

Quantitative evaluation of Synovial Membrane and Effusion in Knee Osteoarthritis:

Junghyo Kim¹, Takashi Nishii², Hidetoshi Hamada¹, Masaki Takao¹, Takashi Sakai¹, Tetsuya Tomita³, Kazuma Futai³, Hisashi Tanaka⁴, Hideki Yoshikawa¹, and Nobuhiko Sugano¹

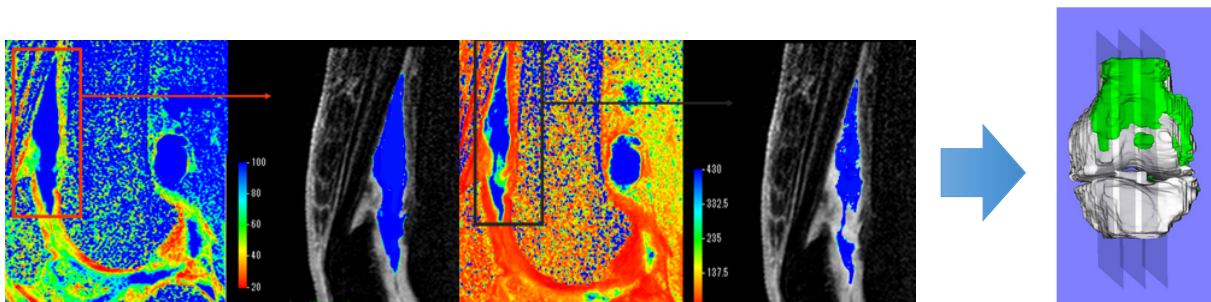
¹Department of Orthopaedic Surgery, Osaka University Graduate School of Medicine, Suita, Osaka, Japan, ²Department of Orthopaedic Medical Engineering, Osaka University Graduate School of Medicine, Osaka, Japan, ³Departments of Orthopedic Biomaterial Science, Osaka University Graduate School of Medicine, Suita, Osaka, Japan, ⁴Department of Radiology, Osaka University Graduate School of Medicine, Suita, Osaka, Japan

Introduction:

Symptom and functional disability in knee osteoarthritis are mainly related with disorders in several principal structures such as articular cartilage, meniscus, ligament, synovium and bone. Among those disorders, synovial inflammatory activities are strongly influential on severity of pain, disability, and prognosis of osteoarthritis. For assessment synovial inflammation, fluid-sensitive fat-suppressed MR proton density or T2-weighted imaging were often employed. Recent MRI studies indicated that contrast-enhanced MR sequences are necessary to distinguish between synovial membrane and synovial fluid in synovial inflammation, due to similar demonstration of synovial membrane and fluid on non-enhanced MR sequences. However, use of contrast agent has risks of serious complications such as nephrogenic systemic fibrosis, especially in patients with renal dysfunction who are often encountered in patients with osteoarthritis. We hypothesized that T2 mapping of knee joints may be useful to discriminate synovial membrane and fluid without using contrast agent, due to remarkable variations of T2 values among those structures. We examined associations of volume of synovial membrane and synovial fluid on non-enhanced T2 mapping with clinical symptom and structural disorders of the articular cartilage.

Methods:

Twenty-one symptomatic patients who showed knee mild or advanced osteoarthritis on plain radiographs and provided consent were included. There were 5 males and 16 females, and the mean age of patients was 72.0 years (range; 53 to 84 years). 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: 12min54sec.) were obtained using 3.0-T MRI system. Previous studies showed mean T2 value of synovial fluid as approximately 650ms \pm 110 and that of articular cartilage or subcutaneous fat as approximately 50 ms \pm 1 ms. On T2 mapping images, we defined synovial fluid as region with T2 value more than 430 ms (average T2 value -2SD according to the previous studies), and synovial membrane as region with T2 value between 100 ms and 430 ms. Manual segmentation of each synovial membrane and fluid was performed for joint cavities at the suprapatellar recess and femoro-tibial joints on a slice-by-slice basis, and volume of synovial membrane and fluid were calculated using our custom-made software (Baum globe, Osaka Univ; Fig 1). To investigate accuracy, measurements of those volumes by non-enhanced T2 mapping were compared with those by contrast-enhanced MRI (CEMRI) in 3 patients. In all patients, severity of knee pain was assessed using the New Knee Society Score (NKSS) and knee structural disorder in cartilage was assessed semiquantitatively using the Whole-organ Magnetic Resonance Imaging Score (WORMS). Associations of severity of knee pain to volume of synovial membrane and fluid, and WORMS scores of cartilage were analyzed.



Result:

In three patients who underwent both non-enhanced T2 mapping and CEMRI, mean difference of synovial membrane and fluid volume was 1.5 \pm 1.9 ml and 0.4 \pm 0.4 ml, and the intraclass correlation coefficient of both imaging methods was 0.822 and 0.956, respectively. Volumes of synovial membrane and fluid in all patients were 15.4 \pm 9.5 ml and 8.2 \pm 7.9 ml. Knee pain scores (NKSS) were significantly correlated with volume of synovial membrane and fluid ($r = -0.515$ and $r = -0.450$, $p < 0.05$), but were not correlated with WORMS score of cartilage.

Discussion and conclusion:

Volumes of synovial membrane and fluid in this study were calculated similarly to previous studies of patients with knee osteoarthritis using contrast-enhanced MR sequences. Significant correlations of volume of synovial membrane and fluid to knee pain score suggested that synovial inflammation activity was more influential on pain worsening than structural disorder in cartilage. Although further extensive studies for validation of segmented volume against the gold standard of reference are needed, T2 mapping of knee joint can be expected to provide reliable quantitative assessment of synovial inflammatory activities without using contrast materials in knee osteoarthritis.