Relationships Between MRI T1rho Values And Histological Findings Of Normal And Torn Menisci In A Pig.

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Disclosures:

Introduction: Previous reports described a high correlation between MRI T1rho value and GAG concentration in articular cartilage, therefore T1rho mapping was useful for evaluation of early osteoarthritis [1, 2]. Recently T1rho mapping was attempted to evaluate meniscus in which degenerative meniscus was shown with higher T1rho value than healthy meniscus [3], however, the significances of the T1rho value in meniscus still remain unknown. Here, we analyzed the relationships between the T1rho values and histological findings in normal and torn menisci of pigs.

Methods: 1. Surgical Procedure
Six pigs were used for this experiment. Transverse tear was created in the middle part of medial meniscus, which was evaluated at 4 weeks after the operation.
2. T1rho mapping
Sagittal T1rho mapping images were taken by 3.0T MRI. MRI protocol was shown by Table 1. In a healthy lateral meniscus, the region of interest (ROI) was set by dividing into three parts. In the torn medial meniscus, the ROI was set based on sagittal section similar to histological section. In each meniscus, two slices were examined. The Tx mapping of Ziosation II (Ziosoft Corporation) was used for the analysis.
3. Histology
Hematoxylin and eosin (HE), safranin-O, and masson trichrome stainings were performed. Immunohistochemistry for type I and type II collagen was performed. Collagen organization in the meniscus was scored (0: normal 1: minimal unorganized 2: moderate unorganized 3: severely unorganized / no organized) [4]. Unstained slides were examined by polarizing microscope (Olympus BX51) in order to evaluate regularity of collagen fiber.
4. Measurement of sulfated glycosaminoglycan (sGAG) content
Seven healthy lateral meniscus of posterior part was divided into three parts sagittaly. Each meniscus was digested for 24 hours at 60°C in papain buffer (Sigma-Aldrich). The GAG concentration of supernatant was determined by the Blyscan-assay (Biocolor Ltd).
5. Statistical analyses
Kruskal-Wallis test and the Scheffe test were used. A value of P < 0.05 was considered significant.

Results: In the inside slice of normal lateral meniscus, the T1rho value in the inner area was significantly higher than that in the central area (P<0.01) (Fig.1A, B). GAG concentration of the inner area was higher than that of the central and outer area. (P<0.01, P<0.05)(Fig. 1C). In the inner area, many round-shaped chondrocytes were observed, and cartilage matrix stained with safranin-o and type II collagen was more abundant than in the other areas. In the central area, fibrochondrocytes represented a majority of cells. In the outer area, synovial tissue existed in addition to fibrous tissue (Fig. 1D).
In the outside slice of normal lateral meniscus, the T1rho value in the outer area was significantly higher than that in the inner and central areas (P<0.01, P<0.01) (Fig. 2A, B). GAG concentration of the inner area was similar to that of the central area and the both areas were mainly consisted of fibrous cartilage (Fig. 2C, D).
In the outside slice of the torn medial meniscus, macroscopically radial tear was covered with the scar tissue (Fig. 3A). In the anterior inner area (Fig. 3, No1), T1rho value was moderate high, and histologically fibroblasts invaded between collagen fibers, and collagen fiber appeared more irregular than in the posterior central area, in which T1rho value showed normal (Fig. 3. No3). In the lesion area (Fig. 3, No2), T1rho value was very high. Histologically, this area was mainly filled with scar tissue. There was a correlation between the T1rho value and collagen organization score (r=0.84; p<0.0001) (Fig. 3C). By polarizing microscope, the posterior central area, where T1rho value was low, showed higher brightness, contrarily the lesion and anterior inner areas, where T1rho value showed high, showed lower brightness (Fig 3B).
In the inside slice of the torn medial meniscus, the T1rho value showed high though the damage of collagen structure was slight.
in the inner area of medial meniscus (Fig. 3B yellow box) where the clustering of chondrocytes was observed, and surface was fraying compared with normal one. Polarizing microscope showed brightness of surface decreased, which means surface irregularity (Fig. 4B). There were correlations between the T1rho values and collagen organization scores in both inner (r=0.67, p<0.01) and central area (r=0.66, p<0.05) (Fig. 4C).

**Discussion:** The T1rho value correlates to the level of collagen fiber disruption and then the T1rho value was thought to be reflected the pathological features of torn meniscus. However these values depended on the location of the meniscus because its structure varied depending on location (Table. 1). Inner area of meniscus has a composition closer to hyaline cartilage, as indicated by higher GAG content, higher water content and lower collagen content comparison to other areas [5]. T1rho value was influenced by content of GAG, water, and collagen content. We also confirmed that T1rho value of articular cartilage was significantly higher than that of meniscus or posterior cruciate ligament (data not shown). T1rho mapping can detect slight change without clear collagen disruption nearby tear site. These findings indicate this technique may be able to detect early change of degenerative meniscus. Present study showed the T1rho value correlated to the extent of collagen fiber disruption, thus T1rho mapping is thought to be useful for evaluation of meniscal lesions but some attentions should be paid to its location.

**Significance:** The T1rho value correlates to the level of collagen fiber disruption in torn meniscus. The present study shows T1rho mapping is a promising non-invasive method to evaluate meniscus pathology.

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