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Original Research

Femoral Neck Stress Fractures and Imaging Features of Femoroacetabular Impingement

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Abstract

Background: Prior literature has suggested an association between the radiographic signs of femoroacetabular impingement (FAI) and femoral neck stress fractures (FNSF) or femoral neck stress reactions (FNSR). At the time of the writing of this article, no study has described the association of FAI and FNSF/FNSR along with the need for surgical intervention and outcomes.
Objective: To determine the prevalence of radiographic features of FAI in patients diagnosed with FNSF.
Design: Retrospective case series.
Setting: Tertiary care, institutional setting.
Patients: A medical records search program (Stanford Translational Research Integrated Database Environment, Stanford University, California) was used to retrospectively search for patients 18-40 years old with a history of FNSF or FNSR. The records were obtained from the period July 25, 2003, to September 23, 2011.
Methods: For assessment of risk factors, plain radiographs and magnetic resonance imaging studies were reviewed for features of cam or pincer FAI. Medical records were reviewed to determine whether patients required operative intervention.
Main Outcome Measures: Incidence of abnormal alpha (α) angle, abnormal anterior offset ratio, abnormal femoral head-neck junction, coxa profunda, positive crossover sign, and abnormal lateral center-to-edge angle.
Results: Twenty-one female and 3 male participants (mean age 27 years, range 19-39 years) were identified with magnetic resonance imaging evidence of femoral neck stress injury. Cam morphology was seen in 10 patients (42%). Pincer morphology could be assessed in 18 patients, with coxa profunda in 14 (78%) and acetabular retroversion in 6 (14%). Features of combined pincer and cam impingement were observed in 4 patients (17%). Seven patients (29%) had operative intervention, with 3 (12%) requiring internal fixation of their femoral neck fractures, and all had radiographic evidence of fracture union after surgery. Four patients (17%) had persistent symptoms after healing of their FNSF with conservative treatment and eventually required surgery for FAI, 3 had no pain at final follow-up 1 year post-surgery, and one patient was lost to follow-up.
Conclusion: The results of the current study suggest that patients in the general population with femoral neck stress injuries have a higher incidence of bony abnormalities associated with pincer impingement, including coxa profunda and acetabular retroversion, although it is unclear whether pincer FAI is a true risk factor in the development of FNSF.

Introduction

Stress fractures can occur anywhere along the femur, but most commonly occur along the femoral neck or shaft [1]. Femoral neck stress fractures (FNSF) can be classified into 3 categories, namely, tension-sided, compression-sided, or displaced. Classification systems of FNSF have been used to describe the degree of bony injury observed with plain radiographs [2] or magnetic resonance imaging (MRI) [3] MRI is the imaging modality of choice because it is highly sensitive and specific for diagnosing stress reactions of the bone, and it avoids the ionizing radiation associated with computed tomography (CT) and scintigraphy [4-7]. Incomplete and compression-sided FNSF are typically treated nonoperatively [8]. Operative fixation is usually reserved for tension-sided and complete fractures or for cases that fail nonoperative management [8].

A number of factors are involved in the development of FNSF, including training intensity, diet, footwear, age, gender, lower limb alignment, and bone mass [9]. An increase in training intensity is the most common risk factor involved [9] and can produce repetitive stresses that outpace the remodeling capacity of bone [10]. The

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abnormal bony anatomy associated with femoroacetabular impingement (FAI) has also been implicated as a factor involved in the development of FNSF [11-13]. FAI is a common cause of hip pain and pathology that results from abnormal contact between the proximal femur and the acetabular rim during terminal range of motion [14]. This pathomechanical process eventually results in characteristic damage to the labrum and acetabular cartilage, depending on the location of the osseous abnormality [14] The 2 most common osseous abnormalities that lead to FAI are a loss of the normal femoral head-neck offset, resulting in cam impingement, and acetabular over coverage, resulting in pincer impingement [14].

In 2010, a retrospective study demonstrated an increased incidence of radiographic features of FAI in military recruits with FNSF compared to those without stress injuries [13]. A more recent study has also shown an association between FAI and femoral neck stress fractures in military personnel [11]; however, the association between FAI and FNSF has not been determined in the general population. The purpose of this study was to determine whether there is an increased incidence of FAI in patients in the general population who presented with stress fractures or stress reactions of the femoral neck.

Method

Institutional review board approval was obtained for data collection. A medical records search program (Stanford Translational Research Integrated Database Environment, Stanford University, California) was used to retrospectively search for patients 18-40 years old with a history of FNSF or femoral neck stress reaction (FNSR). The records were obtained from the period July 25, 2003, to September 23, 2011.

After reviewing the records that the database obtained, we found 24 patients who had radiographic evidence and/or MRI evidence of a FNSF or FNSR.

Radiographic images were reviewed by both a fellowship trained musculoskeletal radiologist (K.J.S.) and an experienced hip arthroscopist (M.R.S.). Anterior-posterior (AP) pelvis and cross-table lateral radiographs of the affected hip were assessed for the presence of radiographic features of FAI. Anterior-posterior radiographs with excessive tilt or rotation were excluded from the final analysis of acetabular morphology. Pelvic tilt was determined to be acceptable if the distance between the sacrococcygeal junction and pubic symphysis was 8-50 mm in males and 15-72 mm in females [15]. Pelvic rotation was acceptable if the distance from the center sacral line to the center of the pubic symphysis was $<$16 mm [15]

Findings consistent with pincer impingement included coxa profunda, where the medial acetabular wall touches or projects medial to the ilioischial line, and acetabular retroversion, indicated by the presence of a crossover sign or a posterior wall sign. A crossover sign was defined as crossing of the anterior and posterior acetabular rims on the AP radiograph [16]. A posterior wall sign was present if the center of the femoral head projected lateral to the posterior acetabular rim [17]. A lateral center-edge angle (LCEA) [18] was also determined by drawing a line from the center of the femoral head to the outer edge of the acetabular roof, then measuring the angle formed between this and a vertical line drawn through the center of the femoral head.

Radiographic findings compatible with cam impingement included an abnormal contour of the femoral head-neck junction (FHNJ), an anterior offset ratio (AOR) of $<$0.18, and an α angle of $>$50° [19,20]. The AOR and α angle characterizes an abnormal FHNJ on the anterior aspect of the femoral neck, whereas a lot of abnormal bony excrescences or cam morphology are seen on the anterolateral or lateral femoral head-neck junction. The FHNJ was called abnormal if there was a bony excrescence along the femoral head-neck junction or lack of offset. The advantage of MRI is multiplanar imaging capabilities, making it easier to evaluate the femoral head-neck junction circumferentially compared to conventional xrays. The AOR (Figure 1) and α angle (Figure 2) were measured on the cross table lateral radiograph in each patient [19,20]. Femoral head-neck junction morphology was evaluated on both plain radiography and MRI by drawing a circle around the femoral head on the AP or cross table lateral radiographs or MR image, and seeing whether a bony excrescence projected beyond the circle or whether the head-neck transition was aspherical and extended outside the circle [20-22].

Radiographs were also evaluated for additional findings that have been associated with both cam and pincer impingement, including the presence of an os acetabuli [23] and fibrocystic changes of the femoral neck [24].

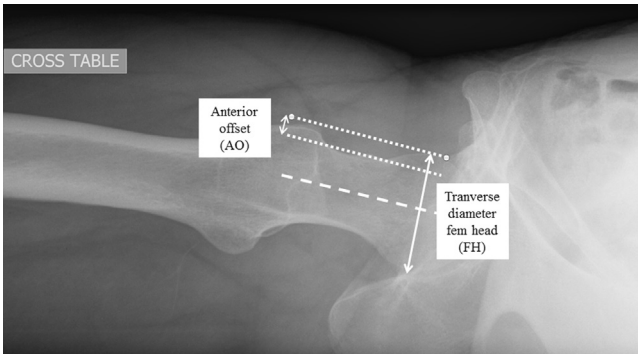

Figure 1. The anterior offset ratio (AOR) was calculated for each patient by placing a line along the central axis of the neck (dashed line) and drawing parallel lines along the anterior cortex of the femoral neck and the most anterior portion of the femoral head (dotted line). The perpendicular distance between these latter 2 lines gives the anterior offset, and the AOR is then calculated by dividing the anterior offset by the diameter of the femoral head (AO/FH).