Depiction of Lateral Ligament Complex of the Ankle using 3D MRI in Healthy Subjects and Patients with Chronic Ankle Instability.

Satoshi Yamaguchi, M.D.¹, Hiroshi Matsumoto, R.T.², Atsuya Watanabe, M.D.³, Takahisa Sasho, M.D.¹, Shunsuke Mukoyama, M.D.¹, Yuta Muramatsu, M.D.¹, Yorikazu Akatsu, M.D.¹, Taisuke Fukawa, M.D.¹, Jo Katsuragi, M.D.¹, Jun Endo, M.D.¹, Yohei Yamamoto, M.D.¹, Hiroko Hoshi, M.D.¹, Kazuhisa Takahashi, M.D.¹.

¹Department of Orthopaedic Surgery, Graduate School of Medicine, Chiba University, Chiba, Japan, ²Department of Radiological Technology, Chiba University Hospital, Chiba, Japan, ³Department of Orthopaedic Surgery, Teikyo University Chiba Medical Center, Chiba, Japan.


Introduction: In most chronic ankle instability, the lateral ligament complex, including anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL), is injured. Evaluation of the integrity of these ligaments, particularly CFL, is critical for the surgical planning as well as assessment for the severity of injury. MRI is used to assess the ligaments, however visualizing them using conventional imaging sequence is difficult because these ligaments are small and run oblique to the standard anatomical planes with large variability among subjects. Three-dimensional acquisition techniques provide arbitrary multi-planar reconstruction images with a slice thickness less than 1mm, and may better visualize the lateral ligament complex. The purposes of this study were to describe normal morphology of the ligaments using 3D MRI, and to clarify the injury pattern in patients with chronic ankle instability.

Methods: Ten healthy subjects (five females and five males, mean age 28 years) and ten patients with chronic ankle instability (two females and eight males, mean age 29 years) were included. Images were acquired with a 3.0 tesla MRI unit (Discovery MR750 3.0T, GE Healthcare, Milwaukee, WI) and an ankle coil. All images were acquired with and without fat suppression. 3D-FSE-Cube imaging was performed with the following parameters: repetition time msec/echo time msec, 1300/30; matrix, 256x256; field of view, 15 cm; section thickness, 0.6 mm, resulting in an isotropic resolution of 0.6 mm. Position of the ankle was normalized with the knee full extension and the ankle neutral position. One experienced foot and ankle surgeon created the reconstructed images for ATFL and CFL, respectively using commercial software (Aquarius NET, TeraRecon, Foster City, CA). Three image set were created for each ligament which were along the direction of the ligament and orthogonal to each other. For the healthy subjects, presence of any signal changes in the ligament was assessed. For the patients with chronic ankle instability, each ligament was graded into the following: 1, intact; 2, partial tear; 3, complete tear. Partial tear was defined as thickening, irregularity, loosening or signal change of the ligament. Complete tear was defined as discontinuity, detachment at the insertion or absence of the ligament. Patterns of the injury were also recorded.

Results: In the healthy subjects, the whole length of the ligaments was visualized in single slices of the oblique sagittal and oblique axial images for both ATFL and CFL (Fig. 1 and 2). The main component and accessory component of ATFL were clearly depicted in six of ten patients (Fig. 1). Importantly, three subjects had linear high signal areas in the mid-substance of ATFL (Fig. 1), and three subjects had high signal areas at the calcaneal insertion of CFL (Fig. 2). These high signal areas were regarded as normal findings. In the patients with chronic ankle instability, ATFLs were abnormal in all patients. Three patients had grade 3 and seven patients had grade 2 injuries. Interestingly, CFLs were also abnormal in as much as nine out of ten patients. Grade 3 tear was found in five patients, all of whom had detachment at the fibular insertion (Fig. 3a and b). Three patients had grade 2 tear. Two patients had signal changes at the fibular insertion, and one patient had thinning of the ligament (Fig. 3c and d).
Fig 1. Reconstructed images of the normal ATFL (Circle). a: Oblique axial, b: Oblique sagittal. The main bundle and accessory bundle were clearly depicted (Arrows), A linear high-signal area was observed in the main bundle (Arrowhead), which was a normal finding.

Fig. 2. Reconstructed images of the normal CFL (Circle). a: Oblique axial, b: Oblique sagittal. A high-signal area was observed in the calcaneal insertion (Arrowhead), which was a
Fig. 3. Images of the CFL in patients with chronic ankle instability. a and b: Loosening, signal change of the ligament, and detachment of the at the fibular insertion (Arrow). c and d: Thinning of the ligament (Arrowhead).

Discussion: The lateral ligament complex of the ankle was better visualized using 3D MRI sequence than using conventional imaging sequence. The reconstructed images provided detailed anatomical structures of the normal ATFL and CFL, and intraligamentous signal changes in healthy subjects which should not be misdiagnosed as ligament injury. Injury patterns of CFL as well as ATFL were also clearly visualized. Depiction of CFL is of clinically significant, because CFL injury in addition to ATFL injury is a negative prognostic factor after conservative treatment of lateral ankle ligament injury. Moreover, need for CFL reconstruction combined with ATFL reconstruction has been a subject to debate. However, there was no imaging method to directly assess CFL injury except for arthrography, which is invasive and not suitable for routine use in clinical practice. Alternatively, stress radiography is used to indirectly assess injury of the lateral ligament complex. However, the test cannot evaluate specific pathology of the injury. Large variability among patients also makes interpretation of the result difficult. Additionally, morphologic abnormality of the ligament may contribute functional ankle instability even without mechanical instability. We were able to assess injury pattern and integrity of CFL using 3D MRI, which would helps the severity assessment and surgical planning of chronic ankle instability. Limitations of this study include a small number of subjects, image assessment by only one observer and lack of standard reference of the ligament injury, such as surgical findings. Further studies with an increased subject number are necessary to validate the usefulness of the 3D MRI sequence for the evaluation of lateral ligament complex injury of the ankle.

Significance: Ankle 3D MRI provides detailed morphology of CFL injury as well as ATFL injury which conventional imaging techniques do not. Evaluation of the integrity of the ligaments helps the severity assessment and surgical planning of chronic ankle instability, and may improve the surgical results.

Acknowledgments:
