Accuracy of 2 Clinical Tests for Ischiofemoral Impingement in Patients With Posterior Hip Pain and Endoscopically Confirmed Diagnosis
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Purpose: To establish the accuracy of the long-stride walking (LSW) and ischiofemoral impingement (IFI) tests for diagnosing IFI in patients whose primary symptom is posterior hip pain. Methods: Confirmed IFI cases and cases in which IFI had been ruled out were identified considering imaging, injections, and endoscopic assessment, combined with pain relief and negative IFI-specific tests after treatment. Demographic data, duration of symptoms, pain location, ischiofemoral space, quadratus femoris space, quadratus femoris edema, surgical findings, and visual analog scale score for pain before and after treatment were computed for all patients included in this study. Sensitivity, specificity, predictive values, likelihood ratios, and diagnostic odds ratios were computed individually for the LSW test and IFI test. Results: Cases from 1,166 consecutive hip operations and charts from 564 consecutive outpatients were retrospectively reviewed to identify patients who underwent injection and/or endoscopic surgery because of posterior hip pain. Thirty individuals (21 women and 9 men) with a mean age of 49.8 years (range, 20 to 76 years; standard deviation, 13.0 years) were included for analysis. Of the 30 patients, 17 (56.6%) were confirmed as positive for IFI and 13 (43.4%) were confirmed as negative for IFI. The IFI test had a sensitivity of 0.82, specificity of 0.85, positive predictive value of 0.88, negative predictive value of 0.79, positive likelihood ratio of 5.35, negative likelihood ratio of 0.21, and diagnostic odds ratio of 25.6. The LSW test had a sensitivity of 0.94, specificity of 0.85, positive predictive value of 0.92, negative likelihood ratio of 0.92, positive likelihood ratio of 6.12, negative likelihood ratio of 0.07, and diagnostic odds ratio of 88.8. Conclusions: In patients with complaints of posterior hip pain and negative evaluation findings for lumbosacral spine involvement or static/dynamic mechanical axis malalignment, the IFI and LSW tests are highly accurate to help identify those with or without IFI. Level of Evidence: Level III, diagnostic study.

See commentary on page 1285

There have been many publications recently on the evaluation and treatment of patients with anterior and lateral hip pain; however, posterior hip pain remains a challenge for clinicians and orthopaedic surgeons. In 1977 ischiofemoral impingement (IFI) was first described by Johnson\(^1\) as a potential cause of posterior hip pain. Reports on surgical intervention for IFI have been published.\(^1-4\) However, there is little information on how to accurately identify individuals with IFI, particularly using clinical examination findings.

Torriani et al.\(^5\) have provided a description and definition of the normal ischiofemoral space (IFS) and quadratus femoris space (QFS) on magnetic resonance imaging (MRI). Although the focus of their description of IFI was the imaging parameters, a comprehensive physical examination of the entire static and dynamic mechanical axis of the hip remains the most important and recommended tool to identify patients with IFI as a cause of posterior hip pain.\(^6,7\)

The original description of IFI proposed that the pain could be reproduced by having the hip in extension, adduction, and external rotation; however, there are no
published. Presurgical imaging evaluation and trochanteroplasty, ischioplasty, or both have been published. Presurgical imaging evaluation and clinical follow-up after surgical decompression of the IFS can identify IFI as a confirmed cause of posterior hip pain; consequently, a new perspective on the diagnostic accuracy of clinical tests used in the examination of IFI can be determined.

The purpose of this study was to establish the accuracy of the long-stride walking (LSW) and IFI tests for diagnosing IFI in patients whose primary symptom is posterior hip pain. We hypothesized that the IFI-specific tests did accurately predict the presence or absence of IFI before imaging evaluation and surgical exploration.

**Methods**

**Patients**

Between January 2011 and February 2015, consecutive hip operations were retrospectively reviewed to identify patients with surgically confirmed IFI. Confirmed IFI was defined as a patient with posterior hip pain as the main complaint and abnormal MRI or computed tomography (CT) scan imaging findings (abnormal IFS, QFS, and quadratus femoris [QF] muscle edema), combined with at least 60% pain relief (using a visual analog scale [VAS]) after full-endoscopic or endoscopic-assisted IFS decompression and negative IFI tests at postoperative follow-up. The IFI tests are part of the assessment of the static and dynamic mechanical axis for the differential diagnosis of other conditions that limit hip extension. Conditions with a static mechanical axis include decreased femoral anteversion greater than −5°, increased femoral anteversion greater than 30°, genu valgum, severe pronation of the hindfoot, severe coxa profunda, and severe coxa valga greater than 150°. Conditions with a dynamic mechanical axis include hip abductor dysfunction.

Cases with posterior hip pain as a major complaint and ruled-out IFI were retrospectively identified from consecutive outpatients between January 2014 and February 2015. A ruled-out IFI case was defined as a case with a normal imaging appearance of the IFS, QFS, and QF muscle combined with at least 60% pain relief (using a VAS) after injection and/or surgery for treatment of a diagnosis other than IFI. Patients were excluded when they had positive clinical or imaging findings for lumbar pathology (physical examination, lumbar spine radiographs, lumbar spine MRI, previous spine surgery), when simultaneous surgical treatment for posterior hip pathology other than IFI was performed, or when patients underwent previous operations involving the ipsilateral ischium or lesser trochanter (LT).

**Imaging Evaluation**

MRI including a T2 axial sequence or an axial CT scan (in 2 cases with previous total hip replacement) was used for measuring the IFS and QFS in all included patients. A protocol was always followed to assess the IFS in a standardized manner by taping the feet in a functional walking position. A decreased IFS was considered imaging evidence of IFI or QFS narrowing with indirect signs of impingement (e.g., QF muscle edema or atrophy) according to the description by Torriani et al. QF muscle edema was classified as grade 1 (mild), 2 (moderate), or 3 (severe) according to the description proposed by Tosun et al.

The IFS and QFS were measured (in millimeters) on the T2 axial MRI or axial CT scan. The IFS was considered the smallest distance for passage of the QF muscle defined by the superolateral surface of the hamstring tendons and the posteromedial surface of the iliopsoas tendon or LT (normal, >17 mm), and the QFS was considered the smallest space for passage of the LT /C14. Before imaging evaluation, guided injections, or endoscopic exploration, all patients underwent systematic history taking and physical examinations that included the LSW test and IFI test.

**LSW Test**

The LSW test is expected to provoke impingement between the LT and ischium in terminal hip extension when the patient walks. The findings of this test are considered positive if the posterior pain is reproducible lateral to the ischium during extension with long strides whereas pain is alleviated when walking with short strides (Fig 1).

**IFI Test**

The IFI test is performed with the patient in a lateral position. The examiner passively takes the patient’s hip into extension. The IFI test is intended to provoke impingement in extension with a neutral or adducted hip (re-creating the posterior pain lateral to the ischium) and relieves the impingement pain in extension with an abducted hip (Fig 2). The results of each of the aforementioned tests were recorded for all patients and used for statistical analysis.

**Statistical Analysis**

The SPSS statistical software package (version 22.0; IBM, Armonk, NY) was used to perform statistical analysis. Descriptive statistics including age, gender, side, body mass index (BMI), duration of symptoms,
pain location, IFS, QFS, QF edema, surgical findings, and VAS score for pain before and after treatment were computed for all patients included in this study. Independent Student t tests were used to compare differences between groups. Sensitivity, specificity, predictive values, likelihood ratios, and diagnostic odds ratios were computed individually for the LSW test and IFI test.

Results
Cases from 1,166 consecutive hip operations and charts from 564 consecutive outpatients were retrospectively reviewed to identify patients who underwent injection and/or endoscopic surgery because of posterior hip pain. Thirty patients met the inclusion criteria. These patients had a mean age of 49.8 years (range, 20 to 76 years; standard deviation [SD], 13.0 years); women were more commonly affected (21 patients, 70%); the mean BMI was 25 (range, 17.2 to 33.6; SD, 4.9); the left side was more commonly affected (20 patients, 66.6%); and the mean duration of symptoms was 39.4 months (range, 3 to 120 months; SD, 39.1 months).

Of the 30 patients, 17 (56.6%) were confirmed to have IFI and 13 (43.4%) were ruled out for IFI. No significant differences were found for age, height, weight, BMI, or duration of symptoms. Table 1 shows a
complete description of demographic and clinical data for all patients and for each group. A number of diagnoses other than IFI were confirmed through pain relief after injection and/or surgery, as shown in Table 2.

The mean IFS and QFS were 11.2 mm (range, 2.3 to 16.3 mm; SD, 3.7 mm) and 6.4 mm (range, 4.2 to 11.3 mm; SD, 2.2 mm), respectively, in group 1 versus 25.3 mm (range, 17.2 to 37.4 mm; SD, 7.6 mm) and 16.3 mm (range, 9.5 to 29.1 mm; SD, 6.6 mm), respectively, in group 2. Statistically significant differences were found for the IFS and QFS between groups (P < .01).

Mild (grade 1), moderate (grade 2), and severe (grade 3) QF muscle edema was present in 8 of 17 confirmed IFI cases (47%), 4 of 17 confirmed IFI cases (24.5%), and 3 of 17 confirmed IFI cases (17.7%), respectively. Because CT scans were used in 2 of 17 cases (11.8%)—the 2 patients with previous total ipsilateral hip replacement—QF muscle edema was not reported for these patients. No cases of QF muscle edema in patients with a diagnosis other than IFI were observed.

Postoperative and/or post-injection assessment was completed at an average of 13.3 months (range, 0.7 to 44.6 months; SD, 14.3 months). For confirmed IFI cases and ruled-out cases, the mean preoperative VAS pain scores were 7.6 (SD, 1.8) and 7.5 (SD, 1.4), respectively, versus mean postoperative VAS pain scores of 1.2 (SD, 1.3) and 1.2 (SD, 1.6), respectively (P < .01).

The most common endoscopic findings for confirmed IFI cases were QF muscle edema and/or atrophy (100%), posterior cortical sclerosis of the LT (82%), and a square shape or large size of the LT (17%). The latter (size/shape) parameter was noted by the surgeon, but no method for evaluating this aspect accurately was conducted.

The presurgical clinical examination found that the IFI test was positive in 14 of 17 patients (82%), the LSW test was positive in 16 of 17 patients (94%), and either a positive IFI test or a positive LSW test was present in 17 of 17 patients with confirmed and treated IFI (100%). The LSW test showed a sensitivity of 94%, specificity of 85%, positive predictive value of 89%, and negative predictive value of 92%. Similarly, the IFI test showed a sensitivity of 82%, specificity of 85%, positive predictive value of 88%, and negative predictive value of 79%. When combined, the IFI and LSW tests showed a good diagnostic yield (Table 3). Table 3 shows the sensitivity, specificity, predictive values, likelihood ratios, and diagnostic odds ratio for the individual IFI-specific tests and combination of IFI-specific tests in detecting IFI.

**Discussion**

The most important finding of this study was that the IFI test and LSW test proved to be valuable tests in diagnosing patients with IFI. Each test showed good sensitivity (≥82%) and specificity (85%) for detecting IFI, and the presence of either a positive IFI test or a positive LSW test confirmed IFI in most of the cases. By contrast, negative tests indicated no impingement with a high degree of accuracy, as observed in Table 3. This study confirms the hypothesis that the IFI-specific tests do accurately predict the presence or absence of IFI before imaging evaluation and surgical exploration.

Although the IFI test proved to be useful, the LSW test was the single best test for diagnosing IFI. Accuracy values for the LSW test showed that only 1 of 10 patients with a negative test had IFI whereas 9 of 10 patients with a positive test were noted to have IFI. The odds of a false positive for this test was 1 out of 88 cases. The ability to accurately diagnose IFI improved considerably when the results of the LSW test and IFI test were combined. The IFI test and LSW test are similar in that both target the musculoskeletal structures in the IFS to elicit symptoms. The IFI test is performed in a passive manner, whereas the LSW test is performed in an active manner. The inherent differences in the tests may explain the difference found in

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**Table 1. Patient Demographic and Clinical Characteristics (N = 30)**

<table>
<thead>
<tr>
<th></th>
<th>All Patients (N = 30)</th>
<th>Confirmed IFI Cases (n = 17)</th>
<th>Ruled-Out IFI Cases (n = 13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, yr</td>
<td>49.8 (SD, 13.0)</td>
<td>46.7 (SD, 13.7)</td>
<td>53.7 (SD, 11.2); P = .147</td>
</tr>
<tr>
<td>Mean height, in</td>
<td>67.2 (SD, 3.5)</td>
<td>66.4 (SD, 3.3)</td>
<td>67.9 (SD, 3.6); P = .294</td>
</tr>
<tr>
<td>Mean weight, lb</td>
<td>161.9 (SD, 37.2)</td>
<td>150.5 (SD, 27.6)</td>
<td>172.3 (SD, 42.7); P = .147</td>
</tr>
<tr>
<td>Mean BMI</td>
<td>25.0 (SD, 4.9)</td>
<td>24.1 (SD, 4.8)</td>
<td>25.9 (SD, 4.9); P = .350</td>
</tr>
<tr>
<td>Female, n</td>
<td>21 (70%)</td>
<td>14 (82%)</td>
<td>7 (53%)</td>
</tr>
<tr>
<td>Mean duration of symptoms, mo</td>
<td>39.4 (SD, 39.1)</td>
<td>30.0 (SD, 30.5)</td>
<td>51.8 (SD, 46.6); P = .133</td>
</tr>
<tr>
<td>Posterior hip pain, n</td>
<td>30 (100%)</td>
<td>17 (100%)</td>
<td>13 (100%)</td>
</tr>
<tr>
<td>Increased pain with activity, n</td>
<td>28 (93.3%)</td>
<td>15 (88.2%)</td>
<td>13 (100%)</td>
</tr>
<tr>
<td>Decreased pain at rest, n</td>
<td>26 (86.6%)</td>
<td>15 (88.2%)</td>
<td>11 (84.6%)</td>
</tr>
<tr>
<td>Pain with sitting, n</td>
<td>26 (86.6%)</td>
<td>15 (88.2%)</td>
<td>11 (84.6%)</td>
</tr>
<tr>
<td>Pain with IFS palpation, n</td>
<td>10 (33%)</td>
<td>6 (35.2%)</td>
<td>4 (30.7%)</td>
</tr>
<tr>
<td>Anterior/groin pain, n</td>
<td>8 (26.6%)</td>
<td>6 (35.2%)</td>
<td>2 (15.3%)</td>
</tr>
<tr>
<td>Lateral hip pain, n</td>
<td>7 (23.3%)</td>
<td>4 (23.5%)</td>
<td>3 (23%)</td>
</tr>
<tr>
<td>Radiating pain, n</td>
<td>6 (20%)</td>
<td>2 (11.7%)</td>
<td>4 (30%)</td>
</tr>
</tbody>
</table>

BMI, body mass index; IFI, ischiolomeral impingement; IFS, ischiolomeral space; SD, standard deviation.
diagnostic accuracy. External foot progression during gait may result in a more decreased IFS, as shown by Finnoff et al.\textsuperscript{14} using ultrasonography in 10 healthy individuals during dynamic assessment of the hip joint. They found a statistically significant difference in IFS measurements according to hip position in the frontal and transverse planes. The IFS was reported to be smaller in adduction and external rotation compared with abduction and internal rotation (mean difference, 21.1 mm; 95\% confidence interval, 13.7 to 28.5 mm).

Since IFI was first described in 1977,\textsuperscript{1} there has been nothing published on the accuracy of clinical examination in identifying patients with IFI. Few case reports and series have anecdotally described clinical findings in patients with IFI.\textsuperscript{1-4} Recently, a report of 5 patients described the IFI test and LSW test as specific standardized tests for suspected IFI.\textsuperscript{6}

Diagnosis of IFI is currently dependent on the MRI findings because of the strong correlation between narrowed IFS, QFS, and QF muscle abnormalities and ipsilateral hip pain.\textsuperscript{15} However, studies reporting normal IFS and QFS in patients with IFI,\textsuperscript{16} as well as observations of narrowed IFS and QFS in asymptomatic hips,\textsuperscript{1} question the absolute utility of the current MRI criteria for IFI.

Sussman et al.\textsuperscript{18} recently performed a cadaveric study in 29 hips. They found that abnormalities of the QF muscle were associated with a greater approximation between the lateral ischium and the LT when moving the hip from a neutral to extended position, as intended with the IFI and LSW tests described in our study. According to these findings, a repetitive hip extension during walking could lead to a chronic rubbing mechanism between the LT and the lateral ischium, thus producing inflammation and pain in the structures between them.\textsuperscript{7}

Martin et al.\textsuperscript{19} reported that contact between the LT and ischium occurred in 84\% of cadavers when the hip was externally rotated in 10° of extension and 10° of adduction. When the hip is in a neutral position, the distance between the LT and ischium will change depending on the amount of hip rotation. The LT can come into contact with the ischium in 10° of extension and 10° of adduction when the hip is externally rotated and may create impingement that may lead to pathology of the QF muscle and/or sciatic nerve entrapment. A large variation in the position of external rotation to elicit a positive IFI test was noted as well.

In our study a minor proportion of cases (11.7\%) had radiating pain down the ipsilateral leg; however, the proportion of patients with radiating pain is smaller than that in previous reports (33.3\%).\textsuperscript{20} This difference could be explained by the exclusion of patients with concomitant sciatic nerve entrapment and IFI in order to explain that the pain relief was specifically due to IFS decompression.

The complex biomechanics of human gait requires a balanced interaction among bony structures, neuromuscular activity, and range of motion. The entire static and dynamic mechanical axis should be evaluated with radiographic and physical examinations to rule out other conditions that limit hip extension. An alteration in any of these aspects could produce kinematic chain disturbances both cephalic and caudal to the affected joint.\textsuperscript{21} The optimal treatment of IFI requires a thorough understanding of the cause. A comprehensive history and physical examination with a multilevel assessment (bone, capsulolabral, musculotendinous, neurovascular, and kinematic chain) and IFI-specific tests allow for appropriate treatment recommendations that could include only conservative measures (e.g., abductor weakness producing ipsilateral IFS narrowing treated with physical therapy or a hyperpronated foot treated with an orthosis). Studies

### Table 2. Alternative Diagnoses Confirmed by Outcomes After Injection and/or Surgery in Ruled-Out Ischiofemoral Impingement Cases (n = 13)

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep gluteal syndrome/sciatic nerve entrapment</td>
<td>4 (30)</td>
</tr>
<tr>
<td>Sacroiliac joint pain/dysfunction</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Greater trochanteric bursitis</td>
<td>3 (23)</td>
</tr>
<tr>
<td>Pudendal nerve entrapment</td>
<td>2 (15)</td>
</tr>
<tr>
<td>Chronic avulsion of hamstring origin</td>
<td>2 (15)</td>
</tr>
</tbody>
</table>

*At the level of the piriformis muscle.

\textsuperscript{1}One of the patients with this diagnosis had concomitant sciatic nerve entrapment.

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### Table 3. Diagnostic Properties of Clinical Examination Test for Ischiofemoral Impingement

<table>
<thead>
<tr>
<th></th>
<th>IFI Test</th>
<th>LSW Test</th>
<th>IFI or LSW Test</th>
<th>Both Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity (95% CI)</td>
<td>0.46 (0.95-0.95)</td>
<td>0.67 (0.69-0.99)</td>
<td>1.00 (0.77-1.00)</td>
<td>0.76 (0.50-0.93)</td>
</tr>
<tr>
<td>Specificity (95% CI)</td>
<td>0.85 (0.54-0.97)</td>
<td>0.85 (0.64-0.98)</td>
<td>0.77 (0.46-0.94)</td>
<td>0.85 (0.54-0.98)</td>
</tr>
<tr>
<td>PPV (95% CI)</td>
<td>0.88 (0.60-0.98)</td>
<td>0.89 (0.64-0.98)</td>
<td>0.85 (0.61-0.96)</td>
<td>0.87 (0.60-0.98)</td>
</tr>
<tr>
<td>NPV (95% CI)</td>
<td>0.79 (0.49-0.94)</td>
<td>0.92 (0.66-0.99)</td>
<td>1.00 (0.66-1.00)</td>
<td>0.73 (0.45-0.92)</td>
</tr>
<tr>
<td>Positive LR (95% CI)</td>
<td>5.85 (1.47-19.52)</td>
<td>6.12 (1.70-22.01)</td>
<td>4.33 (1.61-11.69)</td>
<td>4.97 (1.35-18.27)</td>
</tr>
<tr>
<td>Negative LR (95% CI)</td>
<td>0.21 (0.07-0.60)</td>
<td>0.07 (0.01-0.48)</td>
<td>NA</td>
<td>0.28 (0.11-0.68)</td>
</tr>
<tr>
<td>Diagnostic OR (95% CI)</td>
<td>25.6 (3.63-181.44)</td>
<td>88.8 (7.08-1,094.01)</td>
<td>NA</td>
<td>17.9 (2.7-116.9)</td>
</tr>
</tbody>
</table>

\textsuperscript{CI, confidence interval; IFI, ischiofemoral impingement; LR, likelihood ratio; LSW, long-stride walking; NA, not applicable; NPV, negative predictive value; OR, odds ratio; PPV, positive predictive value.}

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showing decreased IFS in adduction of the hip and/or gait disturbances support this theory.14,20

The high sensitivity, specificity, and predictive values of the LSW and IFI tests will help clinicians and surgeons improve the differential diagnosis of IFI in patients with posterior hip pain. Positive IFI-specific tests could be used for surgical decompression considerations in patients with MRI evidence of IFI and failed nonoperative measures.

Limitations
The limitations to this study should be considered when interpreting the findings. Although a systematic physical examination and standardized imaging protocols were performed, interobserver reliability was not determined. Further prospective studies assessing reliability are necessary. Another limitation is that the diagnostic properties of the tests for IFI were determined from a retrospective review of a selected group of patients recruited from a single surgeon. Test accuracy is dependent on the prevalence of the disease in the studied population. Because this study was retrospectively performed and all included cases were confirmed to have IFI or ruled out for IFI according to the results of an intervention, IFI cases that did not undergo injection or surgery may have been missed.

Conclusions
In patients with complaints of posterior hip pain and negative evaluation findings for lumbar sacral spine involvement or static/dynamic mechanical axis malalignment, the IFI and LSW tests are highly accurate to help identify those with or without IFI.

References