Mechanical Behaviors and Morphological Characteristics of the Sacroiliac Joint

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INTRODUCTION: Dysfunctional sacroiliac joint (SIJ) was considered as a source of the lower back pain. Several researchers investigated anatomy and biomechanics of the SIJ to understand the relationship between the lower back pain and the SIJ. Many studies concluded the SIJ has little movement. However, some of the studies using spinopelvic parameters mentioned high pelvic incidence (PI) change. Moreover, with the development of imaging techniques such as EOS system and vertical CT / MR, interest in sacroiliac joint movement and sagittal balance is increasing. Therefore, in this study, the movement characteristics of the sacroiliac joint were investigated by constructing an environment that could be measured and controlled more precisely than in past experiments. And we compared the morphological parameters of the sacroiliac joint between the small and the large movement groups.

METHODS: We used 38 fresh cadavers (male 18, female 20). The mean age was 84.25 (81~92) years, and the mean height was 155.47 (142~161) cm. The changes in angle between the sacrum and hip bone were measured with prone (unweighting) and sit (body weighting) positions. Six optical markers were fixed on the surface of the bone directly, and five motion tracking cameras were used (Fig. 1). After measuring the SIJ movement angle by weight bearing, the group with small movement and large movement were classified, and the difference in joint surface shape between the groups was analyzed. Based on the SIJ movement angle of 2 degrees, they were classified into two groups. After weight bearing test, the pelvis was harvested by dissection for SIJ stiffness test (Fig. 2). The hip bone, sacrum, coccyx, and ligaments between hip bone and sacrum were preserved. Patient-specific spacer blocks for fixation of the sacrum were designed by CT images and printed by a 3D printer. 3D printed patient-specific spacer blocks were fixated at the anterior and posterior surface of the sacrum, and the sacrum with the spacer blocks was fully fixated. The external load was applied in superior (+) and inferior (-) directions at pubic symphysis (Fig. 2). Hip bone tilt angle, the movement of the pubic symphysis and posterior superior iliac spine were measured with applied load. For these measurements, 13 optical markers and 4 motion capture cameras were used.

RESULTS SECTION: In the group with small movement, the ratio of males was high at 14 males and 5 females, and in the group with large movement, the ratio of females was remarkably high at 4 males and 15 females. There was no statistical difference in the articular surface shape of the SIJ between the two groups. We observed the remarkable SIJ movements in large movement group (Group B). However, only small movements were observed (Group A, -1.75 ± 0.59º degrees and 1.89 ± 0.50º degrees at -/+ 200N, respectively). In the sample where the movement was observed, the hip bone tilt angle was 3.20 ± 0.64º under +100N and 4.67 ± 0.55º when applied with +200N. The tilt angle was 3.15 ± 1.31º when -100N was applied and 5.62 ± 1.50º applied with -200N (Fig. 3). The movement of the pubic symphysis was small (within 0.35 mm) in all cases, and the movement of the PSIS was 0.69 ± 0.52 mm, 0.70 ± 0.72 mm, 0.54 ± 0.02 mm, 0.79 ± 0.02 mm at +100N, +200N, -100N, and -200N respectively. Regardless of the loading direction, it showed an outward-opening behavior.

DISCUSSION: In this study, we confirmed that the SIJ is a joint with movement. This is consistent with recently published clinical papers. In particular, significant movements were observed in females. But we cannot find any morphological differences at SIJ between the groups. Furthermore, when the SIJ were tilted with load, the spacing of the pubic symphysis had little change, and the PSIS moved in the widen direction according to the tilt motion of the hip bone.

SIGNIFICANCE/CLINICAL RELEVANCE: The SIJ is a joint in which +/- 5 degrees of movement can occur due to weight bearing or muscle action, and this behavior should be considered in biomechanical studies. In particular, it mainly occurred in the pelvis of women, and studies on more samples are needed.

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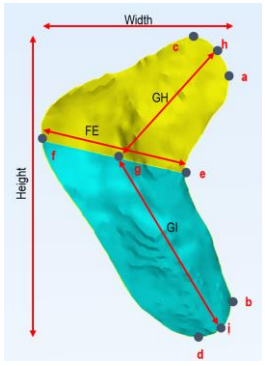

Fig. 1 Measurement parameters for morphological difference

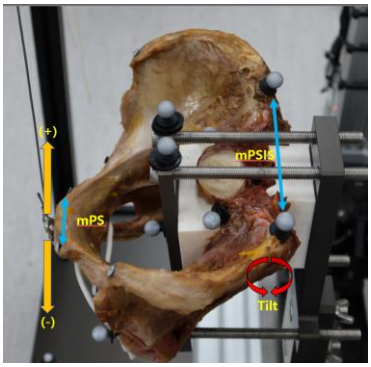

Fig.2 Sample configuration and marker setup

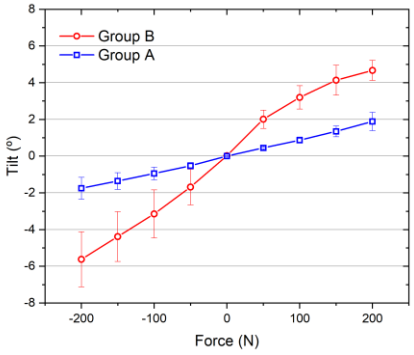

Fig. 3 Hip bone tilt angle with various load