α) is formed between the a-b line from the center of the circle that best fits the femoral head to the point where the radius of the femoral head exceeded the circle and the a-c line from the center of the circle of the femoral head to the center of the narrowest part of the femoral neck.

oblique and radial plane images on 1:30 o'clock were 40.90°±6.06° (29.80° to 56.00°) and 47.27°±5.66° (35.70° to 66.90°) (Table 3).

The radial plane image at 1:30 showed the highest mean angle, and the axial oblique plane image shows the lowest mean angle. The mean alpha angles of the hip joint in men were significantly higher than those in the hip joint in women on the radial image plane at 12 o'clock, 1 o'clock, 1:30, and 2 o'clock. The mean alpha angle on all radial plane images was significantly higher than the mean alpha angle on the axial oblique plane images (Table 4). The mean angle of the radial plane images at 1 o'clock, 1:30, and 2 o'clock was significantly higher than the mean alpha angle of the radial plane at 3 o'clock and 12 o'clock. There was no significant difference in the mean alpha angle between the left and right hip joints.

**Table 2.** Comparison of prevalence between the image planes (total n=226)

| Image planes | n (%) | | Image planes | n (%) | p-value |
|---|---|---|---|---|---|
| Axial 1.30 o'clock | 19 (8.4) | vs. | Axial oblique | 1 (0.4) | <0.001* |
| | | vs. | Radial 12 o'clock | 0 (0.0) | <0.001* |
| | | vs. | Radial 1 o'clock | 11 (4.9) | 0.055 |
| | | vs. | Radial 2 o'clock | 18 (8.0) | 1.000 |
| | | vs. | Radial 3 o'clock | 4 (1.8) | 0.006* |
| Radial 2 o'clock | 18 (8.0) | vs. | Axial oblique | 1 (0.4) | <0.001* |
| | | vs. | Radial 12 o'clock | 0 (0.0) | <0.001* |
| | | vs. | Radial 1 o'clock | 11 (4.9) | 0.147 |
| | | vs. | Radial 3 o'clock | 4 (1.8) | 0.019* |

* Statistically significance; Cochran's Q test significance values have been adjusted by the Bonferroni correction for multiple tests

**Table 3.** Mean alpha angle of each image plane

| Image planes | Total (n=226); mean±SD (range) | Male (n=109); mean±SD (range) | Female (n=117); mean±SD (range) | p-value |
|---|---|---|---|---|
| Axial oblique | 40.90±6.06 (29.80 to 56.00) | 40.82±6.55 (29.80 to 54.80) | 40.98±5.58 (30.20 to 56.00) | 0.845 |
| Radial 12 o'clock | 42.95±4.05 (32.80 to 54.30) | 44.12±4.12 (35.80 to 54.30) | 41.85±3.68 (32.80 to 54.00) | <0.001* |
| Radial 1 o'clock | 46.38±5.57 (34.70 to 68.60) | 48.87±5.94 (38.50 to 68.60) | 44.06±4.03 (34.70 to 54.90) | <0.001* |
| Radial 1.30 o'clock | 47.27±5.66 (35.70 to 66.90) | 48.71±6.12 (35.70 to 66.90) | 45.93±4.86 (36.60 to 59.50) | <0.001* |
| Radial 2 o'clock | 46.98±5.74 (33.10 to 61.50) | 48.24±6.22 (35.10 to 61.50) | 45.79±5.00 (33.10 to 58.60) | 0.001* |
| Radial 3 o'clock | 42.58±6.53 (31.10 to 62.30) | 42.62±7.08 (31.10 to 62.30) | 42.54±5.99 (31.30 to 55.60) | 0.924 |

SD=standard deviation

* Statistically significance; Comparison mean of alpha angle between gender by unpaired t-test

**Table 4.** Comparison of mean between the image planes

| Image planes | Mean±SD (range) | | Image planes | Mean±SD (range) | p-value |
|---|---|---|---|---|---|
| Axial oblique | 40.90±6.06 (29.80 to 56.00) | vs. | Radial 12 o'clock | 42.95±4.05 (32.80 to 54.30) | 0.004* |
| | | vs. | Radial 1 o'clock | 46.38±5.57 (34.70 to 68.60) | <0.001* |
| | | vs. | Radial 1.30 o'clock | 47.27±5.66 (35.70 to 66.90) | <0.001* |
| | | vs. | Radial 2 o'clock | 46.98±5.74 (33.10 to 61.50) | <0.001* |
| | | vs. | Radial 3 o'clock | 42.58±6.53 (31.10 to 62.30) | <0.001* |
| Radial 1 o'clock | 46.38±5.57 (34.70 to 68.60) | vs. | Radial 12 o'clock | 42.95±4.05 (32.80 to 54.30) | <0.001* |
| | | vs. | Radial 1.30 o'clock | 47.27±5.66 (35.70 to 66.90) | 0.059 |
| | | vs. | Radial 2 o'clock | 46.98±5.74 (33.10 to 61.50) | 1.000 |
| | | vs. | Radial 3 o'clock | 42.58±6.53 (31.10 to 62.30) | <0.001* |
| Radial 1.30 o'clock | 47.27±5.66 (35.70 to 66.90) | vs. | Radial 12 o'clock | 42.95±4.05 (32.80 to 54.30) | <0.001* |
| | | vs. | Radial 2 o'clock | 46.98±5.74 (33.10 to 61.50) | 1.000 |
| | | vs. | Radial 3 o'clock | 42.58±6.53 (31.10 to 62.30) | <0.001* |
| Radial 2 o'clock | 46.98±5.74 (33.10 to 61.50) | vs. | Radial 12 o'clock | 42.95±4.05 (32.80 to 54.30) | <0.001* |
| | | vs. | Radial 3 o'clock | 42.58±6.53 (31.10 to 62.30) | <0.001* |

SD=standard deviation

* Statistically significance; Repeated measures ANOVA significance values have been adjusted by the Bonferroni correction for multiple tests

The ICC was used to evaluate intra-rater reliability for each quantitative measurement, which was repeated on 30 hips with 1-month interval. The ICC for intra-rater reliability analysis of the alpha angle was 0.975. The ICCs ranged from 0.948 to 0.988. The present study result showed high agreement within the rater.

## Discussion

The present study is the first prospective study that examined the prevalence of cam-type FAI in the hip joints of asymptomatic Thai individuals using the alpha angle as measured by CT. The authors believe that the information from the present study will be useful in the future to understand the knowledge of FAI in Thai individuals and in further clinical research.

The authors found the cam prevalence in Thai individuals is lower than those in most previous studies[11,12,14,15,17,18]. The prevalence rates of cam-type morphology in the studies of Kang et al[11] from New Zealand, Chakraverty et al[12] from the UK, Hack et al[14] from Canada, Han et al[15] and Kim et al[17] from Korea, and Teke et al[18] from Iran ranged between 3% and 21% on the axial oblique plane, 0% and 9% on the radial plane at 12 o'clock, 18% and 29.8% on the radial plane at 1 o'clock, 46.5% on the radial plane at 1:30 o'clock, 11% and 19% on the radial plane at 2 o'clock, and 3% and 4% on the radial plane at 3 o'clock. However, a study of Ergen et al[13] from Turkey showed a lower prevalence than that in the present study. The prevalence rates of cam-type FAI morphology using alpha angle of 55° or more on Ergen et al's study[13] were 7.6% on radial plane at 1:30 o'clock, 3.8% on the radial plane at 2 o'clock, and 0% on the radial plane at 3 o'clock. The authors assume that the differences between the prevalence of previous studies and the present study may be caused

from the variations in race and ethnicity. Another study that the authors believe may support this hypothesis is the study of Houcke et al[16], which evaluated the prevalence of FAI in young asymptomatic Chinese and white subjects. They found that the prevalence rate of cam-type morphology in white subjects were higher than that in Chinese subjects.

The prevalence rates of cam-type morphology and mean alpha angle on the anterosuperior aspect of the femoral head-neck junction in the present study were significantly higher than those in the anterior aspect. Cam-type morphology in the present study is mostly found and obvious in the anterosuperior aspect of the femoral head-neck junction. The present study result corresponds to those of other studies[10,12-15,21-23], which reported that the reduced offset of femoral head-neck junction is greatest in the anterosuperior aspect.

Ergen et al[13], Hack et al[14], and Han et al[15] found higher prevalence of cam-type morphology and higher alpha angle in men than in women. In the present study, the prevalence rates of cam deformity were 3% to 11% in men and 1% to 5% on women, which aligned with the results of their studies[13-15]. This difference in prevalence between genders may be explained by the vigorous activity that may tend to occur in men than in women. Murray et al[24] and Siebenrock et al[25] reveal increased prevalence in subjects with more sports activities than those with little or no sports activities.

In the present study, the authors also compared the prevalence rates of cam-type alpha angle between the original axial oblique and radial images at 3 o'clock that represent the anterior aspect of the femoral head-neck junction. The authors found no significant difference in prevalence between these two planes. The authors assumed that these two image planes are equally effective in the evaluation of cam-type morphology on the anterior femoral head-neck area.

The limitation of the study is that it did not assess the inter-rater reliability of alpha angle measurement. However, it evaluated the intra-rater reliability, and the result showed excellent agreement. Furthermore, occupational and activity levels were not evaluated or recorded.

The authors assumed that asymptomatic individuals with cam-type morphology in the present study may have significant risk of hip OA in the future compared to individuals who did not have abnormal morphology of the same age, gender, and activity level[5-9]. Further study is required to prove this theory.

## Conclusion

The range of prevalence rates of cam-type FAI morphology is between 0% to 8.4%. The prevalence is different between the image planes and locations of the femoral head-neck junction. The prevalence of cam-type morphology was different from those of previous studies conducted in other countries, which may be caused by variations in race and ethnicity.

## What is already known on this topic?

Cam-type FAI is an abnormality of femur that is characterized by asphericity of the femoral head and loss of femoral head-neck offset. An alpha angle of more than 55° is a tool in the diagnosis of this morphology. It can be noted among asymptomatic individuals with different prevalence rates. However, the prevalence of cam-type FAI in asymptomatic Thai population is unknown.

## What this study adds?

The prevalence rate of cam-type FAI morphology among asymptomatic Thai individuals in one academic center ranged between 0% and 8.4% depending on the image plane. The highest prevalence rate was found in the anterosuperior aspect of the femoral head-neck junction. The prevalence of cam-type morphology in men is significantly higher than that in women.


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## Conflicts of interest

The authors declare no conflict of interest.

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