Section: Orthopaedics

Original Research Article

ANTHROPOMETRIC ANALYSIS OF CAM LESIONS VIA ALPHA ANGLE MEASUREMENT IN A SOUTH INDIAN POPULATION: AN MRI-BASED STUDY

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ABSTRACT

Background: Femoroacetabular impingement (FAI) is a clinical syndrome characterized by abnormal contact between the femur and acetabulum, leading to force loading across the hip joint during extreme ranges of motion. FAI is a recognized pathogenic factor in the development of hip osteoarthritis. The impingement is secondary to anatomic abnormalities at the femoral head-neck junction or the acetabulum The alpha angle is a key radiological measurement used to quantify the concavity (head-neck offset) of the femoral head-neck junction extent of cam-type deformity. The present study aims to determine the prevalence of CAM type of Femoroacetabular impingement (FAI) in the South Indian population by measuring the alpha angle using MRI.
Materials and Methods: A cross-sectional, observational study will be conducted on individuals undergoing MRI of the hip for non-traumatic indications. scans which were available in the Department of Radio-diagnosis, S. Nijalingappa Medical College and Hospital and Research Centre, Bagalkot. Parameters assessed are Alpha Angle in the CHECK (Cohort Hip and Cohort Knee), followed by angle determination using statistical shape modeling (SSM)software. Circle of best fit was defined by use of validated MATLAB (The MathWorks)-based software.
Results: The Alpha angle measured in total of 50 individuals showed 44 individuals with normal morphology of Alpha angle less than 55^0 and 6 patients showed alpha angle more than 55^0 with CAM lesion of FAI.
Conclusion: The alpha angle in measured individuals (50 cases) showed 88% with normal morphology and 12% showed CAM lesions of FAI. These findings highlight that while the prevalence of CAM lesions in this regional population is relatively low, population-specific data remains essential for early intervention to prevent progressive cartilage damage and early osteoarthritis.
Keywords: Anthropometric analysis, CAM Lesion, Alpha angle, MRI scan.

INTRODUCTION

Femoroacetabular impingement (FAI) was initially described by Ganz et al who proposed that certain anatomic variations of the femur and acetabulum lead to abnormal contact and force loading across the hip joint, particularly at extreme ranges of motion. Femoroacetabular impingement (FAI) has become a well-recognized pathogenic factor in the evolution of hip osteoarthritis. The impingement is secondary to an anatomic abnormality of the femoral head-neck junction or the acetabulum. In the pure CAM form of

FAI, the abnormality is an excess of bone or cartilage bulk at the anterosuperior femoral head-neck junction, resulting in reduced offset of the femoral head over the neck and femoral head asphericity.[1-5]
Van Houcke et al compared White and Asian populations and found that asymptomatic White patients had greater average alpha angle (56 degrees vs. 50 degrees). Takeyama et al found that an alpha angle >60 degrees was found in only 0.6% of the studied Asian population.[6-8]
Frank et al per formed a systematic review of 26 studies examining 2114 hips for the prevalence of FAI in asymptomatic individuals. The prevalence of a cam deformity in the asymptomatic general population was found to be 23.1%, compared with 54.8% in the athletic population.[9,10]
Meyer et al showed the 45 degrees Dunn lateral (hip flexed to 45 degrees, abducted 20 degrees, neutral rotation) to provide the most revealing profile of maximal FAI deformity. This gives the best view of the anterior head-neck junction while moving the greater trochanter out of the field.[11-15]
[Figure 1a] shows normal morphology with normal alpha angle, [Figure 1b] shows the CAM type occurs due to asphericity or a bony prominence at the femoral head–neck junction. [Figure 1c] shows the PINCER type results from acetabular over coverage. [Figure 1d] shows the features of both CAM and Pincer deformities.

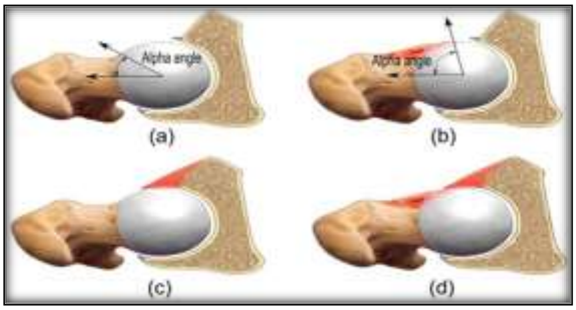


Fig. 1 1a - Normal, 1b – CAM type, 1c – PINCER type, 1c – Mixed type.

MATERIALS AND METHODS

We retrospectively examined the MRI image data of all 50 patients who underwent magnetic resonance imaging (MRI) of the hip. It was done in non symptomatic patients with no history of any trauma. The study included 31 men and 19 women [Figure 2]. Age ranging from 24–80 years. The alpha angle will be measured on radial MRI images through the femoral neck axis, as described by Notzli et al.
MRI was chosen for its superior soft-tissue contrast and multiplanar imaging capabilities compared to CT or standard radiographs. The alpha angle was measured on radial MRI images taken through the femoral neck axis. These radial cuts rotate around the axis of the femoral neck to ensure accurate assessment [Figure 3]. A threshold of >55^0 was usually used to define CAM morphology.

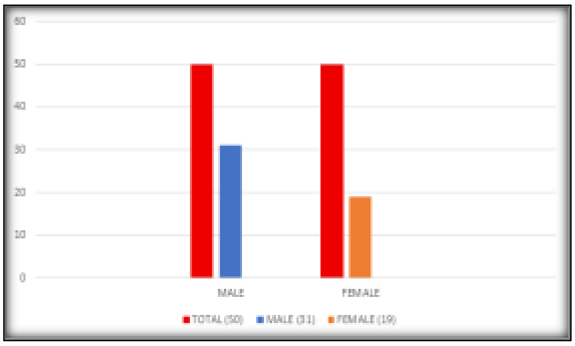


Figure 2: Gender distribution.

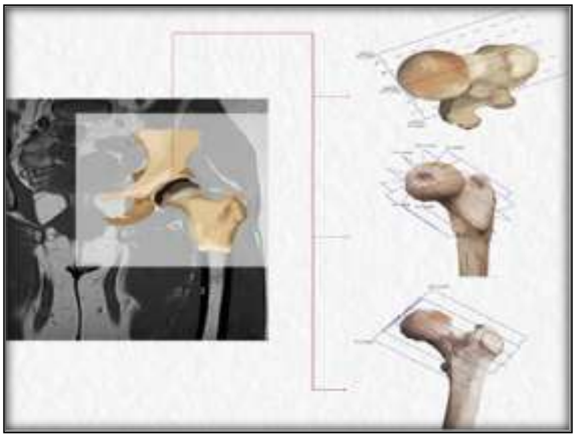


Figure 3: Radial MRI planes, which rotate around the axis of the femoral neck.

As shown in [Figure 4], the axis of the neck clearly indicates how changes in its contour affect the functional articular surface of the head. Widening of the neck anterior to this line reduces the concavity of the neck just as a thicker prosthetic neck reduces the potential movement of a hip replacement. Similarly, the point A where the distance between the centre of hip rotation (head centre) and the anterior cortex exceeds the radius of the joint represents the point at which no more of the femoral head can enter the concentric portion of the acetabulum.

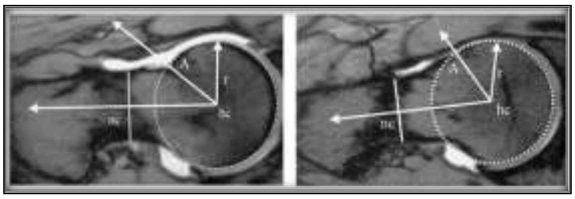


Figure 4: MR scans showing the angle in first fig is normal and in second fig is a pathological hip.

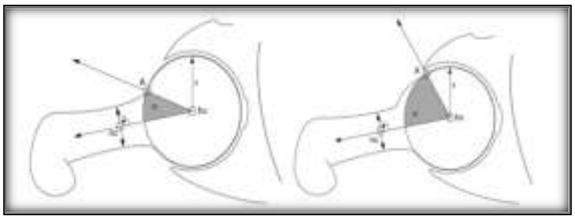


Figure 5: Showing the construction of angle . Point A is the anterior point where the distance from the center of the head (hc) exceeds the radius (r) of the subchondral surface of the femoral head.

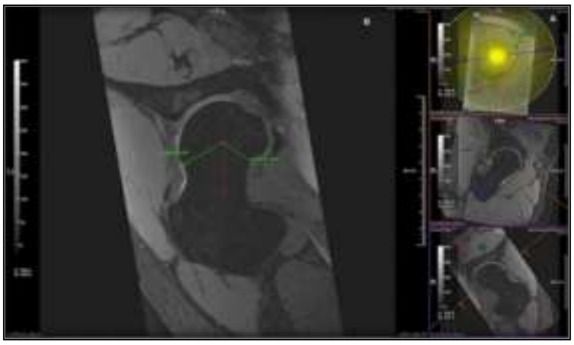


Figure 6

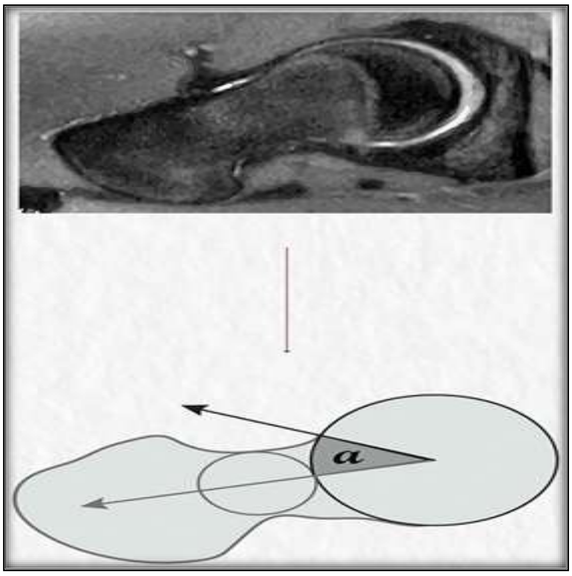


Figure 7a: Top: MRI slice of the femoral head-neck junction. Bottom: Conceptual diagram demonstrating a sample alpha angle measurement using the circle of the best of it method, with the alpha angle measured between the femoral neck axis and a line connecting the femoral head centre with the point of beginning asphericity of the head-neck contour. The centre of the femoral neck is determined as the centre of a circle touching the cortices of the femoral neck on either side. Note that the measurement methodologies for both the femoral neck centre and the alpha angle may vary slightly depending on imaging modality or planes; this diagram is simply meant to communicate the concept of the alpha angle.

Initially described by Notzli et al, 40 the alpha angle is determined by fitting a circle to the femoral head and connecting a line from the centre of this circle to the centre of the femoral neck. A second line is drawn from the centre of the circle to the first point of the superior head-neck junction that lies outside of the circle. The alpha angle is then measured as the included angle between the 2 lines, with the assumption that a higher alpha angle represents a larger, more severe cam lesion [Figure 5]

The alpha angle in the CHECK (Cohort Hip and Cohort Knee) cohort was measured using 8 points to define the circle of best fit, followed by angle determination using statistical shape modeling (SSM) software [Figure 6]. Circle of best fit was defined using 3 points, followed by use of validated MATLAB (The MathWorks)-based software.

The alpha angle is a parameter used to quantify the contour abnormality of the femoral head-neck junction in FAI. [Figure 7a & 7b]

Figure 7b: showing measurement of normal alpha angle on MRI cuts

RESULTS

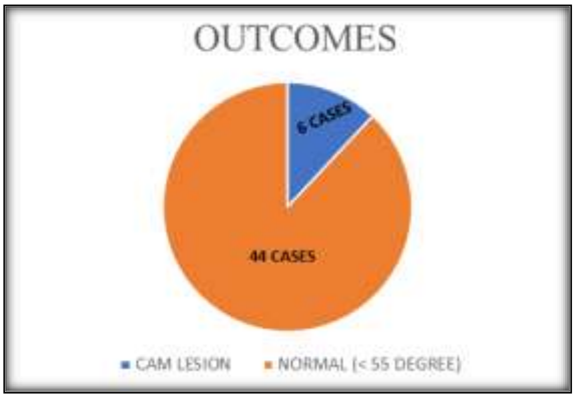
The study examined the average alpha angles across various age groups for both the right and left hips. Data for all age groups between 24 and 80 were recorded. [Table 1]

Table 1

Age(years)	Number of patients examined	Average alpha angle	
		Right	Left
21-25	2	48.80	51.50
26-30	2	46.00	46.50
31-35	3	39.55	42.35
36-40	3	44.45	49.35
41-45	4	46.95	48.20
46-50	5	49.66	52.04
51-55	7	47.85	51.55
56-60	5	43.84	44.68
61-65	7	50.63	49.98
66-70	5	44.90	48.42
71-75	5	47.17	43.32
76-80	2	44.40	47.00

Study shows out of 50 total cases 44 (88%) showed normal morphology alpha angle less than 55^0. Remaining 6 cases (12%) showed CAM type of FAI with alpha angle more than 55^0

2 case out of 6 showed bilateral CAM lesion
4 cases out of 6 showed unilateral CAM lesion



Graph 1

DISCUSSION

Femoroacetabular impingement (FAI) is a well-recognized pathogenic factor in the development of hip osteoarthritis. This clinical syndrome occurs when anatomic variations of the femur and acetabulum lead to abnormal contact and force loading across the hip joint, particularly during extreme ranges of motion.[16-18]

In FAI, a frequent and surgically correctable abnormality is the lack of normal offset or concavity at the femoral head-neck junction. This rendered asphericity causes the femoral head to conflict with the spherical acetabulum. This contour abnormality reduces clearance during joint movement, leading to mechanical limitations and symptomatic restrictions in the range of motion. These altered biomechanics ultimately result in injury to the chondrolabral complex, acting as an initiator for progressive hip osteoarthritis.[19-21]

In this study, the oblique axial image slice through the middle of the femoral neck was chosen because it could be easily determined and reproduced in all subjects. As well, it would allow for the optimal visualization of the anterior head-neck junction, We observed the maximal alpha angle in the anterosuperior region of the femoral head-neck junction from the 1 to 2 o'clock positions.[22-24]

Magnetic Resonance Imaging (MRI) offers superior soft-tissue contrast and multiplanar imaging capability. MRI allows accurate assessment of the alpha angle and associated soft tissue abnormalities compared to plain radiographs or CT scans.[25]

The alpha angle is the most widely utilized quantitative measurement for diagnosing CAM-type FAI. It quantifies the head-neck offset and represents the deviation of the femoral head from a normal spherical contour. Notzli et al, the alpha angle is the most commonly used quantitative measurement of femoroacetabular impingement.[26]

The alpha angle is a parameter used to quantify the contour abnormality of the femoral head-neck junction in FAI. alpha angle can vary at different locations within the anterosuperior quadrant of the femoral head-neck junction in patients with FAI.[27,28]

Repetitive contact from these abnormalities leads to labral tears, cartilage damage, and early-onset osteoarthritis. While Western literature on FAI is extensive, there is a scarcity of data regarding the Indian population, where unique lifestyle factors—such as habitual squatting or cross-legged sitting—may influence hip morphology.[29]

As per the study done based on the MRI scan in South Indian population showed not much significant CAM type morphological changes with 88% showing normal morphology.

Early intervention and management play a key role in modifying the natural history of the FAI syndrome, potentially preventing progressive cartilage damage leading to early osteoarthritis.

CONCLUSION

Causes of impingement due to the shape of the junction such as a wide neck, formation of osteophytes or displacement of the head posteriorly, will cause angle to be high. Other causes of impingement are retroversion of neck or acetabulum, acetabular osteophytes.

This study is done on CAM type of FAI

Showing unilateral CAM lesions [Figure 8a & 8b].

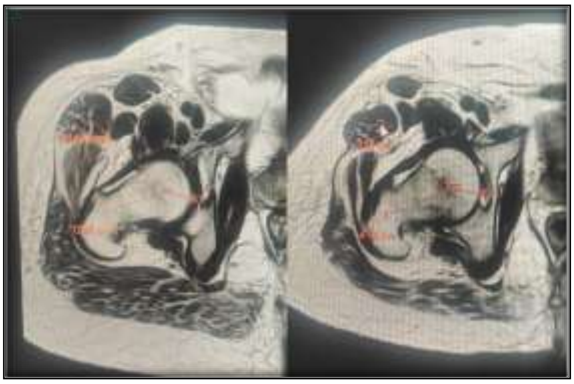


Figure 8: Showing CAM type of Femoroacetabular impingement with increased Alpha angle.

Showing Bilateral CAM lesions [Figure 8c &8d]

Figure 8c: Bilateral CAM lesion of FAI.

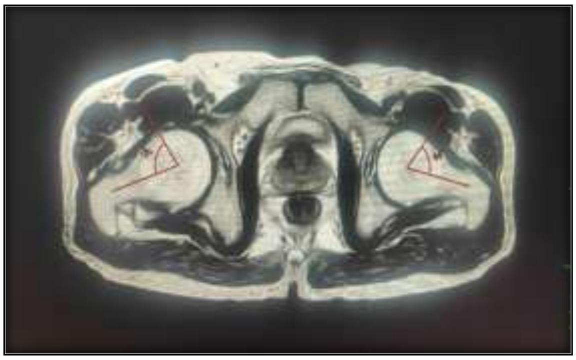


Figure 8d: bilateral CAM lesion of FAI.

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