D13 Improvement of the Human Body Damage Evaluation Method by Computer Simulation: Verification of Infant Bone Properties Compared With Actual Experiments

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Learning Overview: After attending this presentation, attendees will understand 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 computer simulation.

For injuries to young children, quantitative evaluation of external forces is required to find the possibility of abuse and prove its criminality. Previous studies revealed that soft tissues, such as skin and muscle, have a large influence on human body damage by impact force, and soft tissue was taken into consideration in impact force measurements. Also, it is difficult to measure the mechanical properties of soft tissue and quantify the relationship between its thickness and buffering performance. However, the presence or absence of soft tissue is more important than its characteristics in assessing the fracture risk of impact force by hitting. The finite element method is a method of visually expressing the behavior by calculation, and computer simulation of pig tail fracture load by Finite Element Analysis (FEA) analysis revealed that, in Young's modulus of soft tissue, 0.8, 1.4 kgf/mm^2, the fracture load was respectively 693, 710 N (2% difference). In thickness of soft tissue: 0.5, 1.5mm, the fracture load was respectively 690,705 N (2% difference). Fracture load in the absence of soft tissue was 585 N (18% difference, compared to 0.5mm). Therefore, the presence or absence influences the fracture load more than the soft tissue property. On the other hand, bone density and fracture load are closely related, and many studies reveal the importance of bone density such as Okuizumi et al: (Fracture Strength) [N]=501+2908 (BMD: Bone Mineral Density) [g/cm^2].[1] In addition, a detailed risk evaluation method of fracture from an individual bone shape and bone density has been developed and is being used in the medical field in Japan. However, in the risk evaluation of bone fractures caused by blows, it is currently difficult to make detailed evaluations in consideration of an individual's physical characteristics.

The problems in evaluating advanced fracture risk using computer simulation are as follows: (1) it is not possible to quantitatively evaluate the influence of soft tissue; (2) the verification by actual bone is limited to the parts (femur, vertebral column, teeth), and the simulation accuracy of other parts is not sufficiently verified; and (3) it has not been verified whether sufficient simulation accuracy is also obtained for bones having different material properties, such as infant bone.

As mentioned above, point 1 has already been verified, and it is necessary to conduct research on points 2 and 3. Therefore, in this study, fracture experiments on young pig tails and numerical analysis by computer simulation were performed to investigate the simulation accuracy for infant bones with different material properties. After the fracture load was investigated by the static compression test using the material testing machine, numerical analysis was performed by the computer simulation using the FEA under the same conditions as the fracture experiment.

As a result, the average fracture load was 143 N at the jig tip angle 60° to 90 ° in actual experiments, and the fracture load was 151 N in the FEA. Therefore, in fracture risk evaluation using FEA, sufficient simulation accuracy could be confirmed, even with infant bones. This study also conducted a verification aimed at further improving the fracture risk evaluation method using FEA. From these results, the accuracy of the fracture risk evaluation method using computer simulation improved. As a future task, it is conceivable to establish a detailed model construction of an infant skull and establish an evaluation method of infant fracture risk that can be used for appraisal.

Reference(s):

1. Okuizumi, Hiroyasu, Harada, Atsushi, Iwata, Hisashi, Konishi, Nobuo. Effect on the Femur of a New Hip Fracture Preventive System Using Dropped-Weight Impact Testing. *Journal of Bone and Mineral Research* 13 (1998(1940-1945)

Fracture Risk Evaluation, FEM Analysis, Infant Bone