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Are "normal hips" being labeled as femoroacetabular impingement due to EE angle?

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Abstract

Gluteal muscle contracture (GMC) is a clinical syndrome characterized by gait abnormality and limb dysfunction, as well as secondary deformities of pelvis and femur. Femoroacetabular impingement (FAI) typically could be diagnosed on the basis of computed tomography (CT) such as the equatorial-edge angle (EE angle), but it did not work well in GMC patients. In this study, we retrospected all image data and found small EE angles in GMCs, which meant retroverted acetabulum; however, none of them showed no symptoms and signs of FAI. Therefore, we had reasons to think that, some normal hips with unbalanced hip myodynamia as same as GMCs, may be incorrectly diagnosed as FAI through measuring EE angle only.

In consequence, the paper was designed to assess the use of the EE angle in the assessment of FAI in the diagnosis, as described by Werner.

Twenty-three patients (46 hips) were collected and calculated with the "equatorial-edge angle" (EE angle) by CT scans. All of them were excluded from FAI.

Review of the hips showed a mean EE angle was 12.93°, with a minimum of -3.42° and a maximum of 24.08°. The mean value for males and females were 13.52° and 12.40°, respectively, without statistical significance, although the mean value of left hips and right sides reached 13.32° and 12.54° individually, not having statistical differences neither. There were not any symptoms or signs of FAI in all patients. Thus, the reduced EE angle could suggest the local excessive coverage of the femoral head by the anterior acetabular edge, but might not be a reasonably good predictor of FAI.

GMC patient's acetabular deformity mainly manifests as increased retroversion, which may be the anatomical basis for FAI and lead to high risks of the acetabular impingement. However, all patients in this study showed no symptoms and signs of FAI, suggesting that the measurement of EE angle can only be applied to assessing those people with normal hip myodynamia, and the bone deformity and the muscular disorder should be both considered in the diagnosis of FAI.

Abbreviations: 3D-CT = Three-dimensional computed tomography, CT = computed tomography, FAI = femoroacetabular impingement, GMC = Gluteal muscle contracture.

Keywords: acetabular retroversion, EE angle, femoroacetabular impingement, gluteal muscle contracture

1. Introduction

Gluteal muscle contracture (GMC) is a clinical syndrome characterized by gait abnormality and limb dysfunction, as well as secondary deformities of pelvis and femur.[1,2] At present, arthroscopic release, a minimally invasive surgery that was reported by Zhang et al[3] for the first time, has become the gold standard of treatment in GMC patients.[2,4]

Femoroacetabular impingement (FAI) typically could be diagnosed on the basis of computed tomography (CT) such as the equatorial-edge angle (EE angle). Although EE angle may be sufficiently sensitive to identify and differentiate impingement

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Each author certifies that his institution approved or waived approval for the reporting of these cases and that all investigations were conducted in conformity with ethical principles of research.

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Figure 1. (A–C) The 3D reconstruction CT shows a GMC Patient with severe gluteus maximus and gluteus medius atrophy for (A) posterior view, and (B) left side, and (C) right side, which have the contracture bands (white arrow) in left and right side, respectively.

morphologies in all cases and the diagnostic challenges have been previously reported,[5] the judgment method did not work well in GMC patients.

In this study, we retrospected all image data and found small EE angles in GMCs, which meant retroverted acetabulum; however, none of them showed symptoms and signs of FAI. Therefore, we had reasons to think that, some normal hips with unbalanced hip myodynamia as same as GMCs, may be incorrectly diagnosed as FAI through measuring EE angle only. In consequence, the paper was designed to assess the use of the EE angle in the assessment of FAI in the diagnosis, as described by Werner.

2. Patients and methods

The paper was a retrospective study and case series. Ethical approval was obtained from the Ethics Committee at the Peking University Shenzhen Hospital. Twenty-three people of those GMC patients coming for arthroscopic treatment agreed to join in the study. The STROBE checklist for cross-sectional studies was used in manuscript preparation. The study design included prospective enrollment and data collection and cross-sectional analysis. Pelvic CT scans of patients admitted to the Peking University Shenzhen Hospital, Shenzhen, China, were retrieved from the electronic radiological archive.

There were 23 patients (46 hips) who met the premise of having images available (Fig. 1), and all data were further analyzed. Before the CT scans were included, it was required to validate correct patient position and radiographic technique to eliminate any measurement error as possible.

All scans were made from January to July, 2015. In this study, MSCT scans were performed on CT scanners (Discovery 750HD; GE Healthcare, Waukesha, America) with slice thickness varying between 0.625 and 2.5 mm and a gantry tilt of 0°. All scans ranged from the pelvic bone to the proximal femur. The indicator of acetabular retroversion on the CT scans was measured using an adapted version of the method originally described by Werner et al[5] and Reynolds et al[6]: The EE angle was the angle of the acetabular opening at the maximum diameter of the femoral head (Fig. 2), which was represented by the sagittal plane and a line drawn between the anterior and posterior acetabular rim on the appropriate CT slice. In light of Reynolds et al,[6] EE angle was

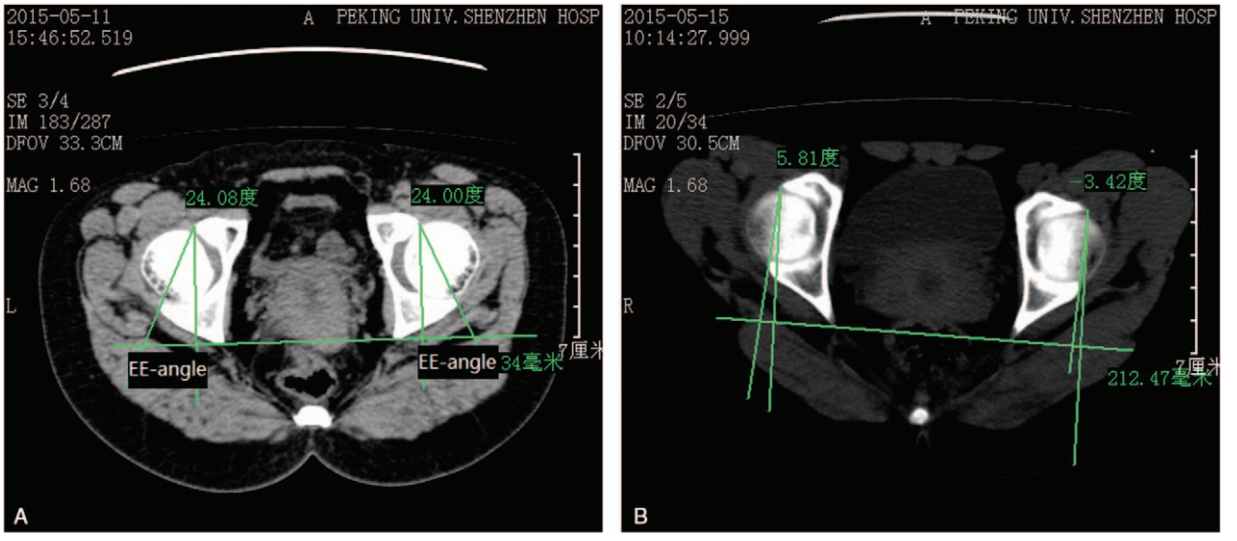

Figure 2. (A,B) The CT slice at the level of the maximum diameter of the femoral head. A line was drawn from the anterior to the posterior border of the acetabulum, as well as a line representing the sagittal plane. The EE angle was the angle which these 2 lines subtended. The graph shows 2 positive angles of (A), one positive and another negative of (B) as well.

Table 1

Values of EE angle measured in all hips and subdivided into different groups.

Angle (degrees)	Mean	SD	Minimum	Maximum	Statistics
CT EE angle (all)	12.93	6.06	−3.42	24.08	
CT EE angle (male)	13.52	5.46	3.32	22.29	$t=0.62$, $P>0.05$
CT EE angle (female)	12.40	6.64	−3.42	24.08	
CT EE angle (left)	13.32	6.19	−3.42	24.08	$t=0.43$, $P>0.05$
CT EE angle (right)	12.54	6.05	3.32	20.73	

CT = computed tomography, EE = equatorial-edge, SD = standard deviation.

defined as "negative" if opening posteriorly (Fig. 2A) and "positive" if opening anteriorly (Fig. 2B).

Statistical analysis was performed using SPSS 13.0 for Windows (SPSS Inc., Chicago, IL). Distributions of angles were examined using histogram, and reported as mean ± standard deviation if distributions were symmetrical. We used independent groups *t* tests for comparisons between groups (sex and side) if assumptions of approximate normality and equal variances were met. A *P* value of ≤ 0.05 was considered to be significant.

3. Results

Review of the hips showed a mean EE angle was 12.93°, with a minimum of -3.42° and a maximum of 24.08° (Table 1). The mean value for males and females were 13.52° and 12.40°, respectively, without statistical significance (Table 1), although the mean value of left hips and right sides reached 13.32° and 12.54° individually, not having statistical differences neither (Table 1). There were not any symptoms or signs of FAI in all patients. Thus, the reduced EE angle could suggest the local excessive coverage of the femoral head by the anterior acetabular edge, but might not be a reasonably good predictor of FAI.

4. Discussion

GMC mainly affects the patient's tensor fasciae latae, gluteus maximus, gluteus medius, and gluteus minimus, what's more, sometimes even involves the lateral rotator group and the joint capsule of hip. These involved muscles may be found with muscle fibers degeneration and necrosis, fibrous connective tissue proliferation, and myofascial and fascia hypertrophy, leading to a sequence of secondary pathological changes, such as the hip muscles out-of-balance, which may cause abduction and external rotation deformities of the hip joint, pelvic tilt, and acetabular dysplasia.[1,7]

FAI is an abnormal condition where chronic pains occur in the hip joint resulted from degenerative changes in the acetabular labrum and articular cartilage, due to the impingement between the femoral head and acetabulum caused by anatomical abnormalities in the hip joint. In these cases, the hip joint's range of motions, especially flexion and internal rotation, are limited, eventually resulting in the hip osteoarthritis. As the good compatibility between the acetabulum and the femoral head is the functional basis for normal movement of the hip joint, morphological changes in any one of them will affect the hip functions. The normal border of the femoral head–neck junction is a concave arc, which can smoothly move into the acetabulum when the hip joint is flexing or internally rotating. When the femoral offset is reduced or vanished, or the acetabular edge excessively covers the femoral head, the acetabular edge and the head–neck junction can be more likely to squeeze and impinge on each other at the end stage of the motion, resulting in FAI.[8–11]

It is traditionally held that FAI is divided into the Cam-type and the Pincer-type.[12] The Cam-type FAI is distinguished by a noncircular femoral head but an anatomically normal acetabulum. The noncircular femoral head may collide with the acetabular edge, leading to cartilage damage and labrum tear and even causing bone cystic degeneration and labrum ossification of the acetabulum. On the contrary, in the Pincer-type FAI, the femoral head is anatomically normal, but the abnormal acetabulum is characterized by the acetabular retroversion or the excessive coverage on the femoral head, causing linear contact between the acetabular labrum and the femoral head–neck junction during the joint motions, thereby leading to the degeneration, hardening, or ossification of the acetabular labrum. Such changes aggravate the wrapping of the femoral head by the acetabulum and further exacerbate the range and severity of the lesion. Actually, some FAI patients can be observed to show the anatomical abnormalities in both the femoral head and the acetabulum, and some researchers have defined this condition as the mixed-type FAI.[13,14]

MSCT has been widely applied in the examination of bone and joint diseases, and its diagnostic value has been recognized as an effective imaging method. As the isotropic advantage of MSCT allows the 3-dimensional reconstruction in any orientation after the scanning, it is more conducive to observe and measure the structural abnormalities in order to evaluate the severity of the disease. It is reported that MSCT is more sensitive than X-ray in displaying many aspects, including the hardening of the impacted area on the acetabular edge, early changes in subchondral bone density, tiny synovial hernia, and acetabular rim ossicles on the acetabular edge.[15]

There were still some shortcomings in this study, such as the relatively small sample size, the absence of a healthy control group, and the lack of a "gold standard" for hip arthroscopy. These deficiencies should be improved and further investigated in the future research.

The previously reported X-ray findings, such as the pistol grip deformity and the cross-over sign are nonquantitative description. In this study, the EE angle was selected to quantify the abnormal bone structure of the hip joint in FAI. The EE angle reflects the degree of the acetabular retroversion in the Pincer-type FAI, which is one of the features of Pincer-type FAI,[16,17] typically manifesting as decreased EE angle. The study of a large sample by Werner et al[5] showed that the EE angle of the acetabular edge "crossing" negative group was 21.0°, while that of the "crossing" positive group was 17.3 °. Similarly, in Chinese populations, Chen et al[18] discovered it was 20.4° in 59 FAI patients. Although in this study, the EE angle was measured as 13.1 ± 3.1° on the left side and 12.5 ± 3.9° on the right side, significantly smaller than previous studies. The reduced EE angle suggested the local excessive coverage of the femoral head by the anterior acetabular edge. According to Werner's study, the

participants in our study should be diagnosed as FAI; actually, there was not any meaningful discovery of FAI in all patients.

In a word, we discovered that GMCs have a higher degree of retroversion (excessive acetabular retroversion) than FAI hips, seemingly suggesting that they should be attributed to FAIs. However, in this study, all patients showed no symptoms and positive signs of FAI. Possible reasons might be that most symptoms of the FAI patients occur during flexion, adduction, and internal rotation, but the GMC is a disease manifested as the abduction and external rotation deformities of the hip joint, and thus the impingement is impossible to happen.

The inconsistent findings speculate that there are 2 possibilities. The first, EE angle can be used for diagnosing the people with balanced hip muscle forces whether have FAI or not, while those populations with imbalanced myodynamia, such as GMCs, were not suitable. Another probability is that, perhaps EE angle is worthy for everyone, but it has its own limitation. In other words, at least, it cannot be a single imaging diagnostic basis; the muscular factor also plays a significant role in FAI pathogenesis. If we neglect this matter, normal hips may be labeled as FAI improperly. Apart from these 2 points, this study also reminded us that, even with the presence of abnormal bone structure, as long as the muscle strength of the hip joint's abduction and external rotation is greater than that of the adduction and internal rotation, the acetabular impingement would not happen. Therefore, some studies indicated that, in the conservative treatment of FAI, the excessive hip flexion, adduction, and internal rotation should be prevented, and most patients' symptoms could be alleviated by doing so.[19] Emara et al[20] reported that 33 of 37 patients showed alleviative symptoms in follow-up, and 6 of them showed recurrence of symptoms, but the pain could be tolerated and no surgery was required.

5. Conclusions

GMC patient's acetabular deformity mainly manifests as increased retroversion, which may be the anatomical basis for FAI and lead to high risks of the acetabular impingement. However, all patients in this study showed no symptoms and signs of FAI, suggesting that the measurement of EE angle can only be applied to assessing those people with normal hip myodynamia, and the bone deformity and the muscular disorder should be both considered in the diagnosis of FAI.

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