Ultrasound in Med. & Biol., Vol. ■■, No. ■■, pp. ■■–■■, 2017

0301-5629/$ - see front matter

https://doi.org/10.1016/j.ultrasmedbio.2017.10.006

● *Clinical Note*

ULTRASOUND DETERMINATION OF THE FEMORAL HEAD-NECK ALPHA ANGLE

D.J. Robinson,* S. Lee,* P. Marks,† and M.E. Schneider‡

* Healthcare Imaging Services, The Avenue X-Ray & MRI, The Avenue Hospital, Windsor, Victoria, Australia; † Imaging Associates Box Hill, Thames Street, Box Hill, Australia; and ‡ Department of Medical Imaging & Radiation Sciences, Faculty of Medicine, Nursing and Health Sciences, Monash University, Clayton, Australia

(*Received* 9 *February* 2017; *revised* 11 *August* 2017; *in final form* 13 *October* 2017)

Abstract—The femoral head-neck alpha angle is used to quantify the degree of femoral head asphericity in patients suspected of cam-type femoroacetabular impingement. The measurement was first performed using magnetic resonance imaging and, more recently, three-dimensional computed tomography (CT). We set out to determine whether the alpha angle could be reliably measured using ultrasound. Patients were recruited from a cohort presenting for CT of the hip. Alpha angles were calculated following the departmental protocol by institutionally accredited radiographers. After the CT, patients were imaged with ultrasound and the alpha angle calculated from the ultrasound image by a sonographer blinded to the CT result. Statistical comparison of the two methods was performed with the Bland-Altman test using SPSS (version 21.0, Chicago, USA), and a $p < 0.05$ afforded significance. Twenty-eight patients were recruited. Eleven patients were bilateral examinations, providing 39 hips for analysis. There were 15 females and 13 males, with 21 right and 18 left hips examined. Average patient age (±standard deviation) was 40 y (±13.9 y). Mean (±standard deviation) measurements for CT and ultrasound were 62.5° (±14.2°) and 64.5° (±12.6°), respectively. The mean absolute difference between the two methods was 10.5° (95% confidence interval 6.9°–14.0°). Sensitivity of each individual ultrasound measurement was 91.3%. The specificity of ultrasound was 43.75%. The positive predictive value was 0.7, and the negative predictive value was 0.78. Overall accuracy of the ultrasound-derived alpha angle was calculated at 0.718. Ultrasound demonstrates good sensitivity and good negative predictive value in calculation of the femoral head-neck alpha angle compared with CT; however, specificity is low. Ultrasound measurement of the alpha angle can provide objective evidence of cam-type femoroacetabular impingement in symptomatic patients and can direct patients to more established imaging techniques where appropriate. (E-mail: djrob6xx@gmail.com)

Key Words: **Ultrasound, Musculoskeletal, Hip, Femoroacetabular impingement, Alpha angle.**

INTRODUCTION

Femoracetabular impingement (FAI) has been postulated to be a cause of acetabular labral and articular cartilage damage to the hip (Nötzli et al. 2002). The sequelae of the condition and the damage that it causes are thought to contribute to early onset of osteoarthritis (OA) (Ganz et al. 2003). Cam-type FAI is impingement of the antero-superior femoral head-neck junction upon the acetabular labrum as the result of an osseous *bump* at the superior end of the upper femoral epiphysis (Ganz et al. 2008; Harris 1986; Stulberg et al. 1975). The bony prominence causes an abnormality of the femoral head-neck contour, manifesting as a loss of sphericity of the femoral head, a shallow head-neck offset and impingement upon the acetabulum, in particular, with flexion of the leg upon the trunk with internal rotation (Ganz et al. 2003). Symptoms of cam impingement occur at the limits of forward flexion and internal rotation where the loss of the normal femoral head-neck offset impacts upon and damages the acetabulum over time (Ganz et al. 2003). Delay or misdiagnosis of cam-type FAI may result in potentially more severe joint damage or unnecessary medical and surgical treatments (Ganz et al. 2003). Qualitative criteria such as a *pistol-grip* shape of the femoral head-neck junction cannot be used to quantify the severity of the condition (Ganz et al. 2003). An attempt to provide an objective measurement of this femoral head *asphericity* coined the *alpha angle* was pioneered using magnetic resonance imaging (MRI) by Nötzli et al. (2002).

The alpha angle was subsequently modified for computed tomography (CT) by Beaulè et al. (2005) with a minor change in the placement of the femoral neck axis

Address correspondence to: David J. Robinson, The Avenue X-ray & MRI, The Avenue Hospital, Windsor, Vic 3181, Australia. E-mail: djrob6xx@gmail.com

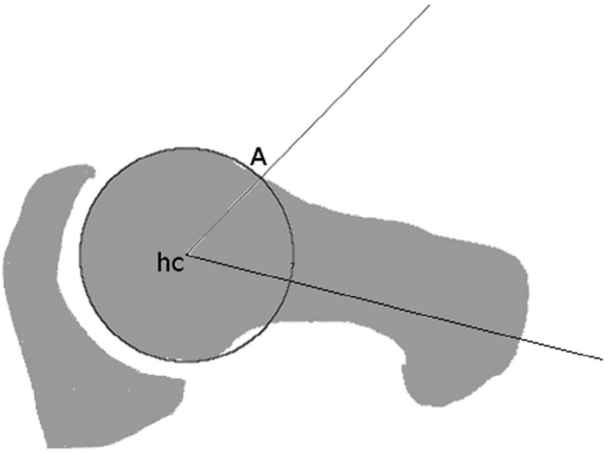

Fig. 1. Diagram of the alpha angle calculation from the axial oblique image as described by Beaulè et al. (2005). A circular template is drawn over the femoral head. From the center of the femoral head template (hc) a straight line is drawn laterally along the long axis of the femoral neck parallel to the anterior bony cortex. A second line is then drawn from the center of the femoral head template to intersect the point where the femoral head-neck contour exits the circular template (point A). The resulting angle between the two lines is the alpha angle.

line (Beaulè et al. 2005; Nötzli et al. 2002) (Fig. 1). With the femoral neck axis line placed parallel to the anterior femoral neck cortex Beaulè et al. (2005) found that their data *closely reproduced* that of Nötzli et al.'s work (2002).

MRI and CT are the imaging modalities of choice for the evaluation of the hip for their ability to image intra-articular causes of symptoms. However, they are expensive, not always readily available, and, in the case of CT, involve ionizing radiation. The ability to make a diagnosis of this abnormality, particularly among younger populations, before major joint damage occurs, using a non-ionizing, widely available, and cost-effective technique for early detection of cam-type FAI would be highly beneficial. Ultrasound can provide imaging of the soft tissues associated with the hip when looking for musculoskeletal disorders and effusions of the joint (Martinoli and Bianchi 2007). Ultrasound can also provide images of the cortical surfaces of the anterior femoral head and neck equivalent to the oblique axial view described by Nötzli et al. (2002) and Beaulè et al. (2005) for MRI and CT, respectively. To date, no study has explored the usefulness of ultrasound in the quantification of femoral head asphericity using an identical method of measurement as an accepted reference standard.

We hypothesize that ultrasound-based calculations of the alpha angle are a clinically useful alternative to those obtained using a CT gold standard when the same measurement method is applied. Our aim was to demonstrate the usefulness of ultrasound in providing objective evidence of FAI when CT is not available or not appropriate.

Table 1. Indications for hip evaluation among 28 patients (39 hips) presenting for CT

Indication	Number of hips (% of 39)
Suspected FAI	14 (37%)
Groin/hip/other pain	6 (16%)
Included as part of bilateral examination	5 (13%)
Dysplasia	3 (8%)
Avascular necrosis	3 (8%)
Post-surgery assessment	3 (8%)
Osteitis pubis	2 (5%)
Osteoarthritis	1 (2%)
Labral tear	1 (2%)
History of # NOF	1 (2%)

FAI = femoroacetabular impingement; # NOF = Fractured neck of femur.

MATERIALS AND METHODS

Ethics approval for the study was received from the Monash University Human Research Ethics Committee. Participants were consecutively recruited from amongst patients attending the department for CT imaging of one or both hips for a variety of indications (Table 1). Written informed consent was obtained from all patients. We prospectively recruited 28 patients with a mean (±SD) age of 40 (±13.9) y. Eleven patients had bilateral examinations, providing a total of 39 hip joints for analysis. The cohort consisted of 15 women and 13 men with measurements taken from 21 right hips and 18 left hips.

CT method

A Toshiba Aquilion 16 TSX101-A Version 3.38 ER005 (Toshiba Medical Systems Corporation, Tochigi-Ken, Japan) was used to perform a 300-mm helical acquisition from above the acetabulum to below the lesser trochanter. Scan parameters were 135 kVP, 120–170 mA and 400-mm field of view. The reconstruction interval (slice thickness) was 2.5 mm. The data block was rotated to create a group of axial oblique images passing through the plane of the femoral neck, from which the alpha angle was calculated by an Institute of Radiography-registered radiographer according to the method described by Beaulè et al. (2005) (Fig. 2).

Ultrasound method

Ultrasound imaging was then performed immediately after the CT using a General Electric Logiq E9 (Wauwatosa, WI, USA) by the same sonographer with 15 y' experience in ultrasound of the musculoskeletal system. Imaging was performed with the patient positioned supine with the leg extended and with approximately 20 degrees of internal rotation. A linear ML6-15 MHz transducer was used to obtain a longitudinal image of the femoral head-neck junction with the cortical surface of the femoral head maximally exposed, and the distal attachment of the iliofemoral ligament visible on the image (Fig. 3). Acoustic