Radiological Assessment of Femoroacetabular Impingement Morphology Using Computed Tomography in Asymptomatic Young Population

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ABSTRACT

Background

Femoroacetabular impingement is regarded as precursor of osteoarthritis. Various studies have discussed the prevalence of femoroacetabular morphology but only few studies have been done on asymptomatic population using cross-sectional imaging.

Objective

To determine the prevalence of femoroacetabular impingement morphology in young asymptomatic population on computed tomography.

Method

This cross-sectional study was done in 200 individuals who underwent computed tomography for abdominal pathologies without any symptoms of hip pain, hip pathology or osteoarthritis. Multiplanar images were reformatted and assessed for the presence of parameters associated with femoroacetabular impingement; alpha angle greater than 55°, femoral head-neck offset less than 8 mm, angle of acetabular version less than 15°, lateral center edge angle greater than 40°.

Result

At least one of the femoroacetabular impingement morphology was detected in 162 hips. The prevalence of abnormal hip joint was higher in male patients than in female patients (47.3% vs 31.8%). Prevalence of cam morphology was 14.5%, pincher was 17.5% and mixed morphology was 8.5%. Prevalence of cam and mixed morphology were common in male hips however there was no statistically significant difference in prevalence of pincher morphology between male and female hips.

Conclusion

Femoroacetabular morphology was noted with high frequency in asymptomatic young population on computed tomography. Diagnosis of femoroacetabular impingement syndrome should be based on combination of clinical and radiological findings.

KEY WORDS

Alpha-angle, Cam, Femoroacetabular impingement, Pincher

INTRODUCTION

Femoroacetabular impingement (FAI) refers to abnormal contact between the femur, typically the junction between the anterior/superior femoral head and neck and the acetabular rim.[1] This results into chondral and labral injury which progresses to degenerative disease of hip joint.[2] Two distinct patho-anatomic types of FAI: Cam and Pincer impingement exist, although mixed types have been described.[3] Cam impingement is caused by an aspherical shape of the femoral head and pincer impingement is due to general or focal acetabular overcoverage.

A number of studies have been done to estimate the prevalence of radiologic parameters associated with FAI but these studies based mainly on plain radiograph.[4-6] A recent consensus meeting stated that hip morphology is best characterised with cross sectional imaging.[7] Overall, the current literature has shown that the currently utilized markers from plain radiographs can be inaccurate and must be used in conjunction with thorough clinical examinations and appropriate advanced imaging modalities.[8]

Only few previous studies have assessed the computed tomography (CT) features that are thought to be associated with cam- and pincer-type FAI in young asymptomatic adult population. These studies have shown high occurrence of morphologic parameters associated with FAI.[9-12] No such studies have been carried out in Nepalese population. Determining these predisposing factors of FAI in asymptomatic population can be useful to predict future risk of cartilage damage and hip pain. Therefore, in this study, we have investigated the prevalence of femoroacetabular morphology on CT in asymptomatic patient.

METHODS

A hospital-based cross-sectional study was carried out in the Department of Radiodiagnosis and Imaging at B. P. Koirala Institute of Health Sciences, Dharan, Nepal for 1 year, from July 2020 to June 2021, after taking the ethical approval from our local institutional review committee with ethical approval number IRC/2109/021. Two-hundred patients aged 18 to 40 years undergoing CT scan of abdomen for causes other than hip trauma or pain were included in the study. CT scan images obtained using a 16-MDCT scanner (Neusoft Neuviz classic 16) on abdomen protocol were included in the study. Patients with hip pain, hip deformity, infection, tumour, prosthesis, degenerative changes or fracture were excluded from our study.

Cam morphology was evaluated by measuring alpha angle (AA) and femoral head-neck offset (FHNO) in oblique axial plane (Fig. 1 and Fig. 2). Alpha angle was measured between line drawn from center of femoral head through central axis of femoral neck and second line drawn from center of femoral head to anterior point where distance from center of head exceeds radius of femoral head. FNHO was

Figure 1. Oblique axial CT scan image showing alpha angle measurement.

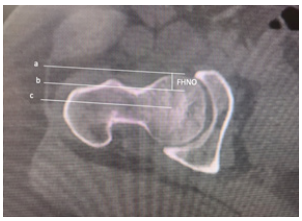

Figure 2. Oblique axial CT scan image showing femoral head-neck offset measurement.

measured between the line parallel to the anterior cortex of the femoral head and line parallel to the anterior aspect of the femoral neck cortex. Participants with an AA > 55° or FHNO < 8 mm were diagnosed with cam morphology.[13,14]

Pincer morphology was evaluated by measuring acetabular angle of version (AV) and lateral central edge angle (LCEA). AV was measured on axial plane (Fig. 3) where acetabular cup was deepest and medial wall of acetabulum was most medial. It was measured as the angle between a line connecting the anterior acetabular margin with the posterior acetabular margin and the line perpendicular to a transverse reference line through posterior corners of acetabulum. LCEA was measured in scout image (Fig. 4) as the angle between two lines drawn from the center of femoral head, one running vertically along the longitudinal axis of the body (perpendicular to a line joining the inferior ischial tuberosities) and the other to the lateral acetabular rim. An abnormal AV was defined as an angle of less than 15° and an abnormal LCEA was defined as an angle of more than 40°.[4,15]

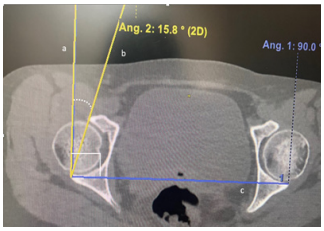

Figure 3. Axial CT scan image showing acetabular angle of version measurement

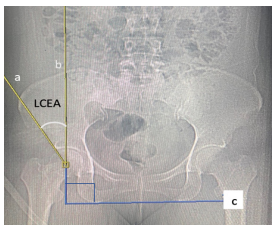

Figure 4. Scout CT scan image showing measurement of lateral center edge angle

Data obtained were compiled and analyzed using IBM SPSS Statistics version 25. Categorical data were reported as frequencies with percentages. Continuous variable data were expressed as mean±standard deviations (range). Differences in the distribution of the FAI morphology according to gender was investigated by using the chi-square test. Gender differences in mean of AA, FHNO, AV and LCEA were examined using the independent samples t-test. For all statistical analysis, p-value < .05 was deemed statistically significant.

RESULTS

During the study period, 400 hip joints of 200 consecutive patients who underwent CT abdomen in our institution were evaluated. There were 112 males (66%) with mean

age 29.1 ± 6.8 years and 88 females (44%) with mean age of 31.3 ± 6.6 years.

At least one of the femoroacetabular impingement morphology (AA > 55°, FHNO < 8 mm, AV < 15°, or LCEA > 40°) was detected in 162 hips (40.5%). The prevalence of abnormal hip joint was higher in male patients than in female patients (47.3% vs 31.8%, respectively). The difference was statistically significant. Prevalence of cam morphology was 14.5%, pincher was 17.5% and mixed morphology was 8.5% as shown in table 1. Prevalence of cam and mixed morphology were higher in male hip joints. The difference was statistically significant. No statistically significant difference was noted in prevalence of pincher morphology between male and female hip.

Table 1. Prevalence of types of FAI morphology in male and female hips.

Radiologic feature	Number (percentage) of Hip joints			
	Male (n=224)	Female (n= 176)	Total (n=400)	P -value
Cam morphology	43(19.1)	15(8.5)	58 (14.5)	<.001
Pincher morphology	38(16.9)	32 (18.1)	70 (17.5)	.78
Mixed morphology	25 (11.1)	9(6.2)	34 (8.5)	.03

Prevalence of abnormal AA and FHNO were statistically higher in male hip joints. There was no statistically significant difference in prevalence of AV and LCEA abnormality between male and female hip as shown in table 2.

Table 2. Prevalence of morphological parameters associated with FAI in male and female hip

Radiologic feature	Number (percentagae) of Hip joints			
	Male (n=224)	Female (n=176)	Total (n=400)	P value
Alpha angle> 55°	68(30.3)	24 (13.6)	92 (23)	.001
FHNO < 8 mm	38(16.9)	14 (7.9)	52 (13)	.03
Acetabular version angle < 15°	50 (22.3)	28 (15.9)	78 (19.5)	.10
Lateral central edge angle > 40°	39 (17.4)	29 (16.4)	68 (17)	.80

The mean alpha angle was 46.3° ± 6.5° with a corresponding calculated normal range between 26° and 66°. There was statistically significant difference between mean alpha angle in male and female hip as shown in table 3.

Table 3. Alpha angle in male and female hip

	Alpha angle: Mean ± SD (range)		
	Male (n=224)	Female (n=176)	P-value
Right hip	49.2° ± 7.5° (34° - 66°)	43.2 ± 7.7° (26° - 63°)	<.001
Left Hip	48.4° ± 7° (32° - 63°)	43° ± 7.4° (26° - 59°)	<.001
Mean	48.8° ± 5.5°	43.1 ° ± 6.3°	<.001

The mean FHNO was 10.1 ± 1.3 mm with a range of 6.7 mm to 13.8 mm. No statistically significant difference was noted in mean FHNO between male and female hip as shown in table 4.

Table 4. Femoral head neck off set in male and female hip

	Alpha angle: Mean ± SD (range)		
	Male (n=224)	Female (n=176)	P-value
Right hip	9.9 mm ± 1.5 mm (6.7 mm - 13.8 mm)	10.3 mm ± 1.3 mm (6.8 mm - 13.2 mm)	.12
Left Hip	10.1 mm ± 1.6 mm (6.7 mm-13.8 mm)	10.2 mm ± 1.3 mm (7.5 mm - 12.8 mm)	.59
Mean	10 mm ± 1.3 mm	10.2 mm ± 1.2 mm	.24

The mean angle of version was 18.8° ± 3.6° with a normal range between 12° to 33°. Men hip had a lower angle of version compared to the female hip than women and the difference was statistically significant as shown in table 5.

Table 5. Acetabular angle of version in male and female hip

	Angle of version: Mean ±SD (range)		
	Male (n=224)	Female (n=176)	P-value
Right hip	17.7°±3.3° (13°-28°)	20.5°±4.8° (12°-33°)	<.001
Left Hip	17.4°±3.3° (12°-30°)	20.2°±4° (13°-31°)	<.001
Mean	17.5°±2.9°	20.3°±3.8°	<.001

The mean lateral central edge angle was 34.7° ± 5.1° with a corresponding calculated normal range between 17° and 50°. There was no statistically significant difference between mean LCEA in male and female hip as shown in table 6.

Table 6. Lateral central edge angle in male and female hip

	Lateral central edge angle in male and female hip		
	Male (n=224)	Female (n=176)	P-value
Right hip	34.3° ± 5.8° (17° - 47°)	35.4° ± 5.7° (19° - 47°)	.9
Left Hip	33.6° ± 6.6° (18° - 47°)	35.7° ± 5.3° (21° - 49°)	.09
Mean	34° ± 5.4°	35.6° ± 4.5°	.16

DISCUSSION

In this prospective cross-sectional study performed in asymptomatic patient population, we found at least one parameter of FAI morphology in 162 hips (40.5%). The prevalence of abnormality was higher in hips of male patients than female patients. Chakraverty et al. reported that 66% hip joints had at least one abnormal parameter associated with FAI in asymptomatic patients in the UK.[16] Teke et al. reported that 64.5% of the 400 joints had at least one abnormal morphological parameter associated with FAI in Turkey.[10] The prevalence FAI morphology in our

study was lower than these studies possibly because of pelvic difference between the various races or difference in diagnostic criteria. A study by Kang et al. showed 39% of hip joints had at least one abnormal parameter on CT analysis of 100 hip joints of 50 young asymptomatic patients. The study showed abnormality was more common in male hip (48%) than female hip (31%).[11] A study by Kim et al. showed at least one abnormal parameter in 40% hips with higher prevalence of abnormity in hips of male patients (43.2%) than female patient (35.4%) on CT analysis of 473 hips.[12] The findings are similar to our study.

Prevalence of cam morphology in a systemic systematic review ranged from 5% to 75%.[17] This wide range across studies was due to different study populations (symptomatic vs asymptomatic and non-athlete vs athlete population), the different alpha angle cut off values, different positions where measurements of cam morphology was done and variation in imaging modality (X-ray vs CT/MRI). Another systematic review reported the prevalence of cam morphology 37% which is higher than our reported prevalence of 14.5% which may be due to the fact the systemic review included large proportion of athlete in study population.[18] There was a significantly higher prevalence of cam morphology in athletes compared to non-athletes.[19,20] In a study by Hack et al. on MRI evaluation of 200 asymptomatic volunteers prevalence of cam morphology was 14%.[21] The findings are similar to our study.

Prevalence of pincher morphology in our study was 17.5%. Prevalence of pincher morphology in asymptomatic population in a systemic review by Mascarenhas et al. and Frank et al. was 57% and 67% respectively.[18,22] However high prevalence in these studies may have been confounded in several ways. Pincer morphologic characteristics were poorly defined among the studies. Furthermore, the included studies used radiography rather than computed tomography for measuring pincer deformity, which is highly affected by pelvic tilt, rotation, and distance from the beam source.

Our study found a male predominance for cam and mixed-type deformities, which is consistent with findings reported in previous studies and metanalysis.[4,16,21,23,24] Siebenrock et al. and Agricola et al. suggested that cam-type impingement is more prevalent among men than women because of gender-related anatomical differences of the femur and excessive physical activity in male adults.[25,26] Multiple studies comparing the prevalence of pincer morphology between males and females have shown conflicting result. A study by Laborie et al reported a higher prevalence of this variant in men versus women (34% vs 17%, respectively).[4] In a study by Bruin et al. higher prevalence of pincher morphology was noted in female.[5] In contrast, some studies have not found differences between sexes.[16,27,28] In our study there was no statistically significant difference in prevalence of pincher morphology between male and female hip.

There were several limitations of our study. First the actual physical examination of hip joint was not carried out to confirm asymptomatic hip. Second, we did not investigate whether hip joint abnormalities of one side have any associations with potential abnormalities of the contralateral hip joint. Third, we did not perform radial AA measurements through the entire circumference of the femoral head and neck. Finally, we could not evaluate other associated features of FAI such as cartilage damage or labrum abnormalities, because these abnormalities are not depicted on CT scans.

CONCLUSION

In conclusion, we found substantial prevalence of FAI morphology in asymptomatic young population, according to the established measurement parameters. This high frequency of FAI morphology found in our study and other several studies may be due to the fact that cut off values for these abnormality may have been set too low. It also emphasizes the fact that presence of radiological abnormality in absence of appropriate symptoms and clinical signs, doesn't not constitute the diagnosis of FAI syndrome. Longitudinal studies with long term follow up of cohorts could determine the whether these morphologic pattern could lead to the development of FAI syndrome and hip osteoarthritis.

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