INTRODUCTION

Anterior cruciate ligament (ACL) rupture is one of the major knee injuries and often combined with meniscus tears. ACL rupture is assumed to be a significant risk factor for subsequent knee osteoarthritis (OA), with estimated prevalence of OA between 1% and 3% for isolated ACL rupture and between 21% and 100% for ACL rupture combined with meniscal tears [1]. Therefore, detailed assessment of early degenerative changes in the articular cartilage is important for ACL ruptured knees.

Magnetic resonance (MR) imaging is one of the non-invasive methods to investigate the cartilage degeneration in detail. Recent studies of MR imaging showed cartilage T2 mapping is closely related to cartilage collagen matrix and water content, with significant correlation between higher T2 values and cartilage degenerative changes. There were only a few reports of assessment of cartilage matrix change in acute injury knee by two-dimensional (2D) MR imaging [2, 3]. However, evaluation of selected 2D images on knee MR imaging may fail to show limited femoral or tibia cartilage lesions without clear demonstration of three-dimensional (3D) extent of cartilage degeneration.

The purpose of this study is to evaluate cartilage degenerative changes in ACL ruptured knees with and without combined lateral meniscal tears using 3D reconstructed cartilage T2 mapping.

METHODS

Institutional review board approval was obtained for this study. Twenty-three patients with ACL rupture scheduled for ACL reconstruction surgery (ACLR) and 12 volunteers who had no pain and no previous surgery in the knee were included. MR imaging of patients with ACL rupture were performed one day before ACLR. Sagittal 3D-FIESTA-C images (TR/TE: 12.7/6.3 ms; slice thickness: 1.5 mm; FOV: 12 cm; acquiring time: 10 min 27 sec) and 2D consecutive sagittal T2 map images (TR: 1500 ms; TE: 8 echoes between 10-80 ms; slice thickness: 3 mm; FOV: 12 cm; acquiring time: 12 min 54 sec.) were obtained using 3.0 T MRI system (GE Healthcare).

After the 3D cartilage and meniscus models was reconstructed from the images of FIESTA-C, T2 color map was laid on the 3D model using custom-made software (Baum, Osaka Univ.). The region of interests (ROIs) were manually defined on each of the medial and lateral femoral condyle cartilages, as anterior area (Z1), weight bearing area covered by meniscus (Z2), and posterior area (Z3) (Fig. 1). T2 value at each ROI was calculated with cartilage at full thickness, superficial and deep layers, respectively.

To assess the specificity and sensitivity of the 3D reconstructed T2 mapping, diagnosis of abnormal lesions by 3D T2 mapping was compared with arthroscopic findings in all patients.

Twenty-three patients with ACL rupture were divided into ACL rupture and combined with lateral meniscal tear (Group L: 10 patients; mean age: 22.1 ± 6.0 years; male/female: 5/5) and ACL rupture without lateral meniscal tear (Group I: 13 patients; mean age: 26.0 ± 7.9 years; male/female: 8/5). T2 value at each ROI was compared among Group L, Group I and volunteers (Group C: 12 volunteers; mean age: 25.0 ± 5.2 years; male/female: 6/6) by unpaired t test.

RESULTS

There were no significant difference in age and gender among Group L, I and C. Duration from initial injury to ACL reconstruction surgery was within 2 years except 1 patient in Group L (10 years).

The specificity of 3D reconstructed T2 mapping was 98% and sensitivity was 76%, using the arthroscopic findings as the reference. T2 values at each ROI in each layer were shown in Table 1. At Z2 of lateral condyle, there were no significant differences of T2 values between Group I and Group C. However, T2 values of Group L were significantly higher than those of Group C (Fig. 2). On the other hand, at Z2 of medial condyle there were no significant differences in T2 value at each ROI among Group L, I and C (Fig. 2).

At Z1 and Z3 of lateral condyle, there was almost the same trend with higher T2 value in Group L. At Z1 and Z3 of medial condyle, there were no significant differences among Group L, I and C (Table 1).

DISCUSSION

In the present study, combined lateral meniscus tear was a significant risk factor of cartilage degeneration with increased T2 values in patients with ACL rupture. In a cadaveric study, the role of lateral meniscus in ACL deficient knee was assumed to be a critical secondary stabilizer of the knee subjected to combined axial and rotatory loads [4]. The present findings may indicate that degenerative changes were likely to occur in a relatively early period after ACL rupture, due to loss of the stabilizing function of lateral meniscus, and patients with ACL rupture and combined lateral meniscal tear may have higher requirements of ACL reconstruction surgery and/or lateral meniscus repair.

In conclusion, 3D reconstructed images of T2 mapping were useful for global and local assessment of the whole femoral cartilage. Patients with ACL rupture and combined lateral meniscal tears may have more severe damage of the cartilage than patients with isolated ACL rupture and may have higher requirements of surgical treatment to prevent further cartilage damage and progression to knee OA.

SIGNIFICANCE

Patients with ACL rupture and combined lateral meniscal tears may have more severe damage of cartilage than patients with isolated ACL rupture and may have higher requirements of surgical treatment.

REFERENCES