

Improving the Accuracy of CAE Simulations for Pedestrian Collision Accidents through Medical-Engineering Collaboration

Mie Tokuyama¹⁾ Takahiro Andoh¹⁾ Koji Onishi¹⁾ Toru Kiuchi²⁾ Takehiro Tsuji²⁾ Noboru Tanase¹⁾

1) Toyota Motor Corporation

1 Toyota-Cho, Toyota City, Aichi Prefecture 471-8572, Japan (mie_tokuyama@mail.toyota.co.jp)

2) Institute for Traffic Accident Research and Data Analysis

5th Floor, 2-7-8 Kanda-Sarugakucho, Chiyoda-ku, Tokyo 101-0064, Japan

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Medical-engineering collaboration combines engineering accident analysis with medical diagnostic information to clarify injury mechanisms and develop effective injury reduction measures. To further improve accident analysis, CAE-based accident reconstruction was applied to an actual pedestrian collision case. This study focused on the influence of body weight distribution on pedestrian kinematics and injury analysis.

Three pedestrian models representing fat, mean, and muscular body types were developed using THUMS v4.02 AM50 while maintaining the same body weight (64 kg). Body mass distribution was modified by adjusting soft tissue density in each body segment. As a result, the center-of-gravity height varied from 104.7 cm to 100.3 cm, and the pitch moment of inertia varied from 10.7 to 12.3 kg·m².

Accident reconstruction simulations were conducted using a vehicle model corresponding to the actual accident vehicle. Vehicle speed, pedestrian posture, walking velocity, and collision location were determined from dashcam footage. During the initial impact, the lower extremities generated the dominant contact force. Consequently, the muscular body type, which had larger lower-limb mass, experienced larger longitudinal acceleration and displacement than the other body types. The head impact position differed by up to 117 mm between fat and muscle type body. (Fig.1) Furthermore, differences in whole-body rotational motion became apparent after upper-body rebound from the hood, where larger inertia resulted in smaller rotational angle. (Fig.2)

To quantitatively evaluate pedestrian motion, a camera-calibration-based image processing method was applied. Anycalib was used to estimate dashcam camera parameters, and the simulated shoulder and hip positions were projected into image coordinates for comparison with accident footage. Comparison of upper-body, shoulder, and hip lean angles indicated that the mean body type most closely reproduced the actual pedestrian motion.

Using the validated mean-body simulation, the mechanism of a parietal subgaleal hematoma was investigated. The collision generated body rotation about the vertical axis, causing the pedestrian's back to contact the hood. Because the right arm became trapped between the thorax and hood, rearward head rotation increased and the top of the head struck the hood, leading to the observed injury. (Fig.3)

These results demonstrate that body mass distribution significantly affects pedestrian kinematics even when height and body weight are identical. Incorporating body-shape information and image-based motion validation can improve the accuracy of pedestrian accident reconstruction and injury mechanism analysis.

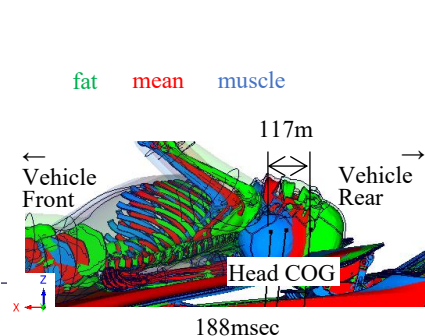


Fig.1 Global X Displacement of Head

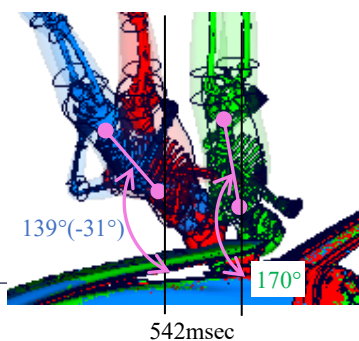


Fig.2 Body Rotation Angle

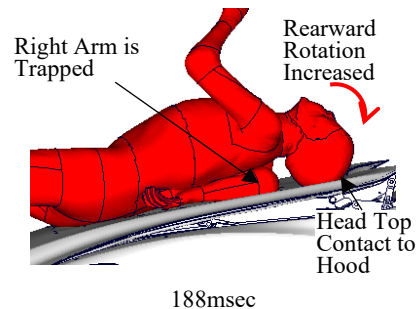


Fig.3 Behavior of Head Contact to Hood Contact Behavior