Age-Related Differences in Radiographic Parameters for Femoroacetabular Impingement in Hip Arthroplasty Patients

Geoffrey S. Van Thiel, MD/MBA[1,2]; Richard W. Kang, MS, MD[1]; Jas Chahal MD[1,3]; Craig J. Della Valle, MD[1]; Charles Bush-Joseph, MD[1]; Shane J. Nho, MD, MS[1]

[1]Rush University Medical Center, Chicago, IL
[2]Rockford Orthopedic Associates, Rockford, IL
[3]University of Toronto, Toronto, Canada

Abstract

Femoroacetabular impingement (FAI) has been proposed as a cause of premature hip degeneration. We hypothesized that FAI findings would be significantly more common in a younger arthroplasty patient population.

Arthroplasty patients over and under 50 years of age were identified. Findings in the subgroup under 50 included; significantly more males, decreased lateral joint space with maintained medial joint space, significantly increased alpha angle on both the anteroposterior view and the frog-leg lateral, significant increase in the Tonnis and Sharp angles, and a significant decrease in the center-edge angle.

The findings illustrate an increased prevalence of FAI findings (specifically CAM pathology) in a patient population under the age of 50 undergoing total hip arthroplasty when compared to a cohort over the age of 50.

Introduction

There are multiple etiologies that can lead to end stage degenerative joint disease of the hip in young patients. Dysplasia, osteonecrosis, Perthes, post-traumatic deformity, and inflammatory arthropathies are among the common causes, however, there are a large number of young patients that appear to have a primary arthritic process. Femoroacetabular impingement (FAI) has been proposed as a significant cause of this premature hip degeneration in the young patient(1-5). Advancements in the diagnosis and understanding of femoroacetabular impingement have led to the development of new treatment algorithms and modalities. This is clearly seen in the exponential increase of arthroscopic hip procedures that are performed in contemporary orthopaedics(6). However, the question still remains as to what is the cause, effect, and relationship of femoroacetabular impingement to early degeneration of the hip.

Clohisy et al(4) recently reported that 33% of patients under the age of 50 that underwent a total hip arthroplasty had radiographic evidence of femoroacetabular impingement. The authors also found a 73% rate of arthroplasty or advancement in osteoarthritis grade in the contralateral hip with bilateral findings of FAI. These results suggest a distinct relationship between impingement and end stage hip degeneration. However, Laborie et al(7) found a 35% rate of CAM deformities and a 34% rate of pincer lesions in males in a prospective study of asymptomatic volunteers. This calls into question the pathologic relationship by demonstrating a high rate of impingement findings in patients with no hip disease. Ganz et al(2,5,8) has also repeatedly proposed that structural abnormalities associated with CAM and pincer impingement can lead to advanced arthrosis. Nonetheless, a direct relationship between FAI and end-stage hip degeneration has not been established and represents the crux of current hip research in the young patient.

The purpose of the current study was to compare the prevalence of femoroacetabular impingement findings between a patient population under the age of 50 and over the age of 50 that underwent total hip arthroplasty. More specifically, radiographic indices for FAI were calculated and compared for each study population. We hypothesized that femoroacetabular impingement would be significantly more common in a patient population that required hip arthroplasty under the age of 50 years than an older patient subset.

Methods

Patients that underwent a total hip arthroplasty between January 2007 and June 2009 were retrospectively identified from a facility repository database. Fifty patients each were then randomly selected from one of two subgroups and all pre-operative radiographs were collected. One subgroup consisted of all patients that were less than 50 years of age (mean 43 years; standard deviation 5.6 years), while the other subgroup contained patients that were 50 years of age or over (mean 68 years; standard deviation 8.3 years). Both subgroups were chosen with specific inclusion/exclusion criteria. Exclusion criteria included the presence of; osteonecrosis, developmental dysplasia of the hip, inflammatory arthritides, and post-traumatic arthritis.

Inclusion criteria included adequate available radiographs with appropriate pelvic tilt and rotation. We assessed the rotation by qualitatively assessing the obturator foramen for symmetry as well as quantitatively by drawing a plumb line from the lumbar spinous processes through the pelvis. A distance between the plumb line and the pubic symphysis of less than 16 mm was deemed to be adequate. Pelvic tilt was determined by measuring the distance between the sacroccygeal joint and the pubic symphysis. An acceptable range for males was between 8 to 50 mm and for females was between 15 to 72 mm(9).

Two blinded independent observers analyzed the pre-operative radiographs and measurements were performed on the AP pelvis and frog-leg lateral of the affected hip. The following parameters were determined(10,11); the center of the femoral head was identified with the use of Mose circles(12), α angle on the AP and lateral, the neck-shaft angle, the Tönnis angle, the center-edge angle, Sharp's angle(13), osteophytes, medial/lateral joint space, congruency, and herniation pits. The radiographs were also assessed for the presence of localized over-coverage, shown radiologically by the cross-over and posterior wall signs, or generalized over-coverage of the femoral head demonstrated in the femoral head extrusion ratio.

Intra- and inter- observer repeatability was evaluated with ϰ statistics for categorical variables and intra-class correlation coefficients (ICC) for continuous variables. Statistical analysis was completed using the SPSS software (Chicago, IL). For categorical variables such as the presence of a cross-over and posterior wall signs, the intra- and inter- observer agreement ϰ statistic was ≥ 0.80. For continuous variables, the intra- and inter- observer ICC were ≥ 0.90. An independent t-test was used to compare continuous variables, a Chi-square analysis was used for discreet variables, and a z-ratio was used to analyze proportions.

Results

Detailed radiographic analysis of the osteoarthritic hips demonstrated a high prevalence of structural abnormalities associated with femoroacetabular impingement in the patient population under 50 years of age as described in Table 1. In the patient group under 50 the average age was 43 (±5.66) years with 78% male / 22% female. This significantly contrasted the over 50 group with an average age of 68 (±8.34) and 36% male/64% female, ($p < 0.05$ and $p = 0.0002$, respectively).

There was no significant difference in lateral joint space, but the under 50 group had a significantly larger medial joint space (1.9 ±2.5 mm vs. 3.28 ±1.8 mm, $p = 0.0022$). There was also a significant difference in the Tonnis and Sharp's angle with the under 50 group having significantly increased values ($p < 0.001$ and $p = 0.0084$, respectively). These findings also correspond with a substantial decrease in the center edge angle for arthroplasty patients under 50 (45.78 ±12.00 vs 34.81 ±7.69, $p < 0.001$). The femoral head extrusion index was also increased in these young patients (0.11 ±0.11 vs 0.18 ±0.10, $p < 0.001$). As predicted, there was a significantly higher alpha angle on both the AP and lateral radiographic views in the patients under 50 years of age (46.2 ±8.90 vs 62.3 ±8.95; 47.8 ±12.78 vs 59.8 ±13.88, respectively). Interestingly, there was no difference in the head-neck offset on the AP view, but there was a significant decrease in offset on the frog-leg lateral view in the patients under 50 (17.2 ±4.08 mm vs 13.1 ±3.62 mm, $p < 0.001$)

There were no significant differences in the presence of osteophytes, ischial spine on the

AP radiograph, position of the ilioischial line, or a cross over sign. In the over 50 group 18% of patients had a positive cross-over sign and 24% of the under 50 group had the same findings. There were also no significant differences in the femoral head congruency, varus/valgus position, neck shaft angle, or presence of herniation pits.

Discussion

The natural history of impingement and associated pathology is poorly understood. A variety of theories have been proposed, but with limited scientific evidence. However, the concept that femoroacetabular impingement can lead to pre-mature degeneration of the hip has been supported by many authors (2-5,14,15). In fact, this is not a new concept, in 1965 Murray (16) described a "tilt deformity" of the femoral head with the formation of excess bone and buttressing of the femoral neck. He linked this phenomenon to premature osteoarthritis in the lateral third of the joint. Early descriptions of the "pistol-grip" deformity in the hip also contributed to our initial understanding of how hip morphology contributes to early degeneration. Ganz and Harris were then some of the first researchers to re-visit this concept and have eloquently summarized the relationship of impingement to early hip degeneration in multiple publications(2,17). The theory that FAI can lead to early arthritis of the hip has been proposed by multiple authors, but not directly established in the contemporary literature. Furthermore, it remains to be seen if this early degeneration leads to end-stage destruction that requires arthroplasty. The current study indirectly supports the relationship between FAI and total hip replacement through the evaluation of radiographic abnormalities found in an arthroplasty population under 50 years of age compared with patients over 50 years of age.

Clohisy et al(4) has recently reported on the results of radiographic evaluation of 710 patients that received a hip arthroplasty before the age of 50. Overall, 17% of the patients were diagnosed with osteoarthritis of "unknown etiology" and received a comprehensive radiographic evaluation. Of these, 98% were diagnosed with CAM, pincer, or combined pathologies. These patients were also more likely to be male. In comparison with an asymptomatic patient population, they found that there was a significant decrease in the head-neck offset ratio and femoral head sphericity in the affected hips. Furthermore, female patients had an increased acetabular inclination and patients with pincer lesions had an increased lateral center edge angle. Interestingly, a subgroup of 70 patients with contralateral imaging, revealed that all of them also had bilateral structural abnormalities and 37% of these pateints underwent contralateral total hip arthroplasty at an average of 5.4 years and 36% of them had an increase in Tonnis grade at an average of 8.4 years. This was a large study with great insight into the concomitant pathologies of patients that require total hip arthroplasty at an early age. An asymptomatic comparison group provided a good reference frame, however, this study did not provide an older cohort that also underwent total hip replacement to determine the increased, decreased, or similar prevalence of structural abnormalities.

The relationship between radiographic findings and articular damage is also supported by Nepple et al(18). The authors studied 355 arthroscopic hip procedures with 67% of the patients having some degree of acetabular chondromalacia. More specifically; male sex, age, and an alpha angle >50 on the frog leg lateral were independent risk factors for more advanced articular damage with an odds ratio greater than 3.0. Pincer type impingement was not associated with an increased rate of degeneration. Johnston et al(19) also described a correlation between radiographic findings and arthroscopic acetabular degeneration. In their study, a higher offset alpha angle was associated with acetabular rim chondral defects and full thickness delamination of the acetabulum.

To further define the degeneration associated with FAI, Beck et al(15) reviewed the results of 244 hips that were treated with an open dislocation and identified 26 hips that had isolated CAM impingement and 16 with only a pincer lesion. The authors found that the hips with CAM impingement had focal damage to the articular cartilage in the anterosuperior region of the acetabulum with separation of the cartilage and the labrum, whereas the hips with pincer lesions had a circumferential thin zone of injury to the articular surface. Anderson et al(14) also found a close association with CAM type impingement and acetabular delamination. In a retrospective review of 64 surgical dislocations for impingement they found 44% of patients with acetabular cartilage delamination. Interestingly, male sex and CAM lesions were strongly associated with the delamination, but acetabular overcoverage was not.

However, results of the referenced studies must also be regarded in the context of an intriguing study completed by Laborie et al(7). In a prospective population based radiographic analysis of asymptomatic hips they found a 35% rate of radiographic CAM impingement in males with an accompanying 34% rate of pincer lesions. However, females had a 10% rate of CAM lesions and a 17% rate of pincer findings. Thus, the question remains as to whether the 35% of asymptomatic patients with impingement lesions in the study by Laborie will develop symptoms, or are the impingement signs in 33% of arthroplasty patients in the study by Clohisy merely incidental findings.

The current study does provide some insight into the complex interactions between femoroacetabular impingement and early end-stage osteoarthritic changes. Similar to other studies, there was a much higher percentage of male patients in the arthroplasty group under 50 years of age. These young patients also showed signs of decreased lateral joint space with relatively maintained medial joint space. This would support the theory that impingement progresses from a lateral to medial direction due to the forces applied on the acetabular cartilage from the impingement lesion. Furthermore, the patients under the age of 50 years also had a significantly increased alpha angle on both the anteroposterior view and the frog-leg lateral. However, there was also a significant increase in the Tonnis and Sharp angles with a significant decrease in the center-edge angle. These findings support the conclusions of Beck et al(15) and Anderson et al(14) that CAM lesions are more detrimental to the acetabular articular cartilage than pincer deformities. In the current study, impingement lesions were analyzed based on a continuous distribution as opposed to the presence or absence of a deformity. The authors believe that there may be a spectrum of deformities and the reporting of “present” or “absent” may overlook the influence of magnitude on the degeneration of the hip.

There are limitations to the current study. One-hundred patients were randomly selected from a larger patient pool for radiographic analysis. The possibility of sampling error does exist, but a power analysis revealed that 50 patients in each group would be sufficient for comparison and it was assumed that the 50 patients would be sampled from a normally distributed population. There is also the possibility of a large degree of variability in many of the measurements taken. However, the inter-observer reliability was acceptable and the statistical testing would have taken into account any variability of results. Lastly, this is a retrospective review and a direct causal relationship cannot be established based on radiographic findings.

It is commonly believed that impingement can lead to end-stage degeneration through a mechanism of mechanical wear and abutment due to morphologic problems with the hip joint. However, these theories have not been robustly defended in the contemporary orthopaedic literature. The current study adds to our understanding of this problem with the comparison of arthroplasty patients in treatment-matched cohorts below and above 50 years of age. The young patients did have more significant CAM findings, decreased acetabular coverage, and a maintenance of medial joint space. These findings would seem to support a degenerative mechanism that is more reliant on the deformity of the proximal femur and does progress from lateral (or anterosuperior) to medial on the anteroposterior imaging.

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DATA TABLE

Measurement	**Over 50 yrs**	**Under 50 yrs**	***Significance (p value)***
Age	67.8 (±8.34)	43.0 (±5.66)	*p< 0.05*
Gender	36% Male, 64% Female	78% Male, 22% Female	*p< 0.0002 (z-ratio)*
Lateral Joint Space (mm)	1.2 (±1.59)	1.4 (±1.53)	*p = 0.50*
Medial Joint Space (mm)	1.9 (±2.49)	3.28 (±1.84)	*p = 0.0022*
Tonnis	2.2 (±0.71)	2.3 (±0.61)	*p = 0.98 (Chi-Square)*
Osteophytes	2.3 (±0.58)	2.1 (±0.61)	*p = 0.095 (Chi-Square)*
Cross Over Sign	18% yes	24% yes	*p = 0.46 (z-ratio)*
Ischial Spine on AP	20%	20% yes	*p = 1.00*
Ilioischial – fossa	54% medial, 28% touching,	74% medial, 20% touching,	*p = 0.073 (Chi-Square)*
Tonnis Angle	4.95 (±4.78)	7.9 (±3.45)	*p < 0.001*
Sharp's Angle	33.81 (±5.23)	37.2 (±4.11)	*p = 0.0084*
CEA	45.78 (±12.00)	34.81 (±7.69)	*p < 0.001*
Congruency	36% (non)	34% (non)	*P = 0.834 (z-ratio)*
Femoral Head Extrusion	0.11 (±0.11)	0.18 (±0.10)	*P < 0.001*
AP Head-neck Offset	46.9 (±6.65)	47.7 (±5.66)	*P = 0.10*
COR-Troch (varus,	36% valgus	52% valgus	*P = 0.107 (z-ratio)*
Alpha Angle	46.2 (±8.90)	62.3 (±8.95)	*P < 0.001*
NSA	130.3 (±5.97)	134.3 (±4.22)	*P = 0.517*
Herniation Pits	20% yes	10% yes	*P = 0.162 (z-ratio)*
FROG LEG LATERAL			
Lateral Alpha Angle	47.8 (±12.78)	59.8 (±13.88)	*P < 0.001*
Lateral Head-neck offset	17.2 (±4.08)	13.1 (±3.62)	*P < 0.001*