IOTA Poster # IOTA 2

Development of a CT-Based Finite Element Analysis Model for Verifying the Effect of Shock-absorbing Floors on Fragility Hip Fracture Prevention: An Industry-Academia-Government Collaboration Project in a Super-Aging Country

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Purpose: Drug/exercise therapy and hip protectors can be effective for preventing fragility hip fractures. However, evidence is lacking for shock-absorbing mats, which are sometimes used as an alternative to hip protectors but can be too soft/unstable during movement. In Japan, a newly developed mechanical metamaterial flooring material (MM-floor), with a structure that achieves both stability and shock absorption, is expected to be incorporated into government-led fragility fracture prevention measures. We developed a CT-based finite element analysis (CT/FEA) model to verify the effect of shock-absorbing floors on hip fracture prevention.

Methods: The CT/FEA model was constructed using physical property values of 3 floor materials (thickness: vinyl sheet, 2 mm; sponge mat, 40 mm; MM-floor, 22 mm). A falling model was configured from CT DICOM data of the contralateral femur of an elderly Asian woman with a history of fragility hip fracture, in which the greater trochanter collided with the floor. Concrete was placed below each floor material. Load cells were placed on the femoral head and diaphysis, and elastic materials were constructed on the contact surface of the femoral head and greater trochanter to avoid excessive element destruction in the contact area. The stress, expressed as the constraint reaction force, that caused hip fracture was extracted by a static analysis. The fracture prevention effect was evaluated by a dynamic analysis that reproduced a drop-weight impact test (mass, 11 kg; drop height, 230 mm) equivalent to the energy of a backward fall.

Results: The static analysis showed that trochanteric fracture occurred at 1400 N. The dynamic analysis showed that stress peaked at 1200 N for sponge mat and MM-floor. These floors bounced without destroying bone geometry. With the vinyl sheet, the proximal femur bone geometry was completely destroyed.

Conclusion: The CT/FEA model could verify the effect of shock-absorbing floors on hip fracture prevention without any risk to human subjects, and could be used to improve products by setting arbitrary physical properties.