Femoral Neck Anteversion and Lesser Trochanteric Retroversion in Patients With Ischiofemoral Impingement: A Case-Control Magnetic Resonance Imaging Study

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Purpose: To assess the relationship between the femoral neck version (FNV) and lesser trochanteric version (LTV) in symptomatic patients with ischiofemoral impingement (IFI) as compared with asymptomatic hips. Methods: The FNV and LTV of patients with symptomatic IFI who underwent magnetic resonance imaging assessment including a standardized femoral version study protocol were compared with those of patients with asymptomatic hips in this retrospective, observational study. Patients with isolated intra-articular pathology, prior hip fracture, and lesser trochanter deformity were excluded. The FNV, LTV, ischiofemoral space, and quadratus femoris space were evaluated on axial magnetic resonance imaging, as well as the angle between the LTV and the FNV. Independent t-tests were used to determine differences between groups. Results: Data from 11 out 15 symptomatic patients and 250 out of 320 asymptomatic patients were analyzed. The mean ischiofemoral space (11.9 ± 22.9 mm; P < .001; 95% confidence interval [CI], 6.9 to 15.2) and mean quadratus femoris space (7.2 mm ± 14.9 mm; P < .001; 95% CI, 5.4 to 8.6) were significantly smaller in symptomatic patients versus asymptomatic patients. There was no difference in mean LTV between groups (23.6° ± 24.2°; P = .8; 95% CI, −7.5 to 6.4), however, the mean FNV (21.7° ± 14.1°; P = .02; 95% CI, −14.2 to −1.1) and the angle between the FNV and LTV on average (45.4° ± 38.3°; P = .01; 95% CI, −12.9 to −1.3) were higher in symptomatic than in asymptomatic patients, with statistical significance. Conclusions: The femoral mean neck anteversion and the mean angle between the FNV and LTV are significantly higher in patients with symptomatic IFI. The mean LTV is not increased in patients with symptomatic ischiofemoral impingement as compared with those patients with asymptomatic hips. Level of Evidence: Level III, diagnostic study.

Ischiofemoral impingement (IFI) is a source of hip pain due to abnormal contact between the lateral aspect of the ischium and the lesser trochanter (LT) of the proximal femur. The narrowing of the ischiofemoral and the quadratus femoris spaces (QFS) has been implicated as a diagnostic feature of impingement. Torriani et al. defined the ischiofemoral space (IFS) on axial magnetic resonance imaging (MRI) as the smallest distance between the ischial tuberosity and the LT. The QFS functions as the passage of the quadratus femoris muscle and is defined as the space between the superolateral surface of the hamstring tendons and the posteromedial surface of the LT. Jonhson first described IFI in 2 patients after hip arthroplasty who were relieved of their pain by lesser trochanterplasty. The proximal femoral anatomy (or a prosthesis orientation), including the LT, could be directly related to the IFS; therefore any change in version (femoral neck or LT) could be a contributing factor to decreasing the space and producing impingement.

The purpose of this study was to assess the relationship between the femoral neck version (FNV) and lesser trochanteric retroversion in patients with ischiofemoral impingement.
trochanteric version (LTV) in symptomatic patients with IFI as compared with those with asymptomatic hips.

The hypothesis for the current study was that those with symptomatic IFI would demonstrate increased retroversion of the LT or increased anteverision of the femoral neck IFS.

Methods

Between January 2012 and January 2014, 1,112 consecutive charts of new patients complaining of hip pain were retrospectively reviewed to identify patients with symptomatic IFI. Asymptomatic hips were identified from a database between January 2006 and January 2010 from patients who underwent evaluation for contralateral hip pain and bilateral version study through a standardized MRI protocol. The number of asymptomatic cases was chosen based on the cases available with a bilateral version standardized study in patients with unilateral hip pain.

The inclusion criteria for the symptomatic group were (1) diagnosis of IFI, (2) records available for review and confirmation on physical examination, and (3) MRI available for review including standardized protocol with axial sequences of the pelvis and the distal femur with leg rotation control from the knee to the femoral neck by tapping the feet in functional walking position.

The inclusion criteria for the asymptomatic group were (1) physical examination for contralateral hip pain due to a variety of diagnoses not IFI and (2) MRI available for review of the asymptomatic side with axial sequences of the pelvis and the distal femur with leg rotation control from the knee to the femoral neck by tapping the feet in functional walking position.

The femoral version assessment is a routine measurement in the senior author's practice (H.D.M.). Complementary axial cuts at the level of the pelvis/hip and the distal femur are always performed to calculate the values accurately.

The exclusion criteria were (1) isolated intra-articular pathology (hip intra-articular hip pain confirmed by injection and negative history and tests for IFI), (2) prior hip fracture or surgery, (3) LT deformity, (4) bone or soft tissue tumor around the IFS, (5) low-quality or incomplete MRI, and (6) incomplete records for review.

The diagnosis of IFI was based on comprehensive history, physical examination, and imaging assessment. Intrarticular injection (steroid plus local anesthetic) under fluoroscopic visualization was also performed to rule out intra-articular problems as the main cause of posterior hip pain when the intra-articular examination was positive. Posterior hip pain was the chief complaint in all patients. A positive physical examination as defined by Hatem et al. was considered necessary for the detection of IFI.

All patients had an MRI, including the standardized protocol controlling rotation from the knee to the femoral neck by tapping the feet in functional walking position. The cutoff values of IFS and QFS considered for the diagnosis were 17 and 8 mm, respectively. The medical records of all patients meeting the inclusion and exclusion criteria were retrospectively reviewed under institutional approval.

Relevant demographic and clinical data, including age, gender, side, pain characteristics, IFI tests, duration of symptoms until diagnosis, and other associated hip conditions were noted for the symptomatic group. The age, gender, and side were noted for the asymptomatic group as well.

The MRI measurements were obtained through the software Virtual Radiology Enterprise Connect PACS (Philips Healthcare Informatics, The Netherlands). The axial cuts of the pelvis and knee were used in this study for the evaluation of the angles. Five parameters were assessed: IFS (mm), QFS (mm), FNVLTV angle (°), LTV (°), and FNVVT angle (°).

The IFS and QFS were measured according to the method described by Torriani et al. (Fig 1). IFS was considered as the smallest distance between the lateral cortex of the ischial tuberosity and medial cortex of the LT; and QFS was considered as the smallest space for passage of the quadratus femoris muscle defined by the superolateral surface of the hamstring tendons and the posteromedial surface of the iliopsoas tendon or LT.

The angles were measured using a method based on studies performed by Unlu et al. and Shon et al. The method was developed by our research group.

![Fig 1. Quadratus femoris space (QFS) (a) and ischiofemoral space (IFS) (b) on an axial MRI of the left hip, T1 sequence. IFS was considered as the smallest distance between the lateral cortex of the ischial tuberosity and medial cortex of the lesser trochanter. QFS was considered as the smallest space for passage of the quadratus femoris muscle delimited by the superolateral surface of the hamstring tendons and the posteromedial surface of the iliopsoas tendon or lesser trochanter. (IT, ischial tuberosity; LT, lesser trochanter.)](image-url)
A preview analysis of the first 30 measurements in asymptomatic hips was made by Interclass Correlation Coefficient (ICCs), with a 95% confidence interval (CI) for inter- and intraexaminer. The ICCs for all measurements by examiner number 1 ranged from .896 to .923. The ICCs for all measurements by examiner number 2 ranged from .788 to .952. The ICCs for both examiners together ranged from .826 to .906.

The measurement process of the method was as follows: (1) Two centroids were positioned in the body of FN or LT, one in the midline of the basis and a second one at the border of the tip as seen in Figure 2A and B. (2) The angle of the line passing between the middle of both centroids and horizontal line was called the femoral neck axis—FNA, or lesser trochanter axis—LTA. (3) The posterior condylar axis (KA) of the ipsilateral knee was used as a reference. When the knee was in external rotation, the angle was considered negative, and positive when the knee was in internal rotation. Formula: \( FNV = FNA - KA; LTV = LTA - KA \). (FNA, femoral neck angle; FNV, femoral neck version; KA, knee angle; LTA, lesser trochanteric angle; LTV, lesser trochanteric version.)

Additionally, the angle between the FNV and LTV was calculated through the formula \( \text{FNVLTV angle} = \text{FNV} + \text{LTV} \) (Fig 3).

The mean, maximum and minimum values, and standard deviations were calculated. Independent Student’s \( t \)-tests with 95% CIs were used to determine differences between groups. An a priori power analysis with a medium to large effect size \((d = 0.6 \text{ and } 0.8)\) with 80% power and alpha = 0.05 was performed. Post hoc power analyses were run for the significantly different variables.

Results

Eleven of 15 patients with symptomatic IFI and 250 of 320 patients with asymptomatic hips met the inclusion criteria (Fig 4). The mean age of the symptomatic group was 40 years (range, 17 to 60 years) at the time of diagnosis. Nine patients were female (81.8%), and the left side was the most commonly affected (6 cases, 54.5%). All 11 patients complained of posterior hip pain reproduced by palpation of the ischial tuberosity, limitation of physical activities, pain with long stride gait, and pain to sit. Moreover, all patients had pain with long stride gait and positive IFI test (reproduction of pain during passive extension with the hip adducted or in neutral position, while passive extension with hip
abduction did not reproduce the symptoms). Other clinical characteristics and associated problems are shown in Table 1.

The mean age of the asymptomatic group was 39.48 years (range, 14 to 73 years) at the time of diagnosis. One hundred sixty-four patients were female (65.6%), and the right side was the most commonly assessed (140 cases, 56%).

The mean IFS (11.9 v 22.9 mm; \(P < 0.001; 95\% \text{CI}, 6.9 \text{to} 8.6\)) were significantly smaller in symptomatic patients versus in asymptomatic patients. There was no difference in the mean of the LTV between groups (\(\sim 23.6^\circ \text{v} 24.2^\circ; \ P = 0.8; 95\% \text{CI}, 7.5 \text{to} 6.4\)), however, the mean of FNV (21.7 v 14.1; \(P = 0.02; 95\% \text{CI}, 14.2 \text{to} 1.1\)) and the FNVLTV angle (45.4 v 38.3; \(P = 0.01, 95\% \text{CI}; 12.9 \text{to} 1.3\)) were higher in symptomatic than in asymptomatic patients, with statistical significance.

Post hoc power analyses run for the significantly different variables were IFS (100%), QFS (100%), FNV (67%), and FNVLTV angle (87.5%) (Table 2).

**Discussion**

The current study suggests that the FNV and the angle between the FNV and the LTV (FNVLTV angle) are significantly increased in patients with symptomatic IFI. In addition, the LTV does not correlate with the presentation of symptomatic IFI.

Although chronic avulsion injury of the hamstrings and multiple hereditary exostoses have been reported as a probable cause of symptomatic IFI, an anatomical abnormality is not present in all cases. Ali et al. performed a study including 16 hips in 13 patients with MRI signs of IFI. They identified quadratus femoris edema or decreased IFS as anatomical abnormalities, but in 5 patients the symptoms were not anatomically related to those abnormalities. In the current study, a decreased IFS was considered as a diagnostic criterion. However, the cause of symptomatic IFI (and decreased IFS) in patients without local anatomic abnormalities is still controversial. Since some investigators have reported satisfactory results with open resection or distal advancement of the LT, the relationship between the version of the proximal femur and the narrowing of the IFS needs further clarification.

Unlu et al. reported a mean LT retroversion of 34.1\(^\circ\) ± 3.0\(^\circ\) at computed tomography of 59 hips, concluding that there is a constant relationship between the LT and posterior femoral condyles. The LTV on average was less than that in the report by Unlu et al. with a significant variability (\(\sim 24^\circ\), range 17 to 54) and no statistical differences between the symptomatic IFI and asymptomatic hips. The difference between the LTV average in asymptomatic hips between the current study and the results reported by Unlu et al. could be due to the measurement method. Unlu et al. used a centroid at the LT to define the center axis, which can contribute to a greater intra- and interobserver variability. In the current study, 2 centroids were used to calculate the LT axis in both groups, a method that proved to be accurate and reliable.

**Table 1. Clinical and Demographic Data and Other Associated Conditions in Symptomatic Patients**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age, Years</th>
<th>Gender</th>
<th>Side</th>
<th>Duration of Symptoms, Months</th>
<th>VAS at Rest</th>
<th>VAS With Activity</th>
<th>Modified Harris Hip Score</th>
<th>Other Associated Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41</td>
<td>Female</td>
<td>Right</td>
<td>108</td>
<td>7</td>
<td>8</td>
<td>58.3</td>
<td>Cam-type FAI</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>Female</td>
<td>Left</td>
<td>48</td>
<td>6</td>
<td>8</td>
<td>50.6</td>
<td>Intrapelvic sciatic entrapment</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>Female</td>
<td>Right</td>
<td>24</td>
<td>3</td>
<td>10</td>
<td>68.2</td>
<td>Cam-type FAI, hiperlaxity</td>
</tr>
<tr>
<td>4</td>
<td>60</td>
<td>Female</td>
<td>Right</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td>72.6</td>
<td>Subspinus impingement, labral tear</td>
</tr>
<tr>
<td>5</td>
<td>47</td>
<td>Female</td>
<td>Right</td>
<td>24</td>
<td>3</td>
<td>8</td>
<td>57.7</td>
<td>Pubenal nerve entrapment</td>
</tr>
<tr>
<td>6</td>
<td>45</td>
<td>Female</td>
<td>Left</td>
<td>66</td>
<td>6</td>
<td>8</td>
<td>48.4</td>
<td>Labral tear</td>
</tr>
<tr>
<td>7</td>
<td>27</td>
<td>Male</td>
<td>Left</td>
<td>60</td>
<td>5</td>
<td>8</td>
<td>73.7</td>
<td>Mild anteroinferior instability</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>Female</td>
<td>Right</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>60.5</td>
<td>Labral tear</td>
</tr>
<tr>
<td>9</td>
<td>59</td>
<td>Male</td>
<td>Left</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>34.1</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>46</td>
<td>Female</td>
<td>Left</td>
<td>48</td>
<td>8</td>
<td>10</td>
<td>68.2</td>
<td>Partial hamstring tear</td>
</tr>
<tr>
<td>11</td>
<td>44</td>
<td>Female</td>
<td>Right</td>
<td>18</td>
<td>1</td>
<td>1</td>
<td>95.7</td>
<td>None</td>
</tr>
</tbody>
</table>

FAI, femoroacetabular impingement; VAS, visual analog scale.
<p>Considering that the LTV was not statistically different between groups, the increased FNVLTV angle in symptomatic IFI is secondary to the increased FNV. The increased FNV has been associated with a variety of lower extremity problems in newborns, children, and adults, however, to our knowledge there are no reports to date showing the relationship between FNV and IFI. All the symptomatic patients had pain with long stride gait. This symptom could explain the implication of our findings, since the observation of increased FNV can create reproducible pain in gait assessment during terminal hip extension.16</p>

The IFI should be understood as a gait-related dynamic area with several contributing factors and treatment possibilities depending on each case. As an example, one of the patients reported by Alı et al.12 had an abnormal gait as the underlying cause of ischiofemoral narrowing. The gait abnormality in this 48-year-old woman resulted from abductor dysfunction, thereby putting the quadratus femoris at risk of impingement because of the resultant adduction during gait. In this case, physical therapy could improve the symptoms by improving the abductor dysfunction.

An important contribution of the present study was the failure to prove the hypothesis that the increased LT retroversion is related to symptomatic IFI. Furthermore, to prove the increased FNVLTV angle and FNV in symptomatic IFI is just a step to direct further assessment.

Studying the IFI in a dynamic fashion allows new possible contributing factors. For instance, in this study most of the symptomatic patients were female (81.8%), comparable with other reported data.3,17,18 Women frequently demonstrate postures that contribute to dynamic knee valgus more than men, and this is one of the reasons for narrower IFI, mainly owing to a greater Q angle, with differences range from 2.7° to 5.8°.13 This anatomic variation could allow an approximation between the femur and the ischial tuberosity (relative adduction). Furthermore, other variations reported in female patients, like wider ischial tuberosity and lesser neck shaft angle, could affect the incidence of IFI.20<br/></p>

Recently, Siebenrock et al.21 found a higher prevalence of extra-articular impingement for valgus hips with increased anteversion. This finding goes in the same direction of the results of the current study because the increased femoral version can change the spatial relationship of the bony structures around the hip during motion, producing extra-articular impingement. To date, the IFI has been understood mainly as a regional anatomic problem around the IFS; however, the symptomatic IFI should be addressed as a dynamic problem related to gait, alignment, muscular balance, and rotational deformities. A complete history and physical exam as well as a complete imaging evaluation to diagnose IFI should be performed, as pathologies other than IFI can cause posterior pain. For instance, 2 cases in the current study presented pudendal and sciatic nerve entrapment; however, all the imaging and clinical criteria for associated IFI were registered.

In patients without a clear anatomic cause of symptomatic IFI, the role of the kinematic chain as an important factor in the pathophysiology of the problem could be an interesting field for further study, including alignment analysis of the entire leg and associated kinematic studies.

### Limitations

A number of limitations in this study should be considered. First, we did not include measurements of the femoral neck shaft angle because we had no information about the MRI’s coronal sequences and anteroposterior X-rays standardization for obtaining an accurate and reproducible measurement. Second, the sample sizes between groups were uneven and the symptomatic group was small. An a priori analysis revealed that 52 to 90 total subjects were needed, with 26 to 45 subjects per group. Post hoc power analyses were found to be high; however, the uneven groups and low symptomatic sample may contribute to the lack of significant findings in LTV.

Third, we did not match the groups by gender, age, or hip side. Fourth, although all the cases met the clinical

### Table 2. Comparison Between the Patients With Symptomatic Ischiofemoral Impingement and Asymptomatic Hips</p>

<table>
<thead>
<tr>
<th>Measure</th>
<th>Symptomatic (n = 11)</th>
<th>Asymptomatic (n = 250)</th>
<th>P Value</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischiofemoral space, mm</td>
<td>11.9 ± 3.5</td>
<td>22.9 ± 6.9</td>
<td>&lt;.001</td>
<td>6.9</td>
<td>15.2</td>
</tr>
<tr>
<td>Quadratus femoris space, mm</td>
<td>7.2 ± 2.3</td>
<td>14.2 ± 4.9</td>
<td>&lt;.001</td>
<td>5.4</td>
<td>8.6</td>
</tr>
<tr>
<td>FNV (°)</td>
<td>21.7 ± 10.4</td>
<td>14.1 ± 10.8</td>
<td>.02</td>
<td>−14.2</td>
<td>−1.1</td>
</tr>
<tr>
<td>LTV (°)</td>
<td>−23.6 ± 11.4</td>
<td>−24.2 ± 11.5</td>
<td>.8</td>
<td>−7.5</td>
<td>6.4</td>
</tr>
<tr>
<td>FNVLTV angle (°)</td>
<td>45.4 ± 7.3</td>
<td>38.3 ± 9.6</td>
<td>.01</td>
<td>−12.9</td>
<td>−1.3</td>
</tr>
</tbody>
</table>

FNV, femoral neck version; FNVLTV angle, angle between the LTV and FNV; LTV, lesser trochanter version; SD, standard deviation.
and imaging criteria for IFI, neither surgical nor long-term follow-up confirmations were included in the current study. And finally, we did not include alignment studies of the entire extremity or lab gait analysis, which are very important to diagnose other contributing factors related to symptomatic IFI.

Conclusions
The mean femoral neck anteversion and the mean angle between the FNV and LTV are significantly higher in patients with symptomatic IFI. The mean LTV is not increased in patients with symptomatic IFI as compared with patients with asymptomatic hips.

References