

# Femoroacetabular Impingement (FAI) Syndrome - the Medical Imaging perspective

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## Abstract

**Introduction:** Sports persons, physicians, orthopods and radiologists have become increasingly aware of the extra stress that is imposed on the hip joints with excessive activity particularly when superadded weight bearing and asymmetrical variations from the normal hip joint anatomy are present leading to Femoroacetabular Impingement.

**Subject:** Presentation of the abnormalities within the ball and socket areas of the hip joint and the resultant types of impingements, the predominant cam, the predominant pincer or mixed types femoroacetabular impingement (FAI) are discussed and illustrated. The different kind of sportspersons that are prone to FAI and the risk factors involved are discussed.

**Method:** The main methods of investigation: The radiological techniques and radiological signs of the disease entity utilizing plain radiography and computerised transverse scanning techniques are elaborated and graphically depicted. Within the ball part of the hip joint, measurements for femoral head asphericity, that is, the Alpha ( $\alpha$ ) angle and the offset distance between the femoral head and neck are presented. With regard to pincer type FAI affecting the socket part of the hip joint, the acetabular version angle and the depth (or shallowness) of the acetabulum with their methods of quantification are discussed.

**Conclusion:** Femoroacetabular Impingement is a syndrome which is currently more appreciated within the sports medicine field and various approaches to assessment have been devised regarding how to diagnose and quantify congenital anomalies and developmental abnormalities within both the ball and the socket regions of the hip joint.

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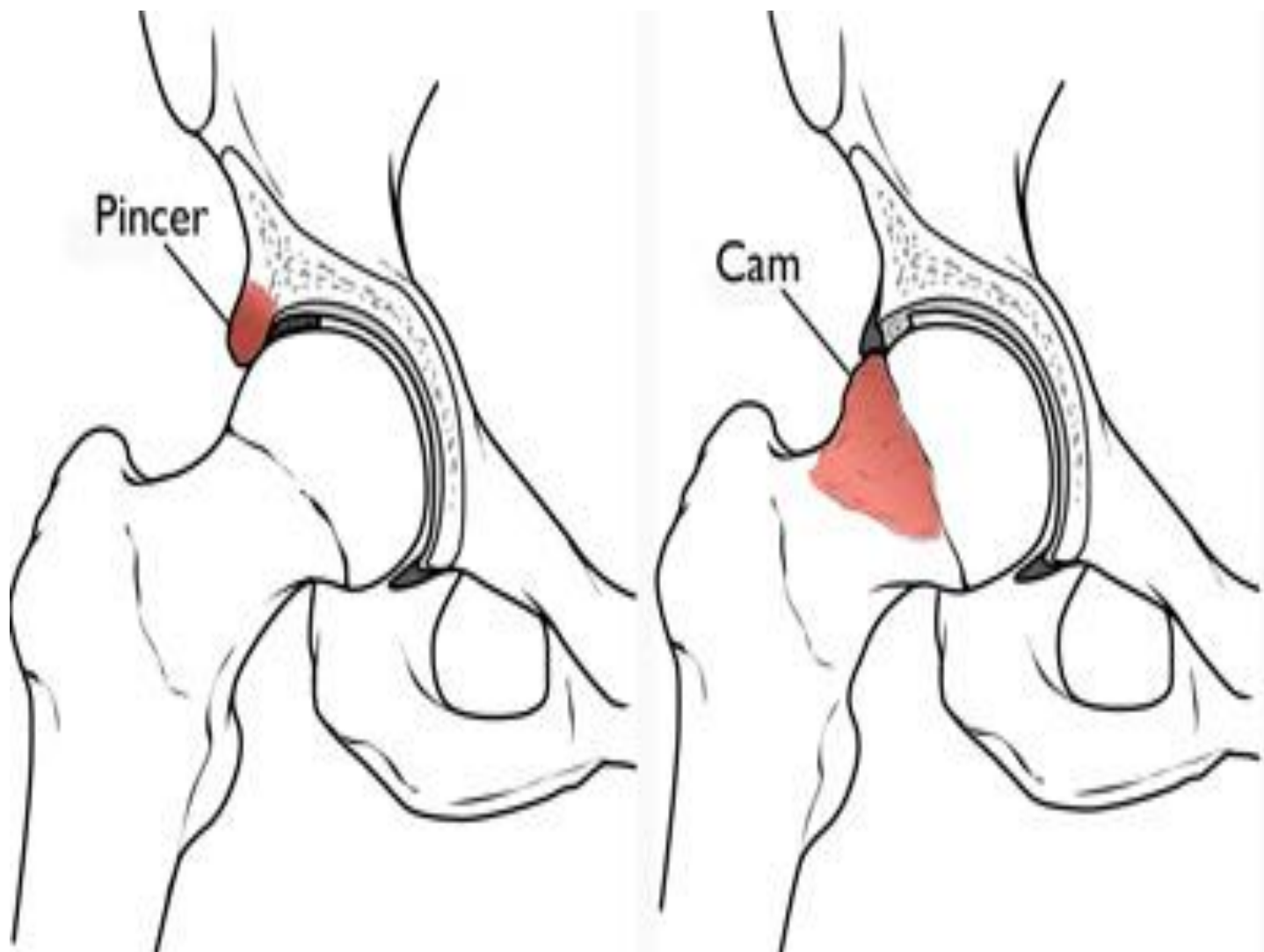
## Introduction

The hip joint is a ball and socket type joint, both aspects of which are prone to congenital anomalies and developmental anatomical variations thereby resulting in impingement with increased activity within several practiced sports. Sometimes anatomically normal hips develop femoro-acetabular impingement (FAI) with extremes of movement.<sup>1-2</sup> There are two main types of FAI first described by Mayer et al in 1999.<sup>3</sup> Abnormalities of the ball, that is the femoral head to femoral neck relationship, which leads to cam type of impingement and abnormalities of the socket or acetabulum which leads to the pincer type of impingement.<sup>2,4</sup> In the cam type FAI, abnormally eccentric femoral head on femoral neck resembling the cam shaft of a car engine impinges on a normal acetabulum. With the pincer type FAI, normally shaped femoral head to neck hinges on abnormally angled or shaped acetabulum resulting in a pincer tight grip on the cartilaginous labrae and the femoral head to neck junction. In 86% of cases subjects have components of both forms of impingement, therefore it is best to talk about mixed type FAI<sup>5</sup> possibly with the predominant cam FAI or the predominant pincer FAI in such patients. The subjects are mostly 20 to 40 year young<sup>6</sup> and are prone to early osteoarthritis.<sup>7-10</sup> The mechanism of each type of FAI is depicted graphically on Figure 1.<sup>11</sup>

## The cam type FAI

With the cam type of FAI, the eccentricly placed femoral head on femoral neck (Asphericity) impinge as it is mismatched to the normal acetabulum. Allen et al reported approximately 78% of cases are bilateral.<sup>12</sup> There is controversy as to whether the presence of the osseous bulge (or bump) at the femoral neck, which is due to hypertrophy of bone, impinges on the acetabulum (commonly on the supero-anterior aspect) is a primary or secondary presentation. Cam type FAI is commoner in physically active males,<sup>13</sup> heavy labourers and sportspersons, with the afflicted groups being dancers, athletes, golfers, runners, ballet dancers, martial arts and yoga participants. The medical history of affected persons usually reveals risk factors such as post-traumatic deformities, post-septic hips, developmental dysplasia of the hip, Perthe's disease, slipped upper femoral epiphysis, coxa vara and avascular necrosis commonly secondary to steroids, barotrauma or the hypercoagulable states.

Figure 1: Taken from "Orthoinfo web site" about FAI demonstrates the mechanism of each type of impingement.



### The Pincer type FAI

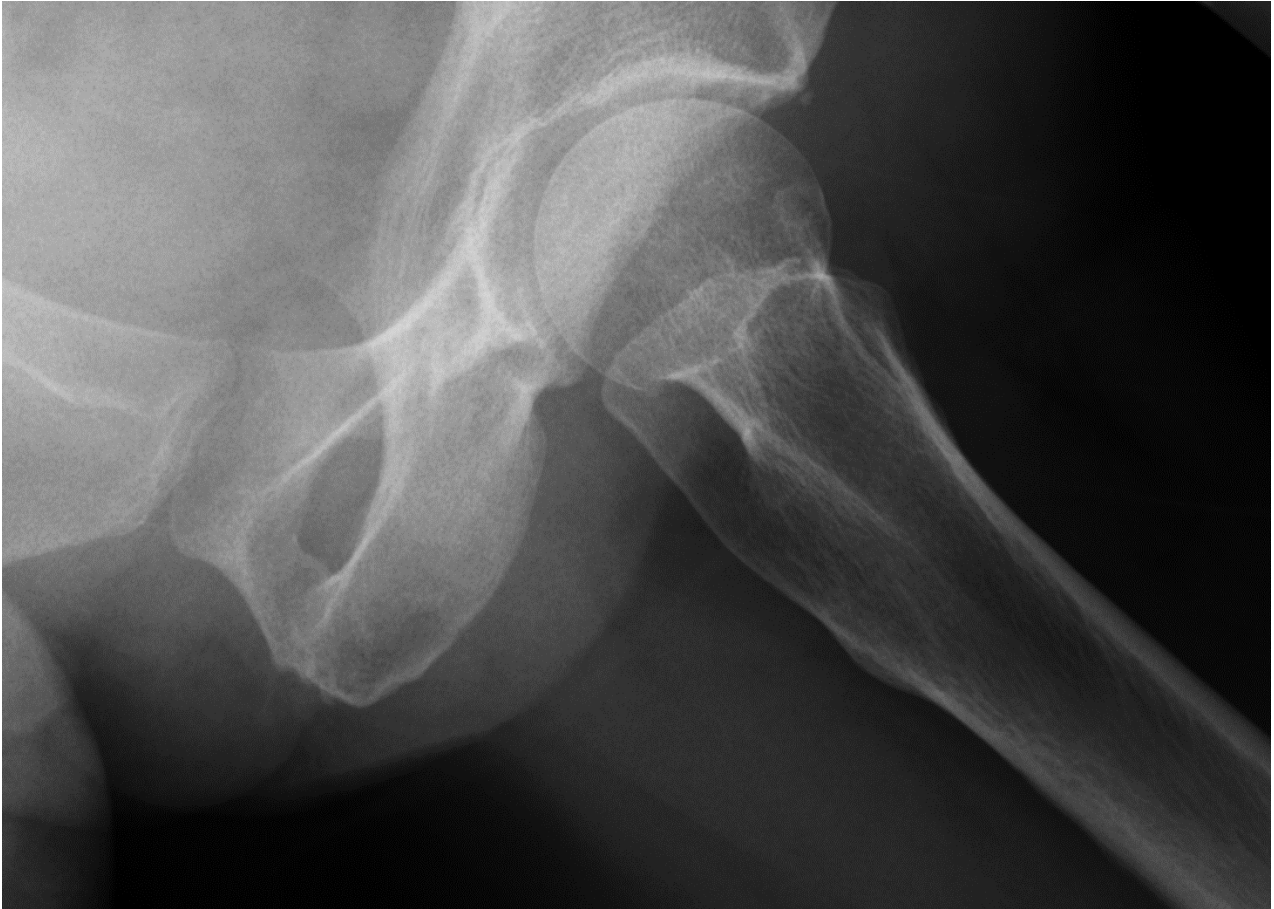
With the pincer type FAI the normally shaped femoral head contacts the abnormally angled or shaped acetabulum. Causes of this type of FAI include acetabular retroversion, acetabular overcoverage (coxa profunda or protrusio acetabuli) and femoral retroversion. This type is commoner in middle aged females<sup>13</sup> engaging in activities requiring extreme ranges of motion such as with ballet dancing or yoga.

### Investigation of FAI

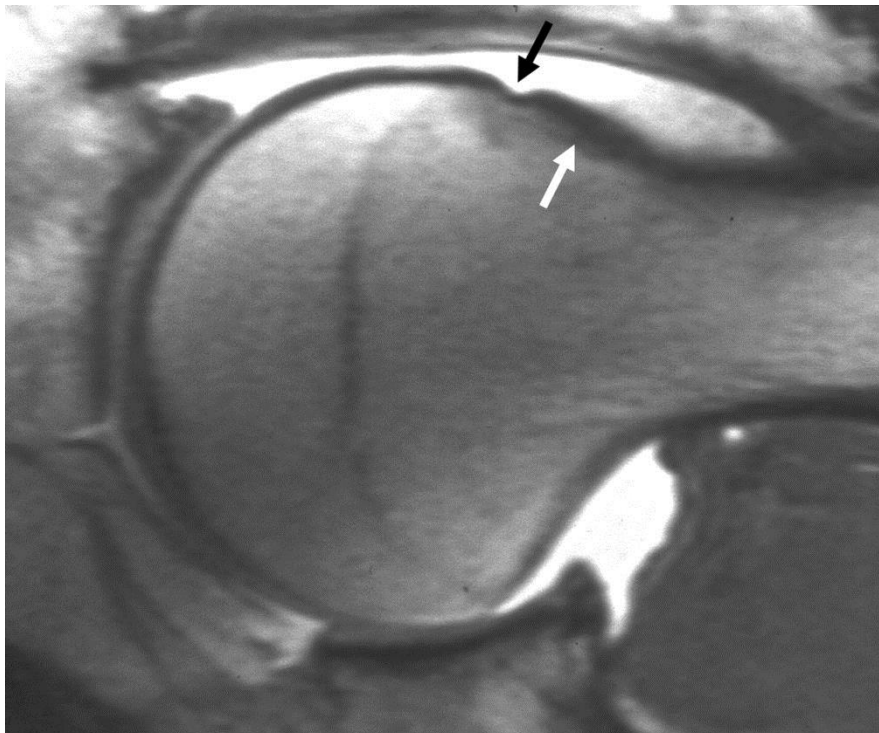
The investigation of FAI with plain radiography involves both conventional and specialised views such as AP Pelvis View,<sup>14-16</sup> Frog Leg Lateral, Cross Table Lateral,<sup>17</sup> False Profile View<sup>18</sup> and Dunn view.<sup>19</sup> Spiral Multidetector CT scan currently has the option of 3D and axial sectioning can be reformatted into axial obliques and coronal planes for diagnostic and quantification purposes. Lately MR techniques are becoming further utilised with suspected FAI in view of their resolution of soft tissue components and because of

the safety aspect as magnetic resonance is not an electromagnetic radiation like Xrays and CT Scan and to visualise the cartilaginous labra. In Cam type FAI, acetabular rim ossicles (or Os Acetabuli), impingement cyst and osteophyte (from early secondary osteoarthritis) are common findings on x-rays, Image 1. Care is indicated not to diagnose these bony fragments as excessory ossicles in symptomatic presenting patients as congenital supernumerary ossicles are usually asymptomatic. The Pistol Grip Deformity described by Stulberg et al<sup>7</sup> is another sign of FAI due to femoral head eccentricity (asphericity) on the femoral neck. One can depict the femoral head to neck eccentricity on axial oblique CT Scan with reformed (computer manipulated) images from scanned axial sections. This can also be assessed on plain x-rays such as with Dunn View or Crosstable Lateral best with internal rotation.<sup>19</sup> Femoral focal osseous bumps or bulges are also well assessed with plain radiography as Crosstable Lateral View. Another approach to this involves CT Scan and if one wishes to avoid radiation and with more invasiveness and complexity by carrying out an MR Arthrogram, Image 2.

**Image 1:** Plain Xray of the left hip (EuroMedic Clinic Cork on a 30 year old patient showing Cam type FAI with ossicle in supero-lateral aspect of the acetabulum, impingement Cyst on lateral aspect of the femoral head and osteophyte on the medial aspect of the femoral head to neck junction.



**Image 2:** MR Arthrography demonstrates: Herniation Pit as black arrow and Osseous Bulge as white arrow. The labrae and articular cartilages are intact and well depicted on 18 year old patient investigated at EuroMedic Clinic, Cork.



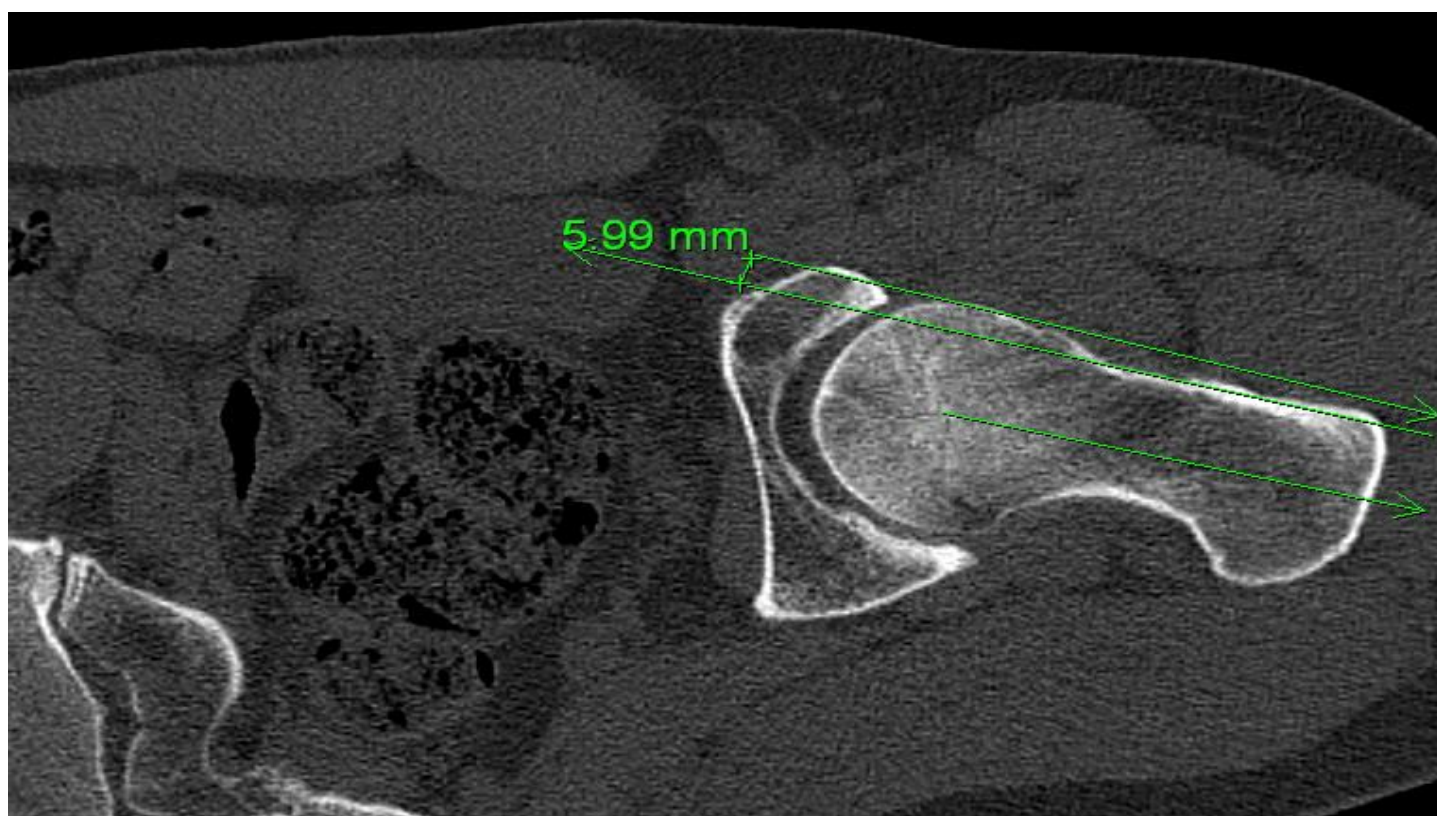
In cam type FAI assessment may also be performed by measuring the femoral head to neck Offset Distance which is the thickness of bony hypertrophy resulting in an osseous bulge and is also proportional to the extent of eccentricity of the femoral head to neck relationship, Image 3 (Normally 9mm or greater).<sup>2,4</sup> The Alpha Angle which is a measurement of femoral head eccentricity,<sup>17</sup> Image 4 (Normal less than 55 degrees) requires CT Scan ideally utilising an axial oblique plane for adequate assessment. Normal acetabular version (Angle of inclination) on simple plain AP Pelvic Xray results in an Inverted V sign arising from the anterior and posterior margins of the acetabulum which projectionally meet at the superior aspect, Image 5. With the pincer type FAI, this sign transforms to a crossover or figure of 8 sign (as the acetabular wall margins cross at three points) depicting acetabular retroversion, Image 6. Acetabular retroversion is also assessed well with crosssectional imaging. The acetabular version angle is more accurately quantified on axial CT Scan, being normally greater than 15 degrees, Image 7. That is the acetabular hollow space is directed anteriorly and downwards.

Measurement of the Center Edge Angle (the line joining the femoral center to superior acetabular margin and the angulation to the vertical line) is also another method of quantifying FAI as a sign of acetabular depth, Image 8. Coxa Profunda is well diagnosed subjectively on plain x-ray and more objectively quantified with Coronal CT Scan utilising the Center Edge Angle and by measuring the depth of the center of the femoral head to the acetabular margin line, Image 9. Acetabular overcoverage is assessed also with plain Xray such as with the False Profile View, Image 10. Microsurgery for FAI is available as Arthroplasty with trimming on the femoral osseous bulges and acetabular rims while the labrum is excised when torn.

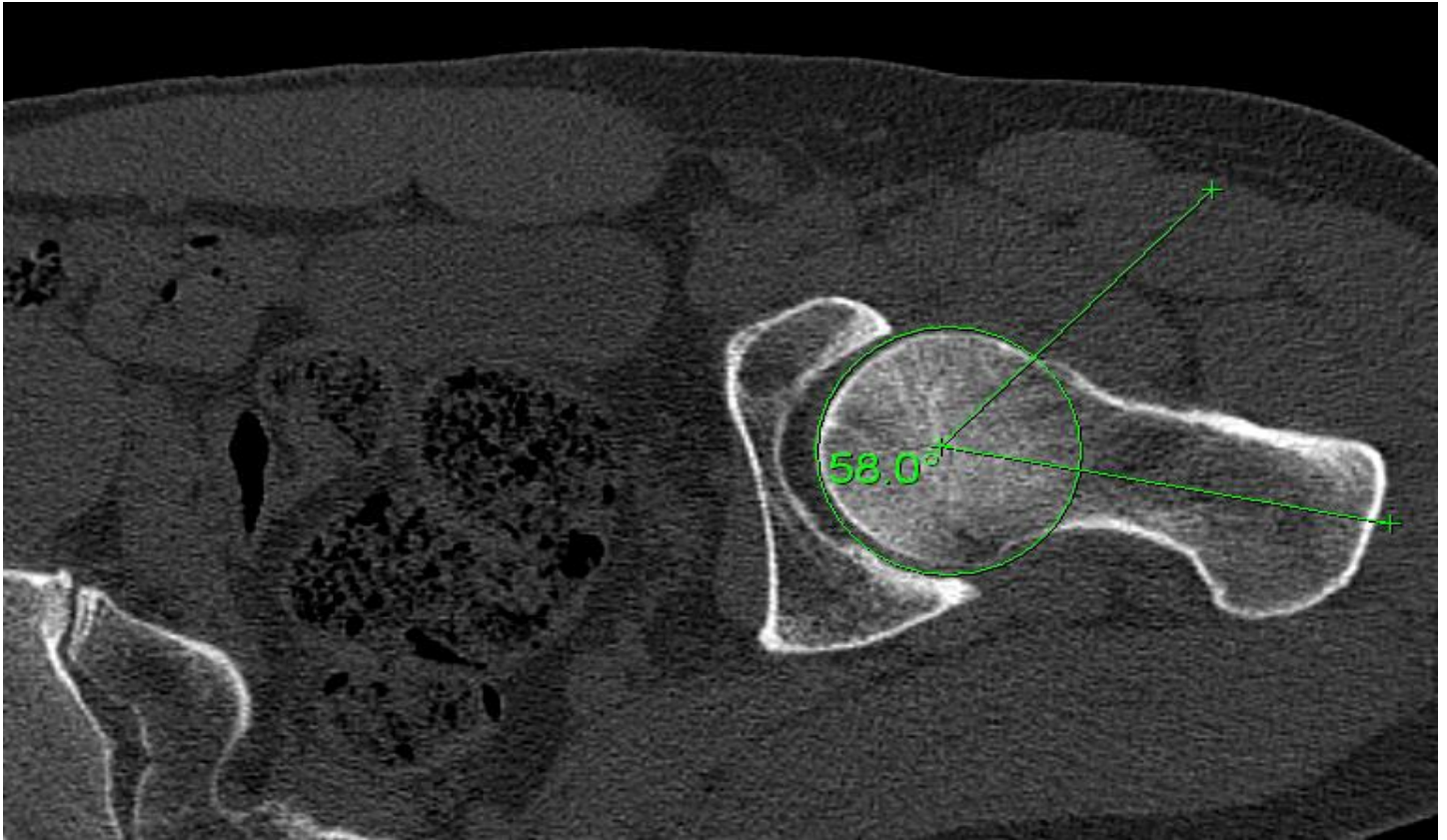
### Conclusion

The Cam and Pincer type of Femoro-Acetabular Impingement is a syndrome with current various modality approaches to assessment regarding how to diagnose and quantify the grade of the congenital or developmental anomalies which create mismatch between the ball and the socket regions of the hip joint. This mainly includes asphericity of the femoral head, acetabular retroversion, Image 6 and acetabular overcoverage, Image 10.

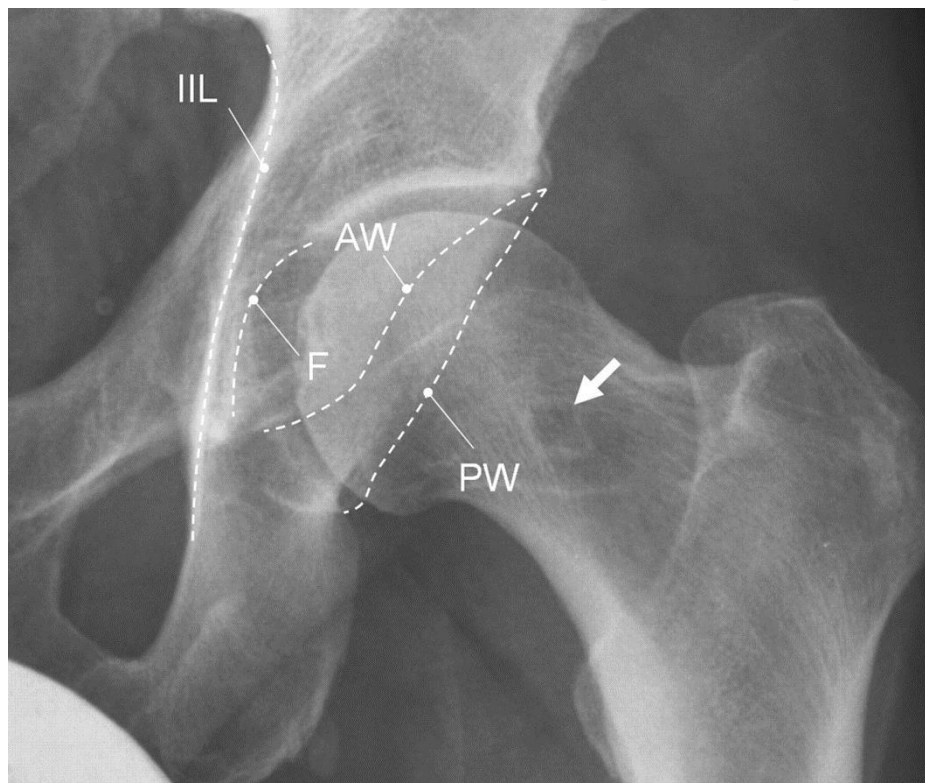
**Image 3:** CT Axial Oblique 0.5 mm collimation from EuroMedic Clinic Cork on a 17 year old patient with the Offset Distance being abnormal at 5.99mms (Normal is 9 or greater mms).



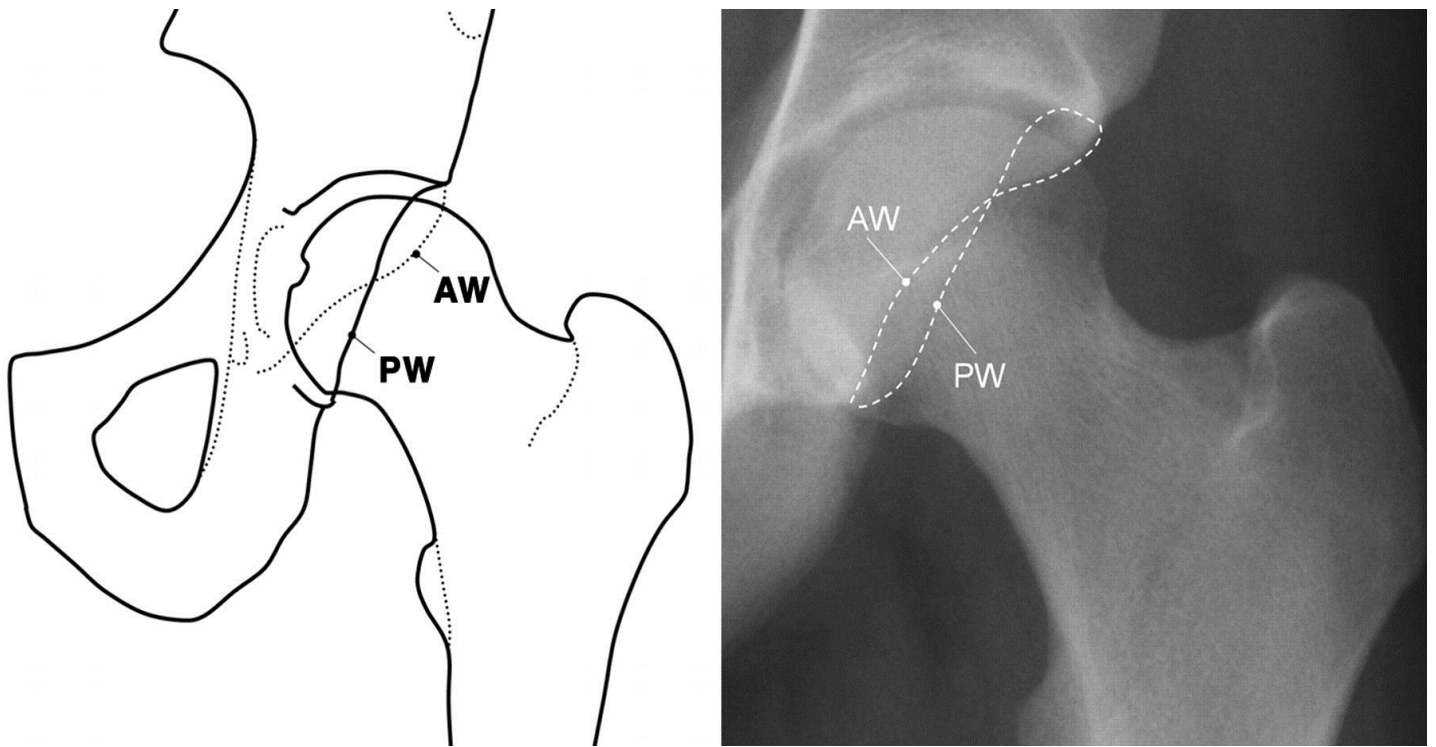
**Image 4:** The Alpha Angle on axial oblique CT Scan (reformated image from 0.5 mm collimation taken in EuroMedic Clinic Cork) in 25 year old patient is 58 degrees. Subjectively the femoral head eccentricity on femoral neck is well shown. An abnormal Alpha Angle would be greater than 55°.



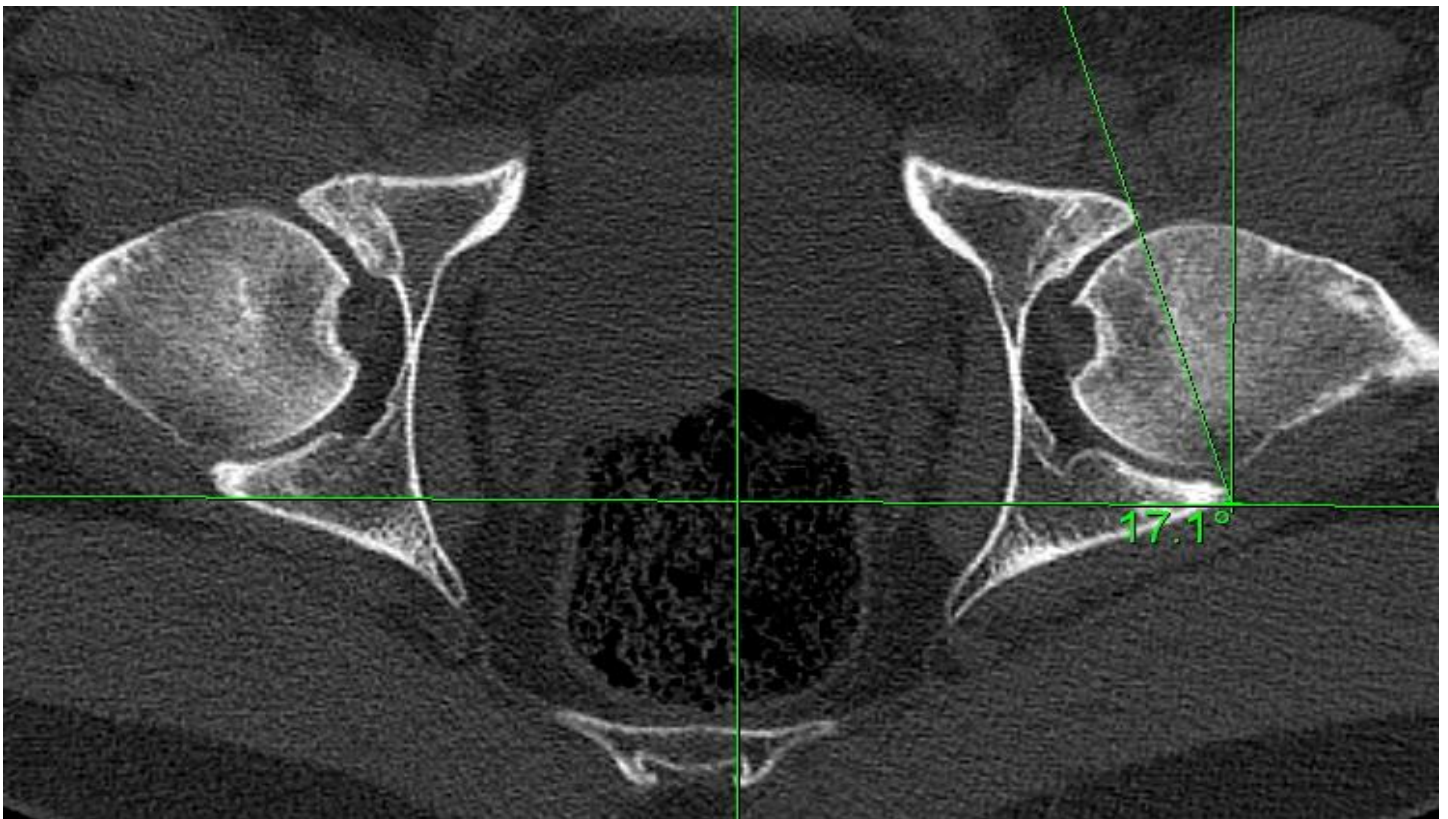
**Image 5:** Plain Xray demonstrates Inverted V Sign. AW-Anterior acetabular wall, PW-Posterior acetabular wall, F-Fovea IIL-Ilieo Ischial Line. Arrow depicts herniation pit.



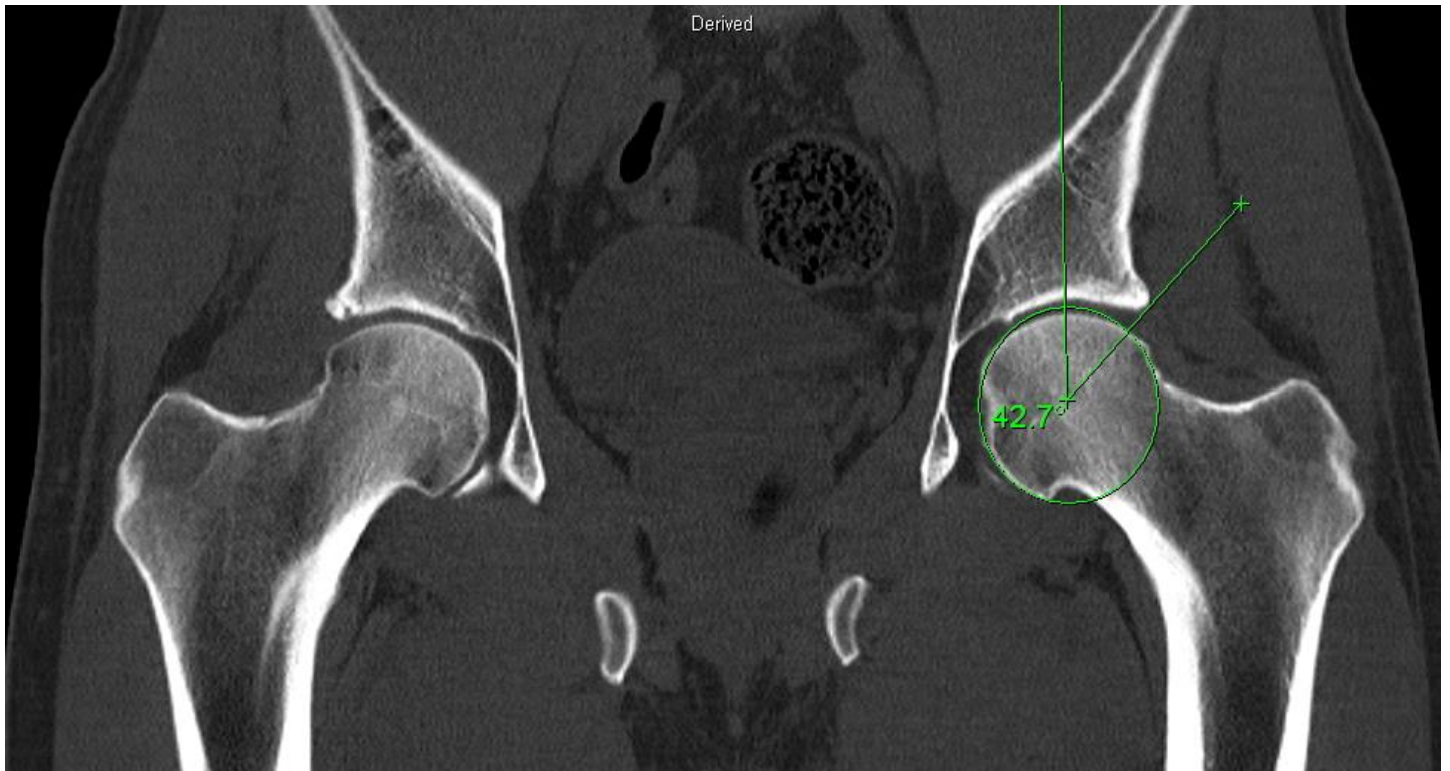
**Image 6:** Diagram and Plain Xray of the left hip with the Crossover or Figure of Eight Sign of the anterior and posterior walls of the acetabulum in a 23 year old patient with Acetabular Retroversion.



**Image 7:** Acetabular Version Angle is  $17.1^\circ$  which has a normal inclination. An abnormal Version Angle is less than  $15^\circ$ .



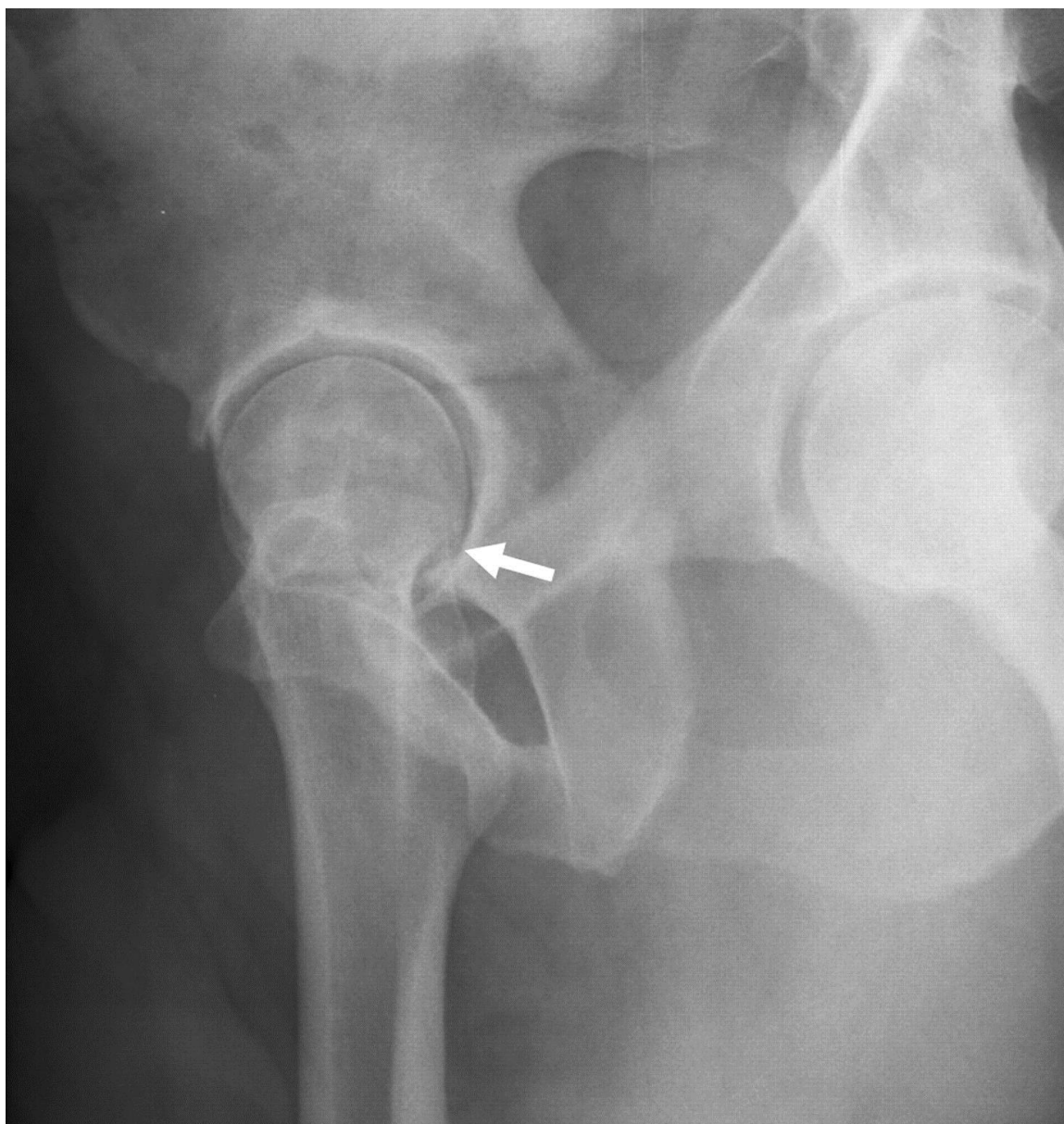
**Image 8:** Coronal reformatted CT Scan 0.5 mm section in 25 year old patient investigated at EuroMedic Clinic Cork. Center Edge Angle (CEA)  $42.7^\circ$  is abnormal as CEA in Coxa Profunda is greater than  $40^\circ$ .



**Image 9:** On CT Scan coronal plane (reformatted image at 0.5 mm slice – EuroMedic Clinic Cork) the Femoral Head Center on 25 year old patient is 4.89 mm deep to the acetabulum.



**Image 10:** False Profile View assesses (anterior) femoral head overcoverage leading to Pincer type FAI. Early hip degeneration in 27 year old and loss of posterior articular cartilage( arrow).



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