Incidence of Radiographic Cam-Type Impingement in Young Patients (<50) After Femoral Neck Fracture Treated with Reduction and Internal Fixation

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Abstract *Background:* Cam-type femoral impingement is caused by structural abnormalities of the hip and is recognized as a cause of degenerative hip arthritis. Identifiable etiologies of this structural abnormality include congenital malformation, pediatric hip disease, and malunion of femoral neck fractures after internal fixation. *Purpose:* The purpose of this study was to determine the prevalence of radiographic impingement in healed Orthopaedic Trauma Association (OTA) type 31B fractures treated with reduction and internal fixation. *Methods:* Seventy OTA 31B hip fractures treated with internal fixation were identified from our institutional trauma database and radiographs were retrospectively reviewed for signs of impingement. Mean follow-up was 53 months after fracture. Alpha angle, Mose templates, and femoral head retroversion were the measurements used to determine impingement. *Results:* The overall prevalence of any sign of radiographic impingement was 75%. Alpha angle was elevated in 32 hips (46%), asphericity was present in 46 femoral heads (65%), and femoral head retroversion was present in 26 hips (37%). The rates were highest in displaced subcapital fractures (OTA 31B-3) with a 63% (13/19) prevalence of elevated alpha angle, 68% (14/19) prevalence of asphericity, and 47% (10/19) prevalence of retroversion. *Conclusions:* Prevalence of radiographic signs of impingement in this population is higher than expected based on population-based controls. Surgeons must be vigilant about reduction and fixation of femoral neck fractures. Malunion should be recognized as early intervention may be beneficial in improving long-term outcomes.

Keywords femoroacetabular impingement · femoral neck fracture · alpha angle · cam lesion

Introduction

Cam-type femoroacetabular impingement is increasingly being recognized as a cause of labral tears and degenerative hip arthritis [4, 9, 14, 15, 19, 23, 25]. There are multiple structural problems that can lead to cam-type impingement including occult slipped capital femoral epiphysis [7, 10, 15], Legg–Calve–Perthes disease [16], and congenital deformity [1]. Another potential cause of cam-type lesions is malunion of femoral neck fractures [8].

Impingement due to malunion is a potentially treatable cause of ongoing hip pain and dysfunction after a femoral neck fracture [8]. Early recognition and intervention for symptomatic impingement may facilitate hip preservation. Neither radiographic nor clinical outcomes related to impingement after reduction and internal fixation of femoral neck fractures in young patients have been reported to our knowledge. Alpha angle, Mose templates, and femoral head retroversion are established radiographic methods of delineating proximal femoral deformity [6, 10]. These three signs were chosen to identify cam-type lesions in our patients.

We hypothesize that the prevalence of these indicators of impingement will be increased when compared to population-based controls. The purpose of this study was to document the prevalence of the three radiographic cam-type lesions in adults who sustained femoral neck fractures treated with reduction and internal fixation. Secondly, we wished to search for a relationship between the development of these radiographic cam-type lesions and evidence of degenerative arthritic change using the Tonnis system [24] on long follow-up radiographs.

Level of Evidence: Level IV, Therapeutic study.

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Patients and Methods

Between 1975 and 2008, 129 femoral neck fractures in 127 consecutive skeletally mature patients were identified from an institutional trauma database at our level 1 trauma center and retrospectively reviewed. All fractures were classified as type 31B according to the system of the Orthopaedic Trauma Association. Internal fixation was performed on all fractures. At our center, younger patients with femoral neck fractures are treated if possible by ORIF. Fifty-six of the fractures identified were excluded. Exclusion criteria were identifiable hip dysplasia (2 hips), fracture due to tumor (1 hip), stress fracture (9 hips), or lack of available radiographic follow-up (44 hips).

With these criteria, we identified 70 fractures in 70 patients. The mean age of the patients was 40.5 years (range 15–50). Forty-six patients were males and 24 were females. Thirty were right-sided fractures and 40 were left sided. According to the system of the OTA (Orthopaedic Trauma Association), there were 9 subcapital (type 31B1) fractures, 27 transcervical (type 31B2) fractures, and 19 displaced subcapital (type 31B3) fractures. Fifteen fractures were not subclassified past type 31B as presurgical injury films were not available due to institutional policy of discarding them after a certain period of time. The choice of fixation device, the operative approach, and the need for capsulotomy were determined by the treating surgeon. Forty-five fractures were treated with cannulated screws; 21 with a sliding hip screw; 3 with a reconstruction nail; and 1 with a fixed angle blade plate. Postoperative care and follow-up was determined by the treating surgeon.

Anteroposterior and either frogleg or cross table lateral radiographs were reviewed for each patient at the time of injury and at the most recent follow-up. Arthritis was graded with Tonnis grading system [24]. Contralateral radiographs were reviewed when available. Contralateral lateral radiographs were available for 11 patients and AP pelvic films including the contralateral hip were available in 62 of the patients. The mean duration of radiographic follow-up was 53 months (range 3–370 months).

The alpha angle was measured on the lateral radiograph by placing a circle of best fit over the outline of the femoral head. A line was drawn from the first point on the femoral head-neck junction which was outside the circle to the center of rotation of the femoral head. A second line was drawn from the center of the femoral head to the midline of the femoral neck and the angle between these two lines was measured (Fig. 1). Angles greater than 42° are considered suggestive of impingement [6]. Mose templates were measured on both the AP and lateral radiographs by placing a clear template over the femoral head and considered positive when any part of the head deviated more than 2 mm from the line of best fit (Fig. 2) [6]. The head was considered aspherical when the head deviated outside the template on either the AP or lateral radiograph (Fig. 3). Femoral head retroversion was also measured on lateral radiographs by drawing a line through the axis of the neck and a line parallel to the edge of the articular surface (epiphysis) and measuring this angle as described by Goodman [10]. Angles less than 86° are considered positive for retroversion.

Fig. 1. The technique we used for the measurement of alpha angle.

Results

Of the 70 fractures reviewed, 32 (46%) had alpha angle greater than 42° measured on lateral radiographs suggesting a cam-type deformity. Analysis of the subgroups of fractures demonstrated that displaced subcapital fractures (type 31B3) had the greatest prevalence of pathologic alpha angle 63% (13/19), whereas types 31B1 and 31B2 were 44% (4/9) and 37% (11/27), respectively. Asphericity of the femoral head as determined by a Mose template on AP or lateral radiographs was present in 46 (65%) of the fractures (Fig. 4). The prevalence was greatest in displaced subcapital fractures (type 31B3; 68%, 13/19). Prevalence in other fracture types was slightly lower with 66% (6/9) of subcapital (type 31B1) and 52% (15/27) of transcervical fractures demonstrating asphericity. Radiographic femoral head retroversion was measured in 37% (26/70) of fractures. The highest

Fig. 2. An X-ray which illustrates a normal Mose template.

Fig. 3. **a** An anteroposterior radiographic example of an OTA type 31B3 fracture. **b** A lateral radiograph that demonstrates an example of an OTA type 31B3 fracture.

prevalence of retroversion was found in displaced subcapital fractures (type 31B3; 47%, 10/19), followed by subcapital (type 31B1; 44%, 4/9) and transcervical (type 31B2; 30%, 8/27) fractures. Avascular necrosis (AVN) was seen in 17% (12/70) of fractures at final follow-up.

Radiographic evidence of the development of degenerative arthritis (Tonnis grade 1–3) was found in 31% (22/70) hips at final follow-up; ten of these were in patients with AVN. Of the remaining 12 patients with radiographic evidence of degenerative arthritis at final follow-up, 83% (10/12) had at least one radiographic measurement suggesting head asphericity or cam-type impingement. In nondisplaced subcapital fractures, 22% (2/9) showed arthritis. In transcervical fractures, 11% (3/27) of hips had arthritis. In displaced subcapital fractures, 58% (11/19) hips showed arthritis. Fifteen fractures (21%) required treatment with total hip arthroplasty by final follow-up. Ten of these were in patients who had AVN. Of the five fractures that resulted in total hip arthroplasty (THA) with no signs of AVN, all had radiographic signs of head asphericity or cam-type impingement. There were 18 patients that had no radiographic signs of impingement, and of these, 94% (17/18) had no signs of arthritis at final follow-up.

When contralateral lateral radiographs were available, pathologic alpha angle, asphericity on lateral Mose template, and femoral head retroversion were seen in 9% of the patients (1/11). When contralateral AP views of the

hip were available from anteroposterior pelvic radiographs, Mose templates measured positive in 15% of patients (9/62).

Discussion

Femoral acetabular impingement as a result of cam-type lesions has been noted as an etiology for chondral and labral lesions and causative factor for development of coxarthrosis in young patients [4, 9, 14, 15, 19, 23, 25]. Cam lesions have been associated with multiple causes including unrecognized pediatric hip pathology [7, 10, 15, 16] and have also been ascribed to congenital deformity of the hip [1]. To our knowledge, prior trauma has been reported as an etiology for cam lesions in only one small series. Subtle malunion in this series led to symptomatic hip impingement requiring operative treatment [8]. Early identification of malunion could facilitate early intervention and hip preservation. This study reports the prevalence of radiographic signs of impingement in a series of femoral neck fractures treated with reduction and internal fixation.

Fig. 4. **a** This anteroposterior radiograph of an OTA type 31B3 fracture demonstrates radiographic signs of impingement. **b** This lateral radiograph of an OTA type 31B3 fracture demonstrates radiographic signs of impingement. Note the out-of-round femoral head resulting from the malreduced fracture.

The major weaknesses of this study are related to its retrospective design. Although this is the largest study to date, the numbers or the length of follow-up may not be adequate to define whether these changes are indeed problematic. Because of the retrospective design, we were unable to use standardized radiographic techniques adding to intrinsic errors already present in making measurements off of radiographs. Also, we were only able to evaluate contralateral X-rays in 11 patients. This forced us to compare our results to population norms instead of the unaffected femora in our series. Short follow-up in many cases made it difficult to know whether some of the cam lesions identified led to osteoarthritis that was subsequently treated outside of our institution.

The definition of a pathologic alpha angle varies across the literature [1, 3, 6, 19], but on review of all definitions, prevalence in the general populations has been reported 14–17% [11, 12]. Our series demonstrated a 46% prevalence of abnormal alpha angle in 31B fractures with a 63% prevalence in type the 31B3 subgroup. The clinical significance of this finding is not clear because correlation between pathologic alpha angle and symptomatic impingement is ill defined. Gosvig et al. reported a prevalence of cam-type impingement to be 17% in males and 4% in females based on alpha angles derived from a standardized AP radiograph. However, there was no association in their series between positive radiographic signs of impingement and self-reported hip pain [11]. Similarly, Allen et al. reported 88 patients with bilateral cam impingement in patients with hip pain, but only 26% of these patients had bilateral symptoms [1].

Mose templates were originally used to measure the sphericity of the femoral head in Perthes disease, but have become another radiographic measure suggestive of impingement when positive [17]. The prevalence of a positive Mose template (aspherical head) in either AP or lateral view was 65% and 68% in our entire series and in type 31B3 fractures, respectively. The asphericity of the femoral head is correlated with late coxarthrosis in Perthes disease [17] and we feel that it is as reasonable to consider this a risk factor for impingement and coxarthrosis in patients who have a positive Mose template after a femoral neck fracture.

Femoral head retroversion was originally described by Goodman [10] in a study of 2,665 cadaver femora analyzed for evidence of slipped capital femoral epiphysis (SCFE) lesions. Retroversion was part of a spectrum of “post-slip morphology” that was found in 8% of the specimens and was associated with an increased risk of severe osteoarthritis. Our series demonstrated retroversion in 37% of the fractures (47% in type 31B3). This suggests that malunited adult femoral neck fractures have similarities to the morphology of SCFE and are also at increased risk for coxarthrosis.

Arthritic changes were seen in 31% of the patients reviewed in this study. A majority of these hips had AVN. Of the arthritic hips that did not have AVN, 83% had at least one radiographic measurement suggesting impingement. Additionally, of the 18 patients that did not have any signs of impingement, 94% did not show signs of arthritis at final follow-up. There was, however, a group of 30 patients who

had at least one radiographic sign of impingement that had no arthritis at an average follow-up of 36 months. With the small numbers and follow-up available in this study, it is difficult to make strong conclusions about the correlation of radiographic impingement and coxarthrosis.

Cam-type impingement is increasingly accepted as a cause of labral tears, cartilage damage, and osteoarthritis [4, 9, 14, 15, 19, 23, 25]. Compared with historical controls [10–12, 17], prevalence of radiographic indicators of cam-type impingement is increased in adults who have undergone internal fixation of OTA 31B femoral neck fractures, especially 31B3 type fractures. The association of these indicators with coxarthrosis, however, remains unclear. Treating physicians should strive for anatomic reduction and stable fixation [13, 22]. Surgeons should also be aware that impingement may be a cause of hip pain in patients who have been treated for these injuries because a number of surgical treatments for femoral acetabular impingement have been reported to give good symptomatic relief and improved function [2, 5, 18, 20, 21]. Clinical and radiographic follow-up after union of these fractures may be indicated if a malunion is noted because early detection of femoral acetabular impingement may be beneficial in optimizing both the outcome and the cost effectiveness of surgery when compared with arthroplasty in such patients. In some patients, especially with major deformity, solving the structural problem earlier may obviate the need for a THA.

Disclosures Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article. One or more of the authors has or will receive monies from a commercial entity that may be perceived as a potential conflict of interest.

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

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