Analysis of Individual Differences in Pelvic Shape and its Impact on the Seatbelt Kinematics in a Collision.

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I. INTRODUCTION

In order to reduce serious abdominal injuries in frontal crashes, understanding of the individual differences of the human body especially in the pelvic and spinal region is necessary. In the past few years, the human skeletal alignment in seated posture has been measured and the occupant kinematics has been studied by using Human Body Models (HBMs). The results indicated that posterior pelvic tilt may affect the kinematics of the occupant and consequently the probability of abdominal injuries [1]. However, the shape of the ilium and flesh thickness may also be the affectors from a viewpoint of the lap belt position and motion, as well as pelvic angle. Though there have been many medical reports on the morphology of the pelvis [2-9], almost none of them focused on the individual differences in the shape of the ilium. In this study, the shape of the ilium, and the distance between the anterior superior iliac spine (ASIS) and pubic symphysis were measured from X-ray image data. Kinematics of occupant and lap belt during frontal crashes was also studied through HBMs with different iliac geometry.

II. METHODS

Research Outline

In this study, the morphology image data of skeletons in standing and seated postures were collected by using X-ray photography. In seated posture, an X-ray device equipped with a seat of the Mazda3 (MY2013-2016) has been used [1]. All procedures in this study were approved by the ethical committees of Yamaguchi University Graduate of Medicine and Mazda Motor Corporation beforehand. From these image data, the shape of the ilium was measured. Based on those measurements, individual differences were analysed from the perspectives of age, gender, height, and BMI. Next, the shape of THUMS's ASIS was modified as reproducing actual shapes of the subjects. Using those HBMs, the motion of the lap belt on pelvis in frontal crashes was analysed.

The Measure of Angle of ASIS and Distance between ASIS and Pubic Symphysis

The shape of the ilium was presented by the angle of ASIS consisting of lines which were extended every 20mm (half width of the seatbelt) from the top of ASIS in oblique directions along the shape of ASIS (Fig.1). Additionally, the distance between ASIS and pubic symphysis [3] was also measured as another factor. Each individual difference was analysed.

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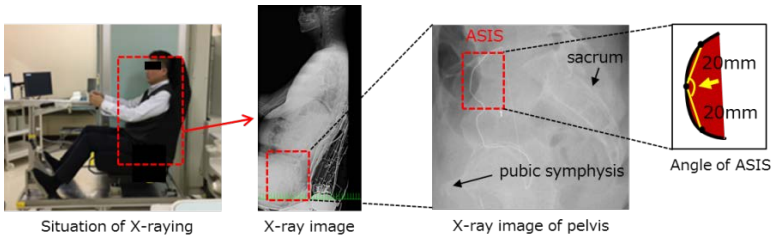

Fig. 1. The image of measuring the angle of ASIS

The Modification of THUMS's ASIS and Analysis of the Lap Belt's Kinematics on Pelvis

In reference to the models, THUMS's ASIS was modified. In this study, simulations were conducted with the same condition of Japan New Car Assessment Program (JNCAP) 56kph full lap frontal impact. Car models, the position of HBMs and restraint state by seatbelt were the same as the simulation conditions in studies of last year [1]. Using the results of FE simulations, the displacement of H-point, rotation of pelvis around the Y-axis, and the lap belt sliding-up movement on pelvis were measured.

III. INITIAL FINDINGS

The shapes of the ilium for 84 subjects were measured. No differences between males and females were seen for the angles of ASIS (Fig.2a). On the other hand, past reports indicate that the pelvis of females tend to be larger than those of males due to parturition [7,9]. Our studies revealed that females have greater individual differences in distance between ASIS and pubic symphysis (Fig.2b). Those factors show less correlation with age, height, and BMI.

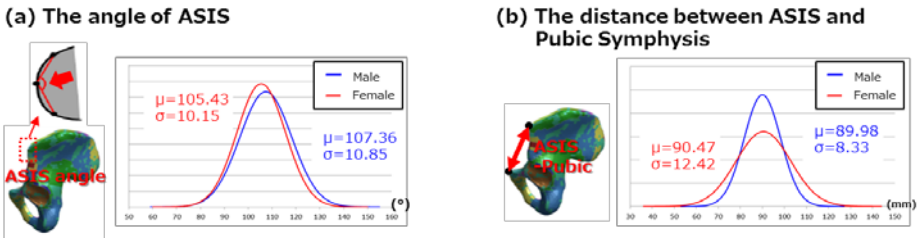

Fig. 2. The individual differences for the shape of ilium

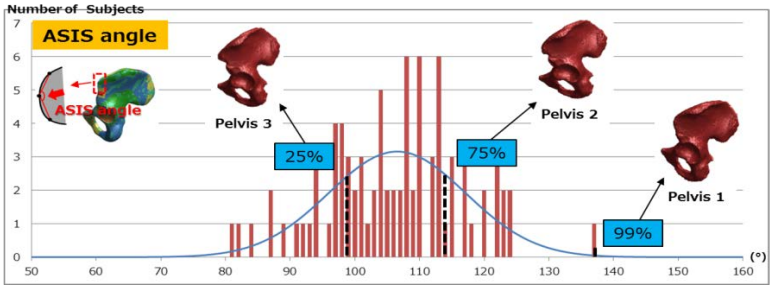

Fig. 3. Normal distribution of ASIS angles and the pelvis equivalent to each percentile

To analyse the effects of the shape of the ilium on the lap belt kinematics in frontal crashes, we selected 99th percentile (equivalent to THUMS ver.4), 75th percentile, and 25th percentile as representative types in consideration of the shape of the ilium and THUMS's ASIS was modified as the shapes of corresponding subjects (Fig.3). In the simulation analysis using those models, there is no difference in the peak movement of the pelvis for the X-axis and peak

rotation angle of the pelvis for the Y-axis. However, the difference was observed in the amount of the lap belt sliding up on the pelvis for the Z-axis (Fig.4). Red arrows in Fig.4 show the difference between the position of ASIS and the centerline of the lap belt.

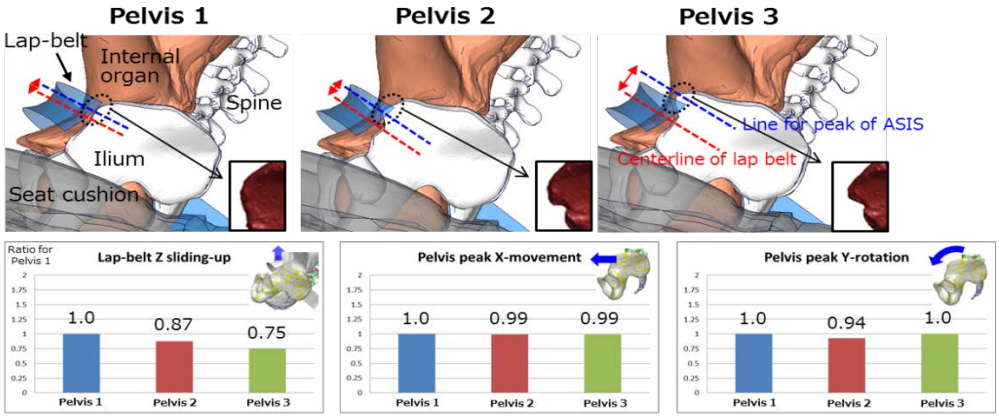

Fig. 4. The results of lap belt and pelvic kinematics using three models

IV. DISCUSSION

The pelvic angle, shape of the ilium (the angle of ASIS and the distance between ASIS and pubic symphysis), and flesh thickness are considered as critical factors for the kinematics of the lap belt on the pelvis. In this study, our analysis revealed that the shape of the ilium is another factor in addition to the pelvic angle. In future, the contribution of the distance between ASIS and pubic symphysis and flesh thickness should also be analysed so that critical factors for the kinematics of the lap belt will be identified and incorporated into models.

LIMITATIONS

In this study, to only investigate the influence of the angle of ASIS, the same model was used in terms of pelvic angle and size, skeletal alignment, and flesh thickness as well as the body size (AM50). Since the actual initial position of the lap belt might be different from that in this simulation analysis and last year's study, the measure for the initial position of seatbelt by the body size should be conducted.

V. REFERENCES

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