BIOMECHANICAL EVALUATION OF HIP PAD FOR ELDERLY MALE HIP FRACTURE

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ABSTRACT

This paper discusses the biomechanical effects of the proposed hip pad using multibody simulation for elderly male combined with a FE thigh model. We considered variety of fall conditions in actual gait of elderlies as analyses conditions for multibody model. The FE thigh model was used to evaluate the stress distributions and the risks of hip fracture. The efficiency of hip pad was evaluated as the decrease of fracture risk in comparison with that in the simulation without hip pad. The simulation results showed the developed hip pads are effective not only for female but also for male.

1. INTRODUCTION

In recent year, the number of fall accidents of the elderly has increased with the population of elderly. Such an accident often causes hip fracture which is a fracture of femoral neck. Mechanical cause of hip fracture is an impact to the greater trochanter of femur, and about 70 percent of this fracture is attributed to fall accident. Due to osteoporosis, the number of incidence increases with age drastically among 70 years of age or more. It takes longer time for treatment and recovery of this fracture for elderly than that of young, thereby it causes gait disturbance and bedridden. Thus prevention of hip fracture is one of the important issues to be solved in the elderly health care and welfare.

We have found that hip pad is effective in the prevention of the fracture in our previous study [1]. The protector designed for elderly female evaluated and commercialized by conventional research. However the effectiveness of this hip pad for elderly male has not been evaluated. The purpose of this study is to develop a hip fracture simulation model for elderly male that considered of various fall factor and condition, and conduct biomechanical evaluations of hip pad for male.

2. ANALYSIS

2.1 Elderly male model and fracture evaluation

A three dimensional elderly male model was developed on MADYMO (Tass International). Using MADYMO, we conducted mutibody-finite element combined simulation to reproduce the body motion during fall and analyze the stress distribution at femoral neck. The male multibody model developed by scaling the female model which had previously developed.

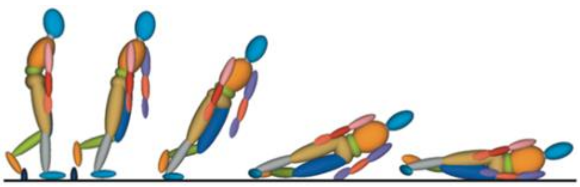


Fig. 1 Fall action by multibody

In order to evaluate the risk of hip fracture, we need to clarify the stress distribution at the femoral neck. By incorporating a hip joint-thigh finite element model into the male multibody model, we conducted stress analyses for the proximal femur considering the impact from the ground due to fall. The hip joint-thigh finite element model was also constructed by scaling the female model.

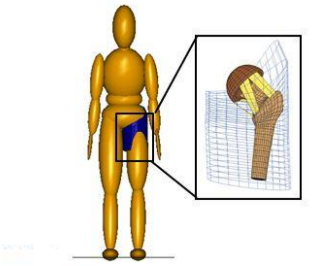


Fig. 2 Multibody-FE model

The fracture risk indexes shown in Equation (1)-(3) are introduced for compressive, tensile and shear modes. S_c, S_t and S_s are the strength of bone for each loading mode which are estimated using bone mineral density. The maximum value of those three indexes is used as the fracture risk for the femoral neck.

$$\sigma_c \;/\; S_c = Fr_c \tag{1}$$
$$\sigma_t \;/\; S_t = Fr_t \tag{2}$$
$$\sigma_s \;/\; S_s = Fr_s \tag{3}$$

2.2 Hip pad

A sample of hip pad model shown in Figure 3.

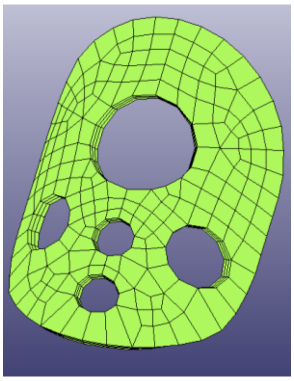
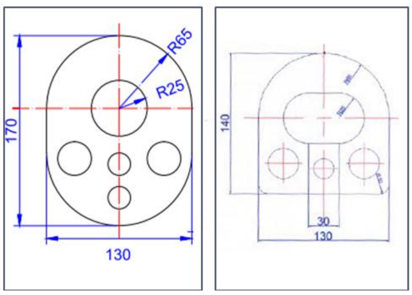


Fig. 3 Hip pad model

We evaluated two types of hip pad models shown in Figure 4. Mode1 1 is a commercial model for female (Kaneka Corporation, Japan). Model 2 is based on the geometry of the hip pad for disposal diaper (Koyo Corporation, Japan).



(a)Model 1 (b) Model 2

Fig. 4 Hip pad

3. RESULTS

Fracture risks Fracture risks of the male fall simulations were smaller than those of female in all conditions. An example of simulation results is shown in Figure 5. Hip pad designed for female showed significant decrease of the fracture risk but the effectiveness of the hip pad (decrease ratio of fracture risk) was less than that of female. We did not find any negative effects of hip pad for male in all simulation conditions.

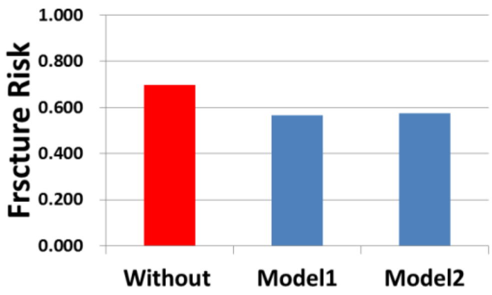


Fig. 5 An example of the effectiveness of hip pad for male (fall by faint)

4. CONCLUSION

Effectiveness of hip pads developed for elderly female was evaluated by multibody-FE combined simulation. The results showed that the hip pads are also effective in elderly male.

REFERENCES

[1] Tanaka, E. et al., Biomechanical Evaluations of Hip Fracture Mechanism in Pedestrian Fall Accident, Transactions of the Japan Society of Mechanical Engineers, Series A, vol. 72 (2006), pp. 1799-1807.(in Japanese)

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