D12 Improving the Accuracy of the Quantitative Method for Evaluating Fracture Load by Blunt Force: A Proposal for the Fracture Load Analysis Method Using a Victim's Bone Shape, Bone Mineral Density Distribution, and Soft Tissue Thickness

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Learning Overview: After attending this presentation, attendees will understand the advanced fracture risk evaluation method.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing an advanced fracture risk evaluation method.

Restrictions on guns are strict in Japan, so many weapons used in murder cases are blunt weapons or knives. In the cases of murder and domestic violence using a blunt weapon, such as a hammer or hand, it is necessary to quantitatively evaluate the external load received by the human body and to objectively show the killing ability of the blunt weapon in court.[1] However, although there are established evaluation methods, such as head injury criterion for brain damage, there is no quantitative method for evaluating the fracture risk using a blunt weapon. Therefore, this study accurately calculated the load on the bone by striking the load cell covered with dummy skin with the blunt weapon, and the method for evaluating the fracture risk was established by comparing with the literature the value for the fracture load in every body part.[2] In addition, bone strength evaluation technology that accurately reflects bone characteristics, such as individual bone shape and Bone Mineral Density (BMD) distribution using computer simulation, has been developed and used in the medical field. It is considered that this technology could be used as an effective tool in fracture risk evaluation, and a quantitative method for evaluating fracture risk by static load, such as nursing care, has been developed. However, in the above two cases, it is not possible to quantitatively evaluate the fracture load by blunt force, such as the impact of the blunt weapon, considering the individual bone characteristics and the soft tissue thickness.

In this presentation, a quantitative method for evaluating fracture load by blunt force was designed and the method is reported. The outline of the method is shown below. The blunt force was applied to the load cell covered with dummy skin, and was converted to energy by measuring the propagation load with the load cell: the energy input to the dummy skin was calculated.[2] Then, the relationship between the input energy and the load that the bone received in each soft tissue thickness was clarified in advance: this is the logistic line of the load that bone received. The load that bone received was calculated by applying it to the input energy calculated for this logistic line. In the past, fractures were evaluated by comparing this load and the literature values for the fracture load, and the effects of bone characteristics in individuals have not been taken into consideration. On the other hand, fractures can be evaluated using the human bone model that reproduces the victim's bone characteristics in bone strength evaluation based on Finite Element Analysis (FEA). However, the buffer property of soft tissue cannot be reproduced during analysis. Therefore, this study combined these experimental and analytical methods. As a result, it was possible to analyze the fracture load by accurately calculating the load received by the bone using the above method and applying this load to the load condition in FEA for human bone model. The proposed method enabled fracture analysis using the victim's bone characteristics and soft tissue thickness.

Super soft urethane resin (EXSEAL) was used for dummy skin, and CLM-10KNS (TML) was used for load cell. As soft tissue, porcine soft tissue, which is a human substitute, was used. MECHANICAL FINDER (RCCM) was used for bone strength evaluation software using the finite element method. With this software, a bone model that accurately reflects BMD can be created by the quantitative computed tomography method.

A prototype has been completed to quantitatively evaluate fracture load by blunt force using the flow and equipment described above. Also, the fracture load F [N] is given by the following formula when a load is applied to the infant skull in the area A=100 to 1,000 [mm^2] in this study.[3] $F=7.7615\,A + 1786$. Thus, it was clarified that the load loading area greatly affects the fracture risk. Therefore, aiming at the application of the load area to the load condition in FEA, the load area that the bone receives is measured experimentally. In addition to experimental verification using this protocol, it is applied to the actual appraisal.

Reference(s):

1. Y. Ito et al., *J.AMME*, Vol.28, No.1, (2008), pp.39-42.
2. T. Fukuoka et al. *Proceedings of the American Academy of Forensic Sciences*, 70th Annual Scientific Meeting, Seattle, WA. 2018. p.430.
3. T. Matsubara et al. *J. JSME*, Vol.18, No.4, (2018), pp.278-282.

Fracture Risk Evaluation, Individual Bone Characteristics, Soft Tissue