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Diagnostic Accuracy of 3.0 Tesla Magnetic Resonance Imaging for the Detection of Articular Cartilage Lesions of the Talus

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Abstract

Background: Talar chondral defects can be a source of persistent ankle pain and disability. If untreated, there is an increased risk of osteoarthritis. The purpose of our study was to determine diagnostic accuracy of 3T MRI in detecting Outerbridge grades 3 and 4 articular cartilage lesions of the talus in a clinical setting, utilizing a standardized clinical MRI protocol.

Methods: Patients who had a 3T ankle MRI and subsequent ankle surgery, by a single surgeon, were included in this study. MRI exams were performed 180 days or less before surgery. Seventy-nine ankles in 78 patients (mean age of 42.3 years) were included in this study. Mean body mass index was 26.3. A standard clinical MRI exam was performed on a 3T MRI scanner. Mean days from MRI to surgery was 39 days. All MRI exams were read and findings recorded by a musculoskeletal radiologist. Arthroscopic examination was performed by a single orthopaedic surgeon. Detailed arthroscopic findings and demographic data were collected prospectively and stored in a data registry. Of the 78 patients, 31 (39.2%) reported previous ankle surgery. Pain was the primary reason for seeking medical attention as reported by 95% of patients, followed by instability in 44% and loss of function with 42%.

Results: Prevalence of Outerbridge grade 3 and 4 talar articular cartilage defects identified at arthroscopy was 17.7%. The 3T MRI demonstrated a sensitivity of 0.714, specificity of 0.738, positive predictive value of 0.370, and negative predictive value of 0.923.

Conclusion: Sensitivity and specificity levels were acceptable for detection of grades 3 and 4 articular cartilage defects of the talar dome using 3T MRI. The high negative predictive value may be beneficial in preoperative planning. While these values are acceptable, a high index of suspicion should be maintained in the appropriate clinical setting.

Level of Evidence: Level II, diagnostic study.

Keywords: talar cartilage, sensitivity, specificity, positive predictive value, negative predictive value, magnetic resonance imaging, 3 Tesla MRI, osteoarthritis

Articular cartilage lesions or chondral defects of the talus can be a source of persistent ankle pain and disability.^{6,15,16,23} These lesions are often the result of trauma, with history of trauma reported in up to 70% of medial lesions and 98% of lateral lesions.¹² Approximately half of ankle sprains sustain cartilage damage,²³ and there are nearly 2 million ankle sprains occurring per day in the United States.²⁷ Acute ankle fractures carry an even higher risk of cartilage damage, with approximately 73% to 80% of acute ankle fractures found to have cartilage damage at arthroscopy.^{15,16}

If these lesions go unrecognized and untreated, there is an increased risk of osteoarthritis (OA), with degenerative changes seen in up to 50% of cases.^{7,25} The impact that ankle OA has on quality of life should not be

underestimated. Studies have shown that end-stage ankle OA can be severely debilitating and lead to a large reduction in the quality of life.^{1,13,21} Therefore, it is important to recognize these injuries early so that the appropriate treatment can be prescribed.

Diagnosis of articular cartilage lesions of the talus can be challenging.² These lesions are not well visualized on plain film radiographs, unless there is underlying osseous involvement.^{2,5} Loomer and colleagues demonstrated that

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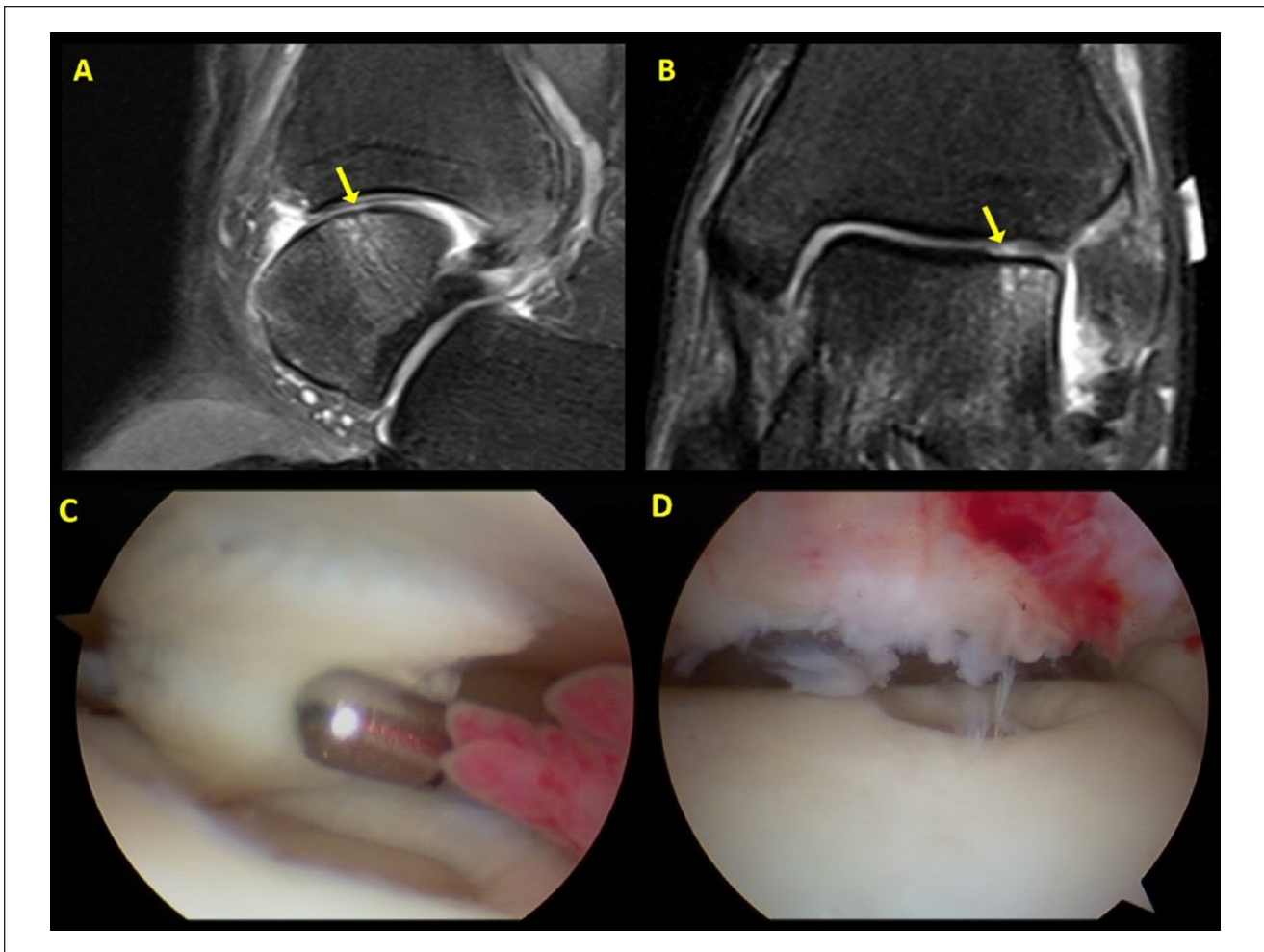


Figure 1. Sagittal (A) and coronal (B) PDFS images demonstrating chondral thinning and fissuring with defects to bone and subchondral bone edema along the lateral aspect of the talar dome over about a 1.0 cm wide area with areas of undermining and possible small chondral flap. Arthroscopic images: (C) Grade 4 articular cartilage lesion with a loose cartilage flap and exposed subchondral bone; (D) articular cartilage lesion, which measured 4 mm by 9 mm, along that lateral aspect of the talar dome.

only 50% of all osteochondral lesions in their study were noted on initial radiograph, and only 66% were detected on radiograph retrospectively after confirmation of the lesion.¹⁷ This has led to the use of other various imaging techniques to better characterize these lesions.^{8,11,14,19,26}

Magnetic resonance imaging (MRI) has since become the preferred noninvasive diagnostic testing modality.^{10,22}

MRI is also endorsed by the American College of Radiology as the next appropriate test following normal radiograph if a talar cartilage defect is suspected in the setting of ankle pain for greater than 6 weeks.⁹ While there are varying reports on the use of 1.5 Tesla (T) MRI in the setting of osteochondral lesions of the talus,^{14,18} there is less known about 3T MRI in the detection of articular cartilage lesions of the talus, especially in a clinical setting. The purpose of our study was to determine the sensitivity, specificity, positive predictive value and negative

predictive value of 3T MRI in detecting Outerbridge²⁰ grades 3 and 4 articular cartilage lesions of the talus in a clinical patient setting, utilizing a standard clinically functional MRI protocol.

Methods

This study was approved by an institutional review board. Between August 2011 and February 2014, all consecutive patients who received a 3T MRI exam of the ankle and underwent subsequent ankle surgery, by a single surgeon, were included in this study. All MRIs were performed 180 days or less, prior to surgery. There were 79 ankles in 78 patients (36 females, 42 males) with a mean age of 42.3 years (range, 13 to 71 years) who fit the inclusion criteria and were included in this study. Mean days from MRI to surgery was 39 days (range 0 to 140 days). Mean body

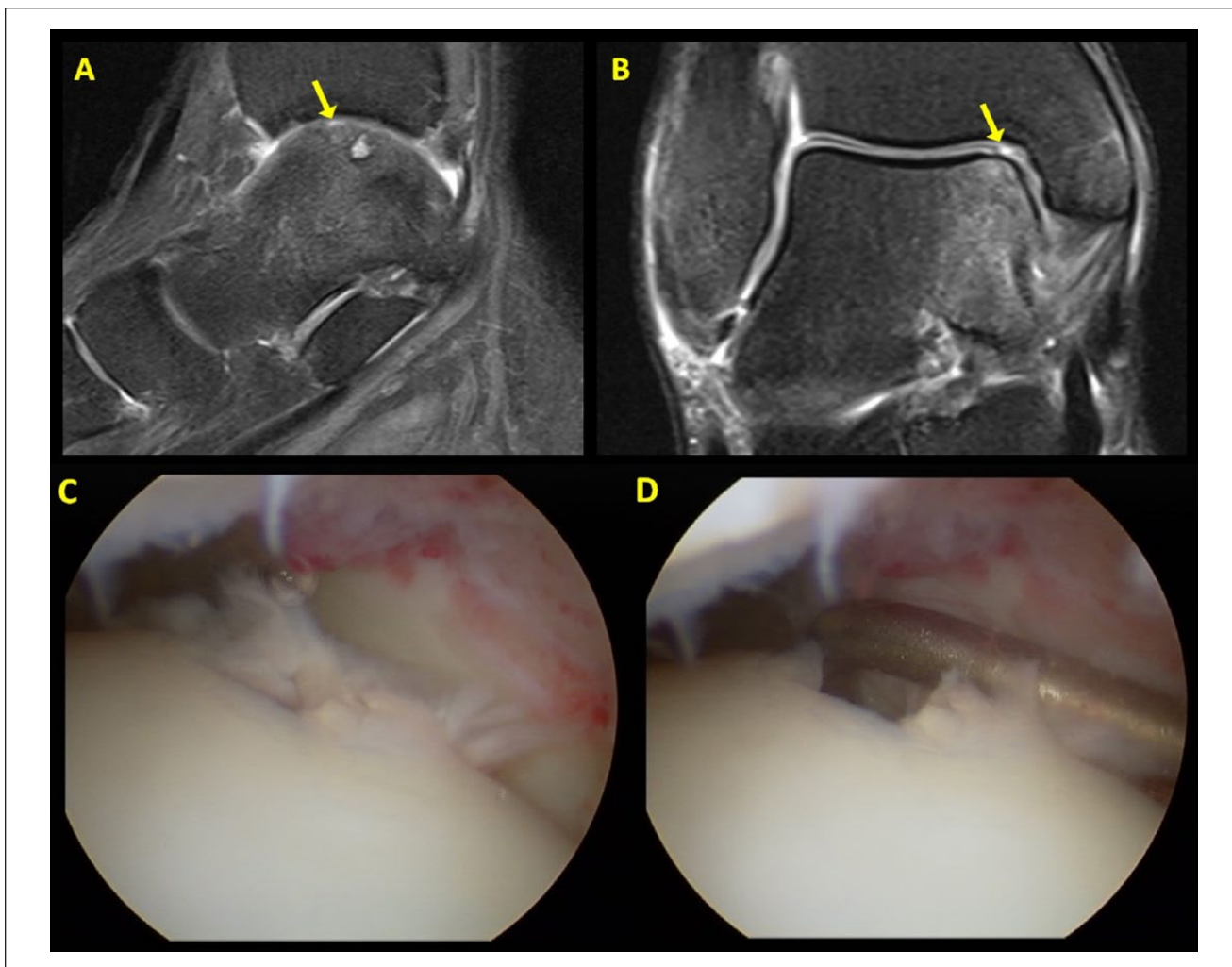


Figure 2. Sagittal (A) and coronal (B) PDFS images demonstrating chondral thinning and more focal fissuring or small linear, few millimeter defect to bone along the medial talar dome with poorly defined edema and slight pitting of the subchondral bone about the focal chondral defect, which may be from contusion or slight impaction injury. Arthroscopic images: (C) Initial view of the articular cartilage lesion along the central aspect of the medial talar shoulder, which measured 12 mm anterior to posterior and 6 mm medial to lateral after debridement to stable vertical edges; (D) articular cartilage lesion demonstrated with arthroscopic probe down to subchondral bone.

mass index (BMI) was 26.3 (range, 16.7 to 40.0). Twenty-one patients (26.6%) reported having had a previous ankle injection on the injured ankle and 31 patients (39.2%) reported having previous ankle surgery on the injured ankle. Pain was the primary reason for seeking medical attention as reported by 95% of patients ($n = 75$), followed by instability in 44% ($n = 35$) and loss of function with 42% ($n = 33$). Median time from injury to MRI was 10.7 months (range 2 days to 44.6 years). Mechanism of injury was also documented and can be seen in Figure 3.

A standard clinical MRI exam was performed on a 3T MRI scanner (Verio, Siemens, Erlangen, Germany) using an 8-channel dedicated foot and ankle coil (Invivo, Gainesville, FL). Imaging protocol included axial T2,

proton density sagittal and coronal and volume rendered 3D proton density fat saturation (PDFS) sequence with reconstruction (Figures 1a, 1b, 2a, and 2b) in 3 planes (axial, sagittal, and coronal). All MRI exams were read prospectively for any derangement (including chondral changes) by a fellowship-trained musculoskeletal radiologist. Imaging findings data were collected prospectively and stored in a data registry.

Arthroscopic examination was performed by a single orthopaedic surgeon (T.O.C.) over the duration of the study period (Figures 1c, 1d, 2c, 2d). Detailed arthroscopic findings and concomitant operative pathology were documented prospectively at the time of surgery and stored in a data registry. Demographic data were also recorded.

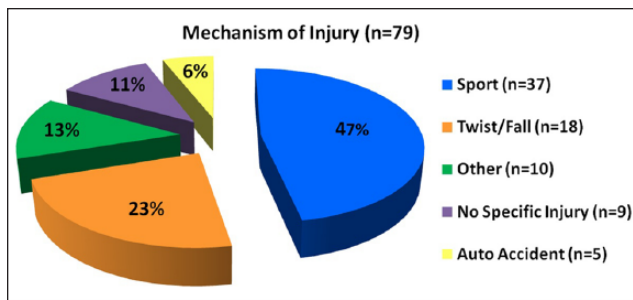


Figure 3. Mechanism in which ankle injury was sustained.

Statistical Analysis

Using arthroscopy as the gold standard, diagnostic accuracy parameters including the sensitivity, specificity, and positive and negative predictive values with confidence intervals were calculated for the ability of 3T MRI to detect Outerbridge grades 3 and 4 talar articular cartilage lesions in our consecutive series of patients. The prevalence of grades 3 and 4 talar articular cartilage lesions at the time of surgery was also determined.

Results

Overall prevalence of grades 3 and 4 articular cartilage defects of the talus identified at arthroscopy was 17.7% in this patient population. Upon analysis, 3T MRI demonstrated a sensitivity of 0.714 (95% CI = 0.440-0.904) and a specificity of 0.738 (95% CI = 0.612-0.836). The positive predictive value was 0.370 (95% CI = 0.200-0.575), and the negative predictive value of 0.923 (95% CI = 0.806-0.975).

Discussion

This study demonstrated acceptable levels of sensitivity and specificity, which were 71% and 74%, respectively, for the detection of Outerbridge grades 3 and 4 articular cartilage defects of the talar dome using 3T MRI. The positive predictive value was low at 37%. This may be due to reading the MR exams too critically and overestimating chondral changes since the long-term sequelae of undiagnosed talar chondral defects can be devastating for the patient. However, the negative predictive value was high at 92%, which is useful when considering these lesions as important causes of persistent ankle pain and disability, as well as for preoperative planning.

Several studies have investigated the use 3T MRI in cartilage or osteochondral lesions of the ankle, specifically the talus, although these studies differ a great deal from our study.^{3,4,24} While previous studies have shown improvements in 3T MRI image quality, these studies were

performed in cadavers.^{3,4,24} The ankle articular cartilage lesions in 2 of the 3 cadaver studies were artificially produced, which may yield more sharply margined focal chondral defects, making it more difficult to compare to an actual pathologic lesion.^{4,24} In addition, images in these studies were obtained using quadrature knee coils, not a designated foot and ankle coil. The MR images in our current study were obtained utilizing a standard clinically functional MRI protocol and a dedicated 8-channel foot and ankle coil in patients presenting to an orthopaedic foot and ankle surgeon for evaluation of ankle clinical pain and disability.

Bauer and colleagues completed a study comparing 1.5T to 3T MRI in the detection of cartilage and ligamentous lesions of the ankle for various imaging protocols.⁴ Results show that specificity was high for all groups, ranging from 98% to 100%, but the highest sensitivity at 3T was reported to be 71%, which was significantly improved from 49% at 1.5T for the same imaging protocol.⁴ While sensitivity in the Bauer et al study was the same as the sensitivity found in our study, the difference in specificity could be due to the fact that the lesions were artificially created in a cadaver model. Our study reported on clinical lesions in the patient population of the treating surgeon.

Mintz and colleagues also investigated the use of 3T MRI in osteochondral lesions of the talus in a clinical population.¹⁸ Sensitivity and specificity were reported to be as high as 95% and 100%, respectively, and positive predictive value was 100% and negative predictive value was 88%. In that study, the patient population was obtained by retrospectively searching a radiology database for all patients with osteochondritis dissecans and chondral injury of the ankle, as well as from operative billing records of 2 foot and ankle surgeons. This methodology could potentially produce artificially high results, as the inclusion criteria required patients to have a positive MRI for ankle chondral damage or have evidence of ankle cartilage operative treatment. In our study, all patients who had an ankle MRI and subsequent ankle surgery, regardless of pathology and clinical diagnosis, were included to be more representative of our patient population as a whole.

Limitations

This study had several limitations. All data were reviewed retrospectively; however, data were collected prospectively. All patients were seen at a tertiary referral clinic and may not be representative of the general population. The radiologist was blinded to the results of arthroscopy; however, the surgeon arthroscopically evaluating and treating the ankle was not blinded to the results of the MRI. The MRI is an important tool in preoperative planning and blinding the surgeon to the results of the MRI may have compromised the level of care the patient received.

Conclusion

This study demonstrated acceptable levels of sensitivity and specificity for the detection of Outerbridge grades 3 and 4 articular cartilage defects of the talar dome using 3T MRI. The high negative predictive value may be particularly beneficial in preoperative planning of the treatment method selected and operative procedure being performed. While these values are acceptable, a high index of suspicion should be maintained in the appropriate clinical setting.

Declaration of Conflicting Interests

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