The site of the meniscal tear effects the rotational stability of knee and articular cartilage degeneration

Himari Miyamoto[1], Saaya Enomoto[1], Yuna Usami[1], Takanori Kokubun[1,2]
[1]Graduate School of Health, Medicine, and Welfare, Saitama Prefectural University, Saitama, Japan,
[2]Department of Physical Therapy, School of Health and Social Services, Saitama Prefectural University, Saitama, Japan
Email: 2581313o@spu.ac.jp

Disclosures: None of the authors have anything to disclose

INTRODUCTION: The meniscus has the role of stability, distributes axial load, absorbs shock, and provides lubrication, proprioception, and nutrition to the knee joint. In particular, the functions to stabilize by breaking the translational and rotation motion of the knee like a tire stopper and to reduce the joint surface's compressive stress by converting axial load to hoop stresses play an essential role in knee joint stability. So meniscal tears can cause profound functional, biomechanical, and kinematic derangements within the knee joint, leading to accelerated degeneration of the articular cartilage, and relatively rapid and progressive knee osteoarthritis (OA) [1]. On the other hand, clinically, the locations of a meniscus tear are variable (Medial or lateral, anterior, or posterior, and so on), so the difference in the sites of meniscal injury may affect the movement of the rotation and articular cartilage degeneration. However, no studies focused on the relationship between the tear location-specific functional and degenerative changes after meniscus injury. This study aimed to investigate whether the differences in the sites of meniscus tears affect joint stability and secondary articular cartilage degeneration using two rodent meniscus injury models.

METHODS: This study was approved by the Ethics Committee of Saitama Prefectural University and strictly adhered to the on-campus animal experiment guidelines (Approval number: 2022-15). Twelve C57BL/6 female mice (12-week-old) were divided into 2 groups: the DMM group (n=6) and the MMT group (n=6). In the DMM surgery, based on previous studies, the medial tibial meniscus ligament was incised. In the MMT surgery, the medial collateral ligament and medial meniscus attachments were separated, and the medial meniscus was cut at the midsection site. These procedures were performed on the left knee joint, and the right knee, not subjected to surgery, was used as the Intact group (n=6). All mice were euthanized 8 weeks after surgery, and then the hind limbs were harvested. We reproduced the rotation of the knee joint and measured the angles using a self-made device and a soft X-ray device to assess the joint instability (Fig1-A). After that, the samples were embedded in paraffin, and sections were prepared through a coronal incision. Subsequently, we performed safranin-O/fast green staining and evaluated the cartilage degeneration in the medial tibia in three sections: 1) the front section,2) the midpoint between the two, and 3) the middle section to examine the specific changes in each of the two models with different damage sites (Fig2-A). The Osteoarthritis Research Society International (OARSI) histopathological grading system was used for scoring [2]. All data were analyzed with the Kruskal-Wallis test, and only those with significant differences were analyzed for multiple comparisons using the Steel-Dwass test using the Python programming language.

RESULTS SECTION: The changes in angle of internal and external rotation showed a slight tendency to increase in the DMM and MMT groups compared to the intact group, especially during internal rotation, but there was no significant difference between the two groups (Fig.1-B). The total knee range of motion of rotation was also higher in the DMM and MMT group than in the Intact group, indicating that regardless of the starting position at the time of measurement, an increase in range of motion was caused by the damaged meniscus (Fig.1-C). OARSI scores were higher in the MMT group for all sites, but the three sites analyzed had almost identical scores (Fig.2-B, C). No significant differences were observed in all analyses.

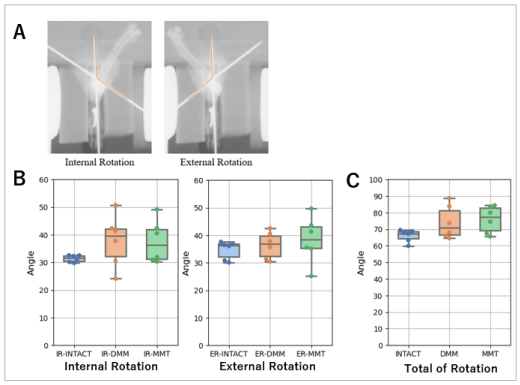

Fig1: (A) X-ray image during measurement of angle of rotation (B) Change in angle of the internal and external rotation (C) Change in angle of the total range of rotation

DISCUSSION: In this study, we examined the effects of different meniscus tear sites on knee joint stability and articular cartilage degeneration. The results showed more severe articular cartilage degeneration after 8 weeks in the group with damage to the midsection of the meniscus, suggesting that different sites of meniscus damage have an effect on the progression of secondary osteoarthritis. The meniscus enhances bone conformity and reduces compressive stresses on the articular surface [3]. In addition, the meniscus follows the direction of motion of the femoral condyle, braking knee joint motion. Although the disruption of these functions is thought to be an important risk factor for the development of knee OA, as a result, there was no difference between the two meniscus injury models in the rotation angles measured in this study. However, considering that the rotation angles were measured under static conditions, different joint instabilities may be observed between models in the actual joint motion of mice during walking. Therefore, as a future strategy, it is desirable to analyze the rotation changes during actual gait using movie analysis. In addition, it is necessary to measure load distribution and contact pressure on the tibial plateau using a pressure mapping sensor or similar device to determine the increase in compressive stress on the articular surface in each model. These indicate that different sites of meniscus injury may have different secondary effects on the knee joint.

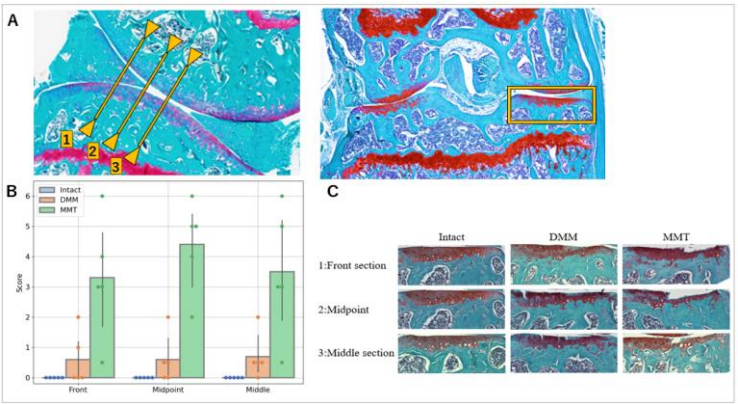

Fig2: (A) Analysis site for OARSI score (B) OARSI score (C) Representative images of safranin-O/fast green staining

SIGNIFICANCE/CLINICAL RELEVANCE: It was suggested that different sites of meniscus injury have different effects on articular cartilage degeneration and subsequent progression of knee OA. Further validation of the differences between the models will provide fundamental insight into the development of OA after meniscus injury.

REFERENCES: [1] Mameri et al., *Curr Rev Musculoskelet Med*,2022 [2]Glasson et al., *Osteoarthritis Cartilage*, 2010. [3]Makris et al., *Biomaterials*,2011.