Increased Accuracy of Varus Stress Radiographs Versus Magnetic Resonance Imaging in Diagnosing Fibular Collateral Ligament Grade III Tears

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Purpose: To evaluate the diagnostic accuracy of magnetic resonance imaging and varus stress radiographs for fibular collateral ligament (FCL) tears, and compare these modalities to intraoperative findings. **Methods:** All patients who underwent an isolated FCL or combined anterior cruciate ligament (ACL)/FCL reconstruction by a single surgeon between 2010 and 2017 with preoperative varus stress radiographs and magnetic resonance imaging (MRI) were included in this study. A control group was composed of patients with an MRI and intact ACL and FCL. Sensitivity and specificity of diagnosing FCL injuries on MRI were determined based on review by a fellowship-trained musculoskeletal radiologist, blinded to the pathology associated with each patient (FCL injury vs control), and compared with the gold standard of examination under anesthesia, followed by surgical confirmation of an FCL tear at the time of FCL reconstruction. The sensitivity of diagnosing an FCL injury based on varus stress radiographs was also determined. Furthermore, the ability of both imaging modalities to identify an FCL injury was stratified based on acute versus chronic etiology. **Results:** A total of 232 patients were included: 98 patients in the FCL tear group (mean age: 33.6 ± 12.2 years) and 134 patients in the control group (mean age: 44.0 ± 17.2 years). Varus stress radiographs were determined to be more sensitive in diagnosing FCL injuries compared with MRI, with an overall sensitivity of 70% compared with 66%, respectively. Based on MRI, overall specificity was 68%. Based on chronicity of the injuries, MRI was more accurate for detecting acute FCL injuries than chronic injuries ($P = .002$), and varus stress radiographs were more accurate for detecting chronic FCL injuries than acute injuries ($P = .041$). **Conclusions:** The results support the use of both varus stress radiographs and MRI in diagnosing FCL injuries, because MRI is more sensitive in diagnosing an acute FCL tear, and varus stress radiographs are more sensitive in diagnosing a chronic FCL tear. Both imaging modalities are recommended to diagnose both acute and chronic FCL injuries. **Level of Evidence:** Level II, case-control study.

The fibular collateral ligament (FCL) stabilizes the lateral side of the knee through the whole range of knee motion, and resists external rotation near full extension.[1,2] Injuries to the FCL are commonly associated with other knee ligament injuries such as other posterolateral corner (PLC) structures, the anterior cruciate ligament, posterior cruciate ligament, and multiligament knee injuries.[3,4] FCL tears can be

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overlooked because of other concomitant injuries, and the challenge is in the proper diagnosis.

Given the low sensitivity of the varus stress test on clinical examination as a result of physiological differences in lateral compartment laxity among patients, diagnosing FCL tears can be challenging. Both magnetic resonance imaging and varus stress radiographs are used to further refine the diagnosis of FCL tears. There is some controversy in the literature regarding the sensitivity of these modalities. Bonadio et al.[5] reported a sensitivity of 58% for the diagnosis of FCL tears on magnetic resonance imaging. However, Theodorou et al.[6] reported a sensitivity of 100 for FCL tears on magnetic resonance imaging (MRI). LaPrade et al.[7] advocated for the use of varus stress radiographs in the assessment of isolated FCL and grade III PLC injuries, reporting a good reproducibility and repeatability.

It is important to diagnose these injuries because varus instability increases the forces on the anterior cruciate ligament and the posterior cruciate ligament.[8,9] Therefore, untreated FCL tears will put stress on the cruciate ligament reconstruction grafts, increasing the risk of graft failure. Furthermore, persistent varus instability of the knee results in a varus thrust gait with increased forces on the medial compartment of the knee. In the long term, this can result in meniscal injuries and medial compartment osteoarthritis.[3,10] Thus, there is a need to improve the diagnosis of FCL tears because of the detrimental effects of a missed diagnosis. Therefore, the purpose of this study was to evaluate the diagnostic accuracy of MRI and varus stress radiographs for grade III FCL tears, and compare these modalities to intraoperative findings. It was hypothesized that varus stress radiographs would have higher sensitivity for FCL tears than MRI.

Methods

Study Design and Demographics

An institutional review board–approved retrospective review of prospectively collected data was performed from April 2010 to August 2017 to identify 2 patient groups. The first patient group included patients who had an isolated FCL reconstruction or a combined anterior cruciate ligament/FCL reconstruction without additional ligamentous injury. Isolated grade III varus laxity on an examination under anesthesia followed by FCL ligament reconstruction served as the gold standard for diagnosis in this patient group. The second patient group included patients who had an available preoperative knee MRI (from 2010 to 2017) without evidence of ligamentous injury, confirmed by physical examination; this group was used as uninjured controls for comparison to the FCL-injured group. Exclusion criteria for both groups were the following: open physes, additional ligament injuries including posterior cruciate ligament, PLC, and medial collateral ligament, incomplete (grade I and grade II) FCL injuries treated nonoperatively, concomitant intra-articular fracture, prior osteotomy on the ipsilateral knee, or previous injury or surgery to either the FCL or PLC on the contralateral knee. Patient demographic data including age, sex, and concomitant meniscal pathology were collected. FCL tears were diagnosed preoperatively based on clinical examination and imaging studies and confirmed by the examination under anesthesia. Isolated grade III varus laxity on an examination under anesthesia served as the gold standard for diagnosis in this patient group. Varus stress examination at 0° and 30° of knee flexion and bilateral varus stress radiographs with maximum physician-applied varus load at 20° of knee flexion with the use of a foam wedge in the clinical setting were performed by the senior author (R.F.L.) with the patients awake, and magnetic resonance imaging (MRI) was performed in all patients. The knee flexion angle of 20° was chosen according to a previously validated method of stress radiographs and was controlled for by the use of a foam wedge.[7] A positive FCL tear on varus stress radiographs was considered an increase of 2.0 mm in the lateral compartment of the injured knee compared with the uninjured knee (Fig 1).[11] Acute injuries were considered to occur $\leq$6 weeks before MRI and/or varus stress radiographs; chronic injuries were considered >6 weeks from time of injury until MRI and/or varus stress radiographs.[12]

All MRIs were reviewed by a fellowship-trained, musculoskeletal radiologist (E.C.) who was blinded to the pathology associated with each patient. MRI scans were performed on a 3.0-T scanner (Siemens Healthcare) using a 15-channel dedicated knee coil. The slice thickness was 3 to 4 mm, with a 0.5- or 1.0-mm intersection gap. Axial and coronal T2-weighted fast spin echo sequences with fat suppression and sagittal T1-weighted and proton density fast spin echo sequences with fat suppression were reviewed.

Statistical Analysis

Diagnostic accuracy including sensitivity, specificity, and positive and negative predictive values were calculated for the ability of 3-T MRI to detect FCL tears. The positive predictive value was defined as the percentage of MRIs that positively identified FCL tears using the examination under anesthesia with grade III varus laxity and the need for surgical reconstruction as verification that an FCL tear was present. Negative predictive value was defined as the percentage of MRIs that did not identify FCL injuries using the examination under anesthesia and surgical reconstruction as verification that an FCL tear was not present. The diagnostic accuracy parameters were calculated for the FCL tears