D1 The Development of a Fracture Risk Evaluation Method by Computer Simulation That Reproduces Pressure Distribution on Bone Due to Compression and Striking

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Learning Overview: After attending this presentation, attendees will have knowledge of the advanced fracture risk evaluation method using computer simulation.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing an advanced fracture risk evaluation method using the Finite Element Method (FEM).

Background: In Japan, which faces a super-aged society, caregiver abuse of the elderly has become a social problem. Quantitative evaluation of external force received by a victim is necessary as a means to prove the murder of the perpetrator when an abuse case occurs. In recent years, it has become possible to evaluate fracture risk considering bone shape and bone density distribution by using computer simulation. Furthermore, a method has been developed to analyze the pressure distribution with high accuracy when the external force applied to the bone is static. On the other hand, even when the external force applied to the bone is dynamic, a uniform average pressure is used as the external force condition in the analysis, even though the pressure distribution varies greatly depending on the tip shape of the blunt instrument. This may reduce the accuracy of the analysis results (fracture risk evaluation).

Purpose and Experimental Outline: This study proposed a fracture risk evaluation method by computer simulation that reproduces the pressure distribution on the bone due to compression and striking, and its usefulness was verified by using it for two cases.

Case 1: Ribs of the Elderly Undergo Static External Forces During Caregiving. When static external force acts on the human body, fracture risk evaluation that reproduces the pressure distribution on bone can be performed by the following procedure: (1) the external force, which is applied to the human body using the pressure textile sensor, is measured. The pressure distribution applied to the bone is estimated by comparing the measured external force with the bone image of the part to which the external force is applied, and (2) the fracture risk is evaluated by adding the estimated pressure distribution to the bone model on FEM.

Case 2: An Infant's Skull Receives a Dynamic External Force When Hit by a Blunt Instrument. When a dynamic external force acts on the human body, fracture risk evaluation that reproduces the pressure distribution on the bone can be performed by the following procedure: (1) a falling weight experiment that reproduces how a steel ball (blunt instrument) collides with the head is performed. The maximum load at the time of collision is measured with a load cell, and the maximum pressure distribution is measured with pressure-sensitive paper; and (2) the fracture risk is evaluated by adding the pressure distribution estimated by the load cell and pressure-sensitive paper to the bone FEM model.

Results and Discussion: It was shown that a bone fracture risk evaluation method by computer simulation, which reproduces the pressure distribution, can be performed by measuring the maximum pressure distribution applied to the bone using the pressure textile sensor in the case of static external force or pressure-sensitive paper in the case of dynamic external force, depending on the load speed of the human body. It was also shown that the conventional analysis method in which the average pressure was applied to the entire external load area of the bone calculated the fracture risk lower than that of the method proposed in this study.

The human body receives dynamic external force not only when it is hit with a blunt instrument or a fist, but also when it crashes, falls, and collides with the floor or road surface. It is considered that the fracture risk evaluation method developed here that reproduces the pressure distribution on the bone by computer simulation would be also a useful tool for evaluating the risk of falling fractures in the elderly and the interpersonal safety of caregiving robots.

Fracture Risk Evaluation, FEM Analysis, Pressure Distribution

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