

Basic Research on Development of Dummy Skin for Risk Evaluation of Fracture and Skin Injury



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AMERICAN ACADEMY OF FORENSIC SCIENCES

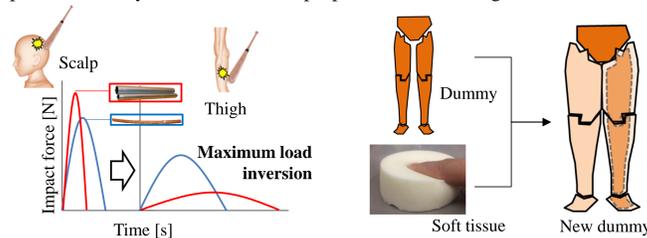
February 13-18, 2017
 Hyatt Regency New Orleans
 601 Loyola Avenue, New Orleans, LA, USA, 70113

Abstract

In this study, focusing on urethane gel as the material of the dummy skin, we measured the dynamic viscoelasticity and the buffer performance against the impact load using a rheometer and drop tester. In the measurement of dynamic viscoelasticity, covered the surface of the urethane gel in simulated epidermis. Further simulated epidermis by loading the tension of the two-axis, was found to be able to simulate the dynamic viscoelasticity of the human skin of 20s men. In the measurement of the buffer performance, detained the side of the urethane gel. We performed the comparison with the cell sponge which had been used as biological soft tissue substitute materials for blow evaluations until now. As a result, urethane gel detained sides in a wide energy range than sponges, was found to be usable as a biological soft tissue substitute material for blow evaluation.

Introduction

It has been revealed that presence of biological soft tissue such as skin and muscle has a large effect on the presence or absence of bone fracture resulting from a dynamic load such as hit by a blunt object. However, the effect has not been quantified to date since the technique of accurately measuring dynamic mechanical properties of biological soft tissue does not yet exist. In addition, data regarding the dynamics properties including the viscoelasticity of skin are essential to evaluate skin damage caused by external forces. Since the presence of biological soft tissues has a great influence on the presence or absence of fracture due to dynamic loading, it is necessary to incorporate the soft tissue of the body in the physical model used for human body damage evaluation. However, there are few examples in which living body soft tissues are actually incorporated. In this study, we measured the dynamic viscoelasticity and the buffer performance against the impact load of the urethane gel for the development of dummy skin which reproduced the dynamic mechanical properties of the biological soft tissue.



Shock-absorbing properties using drop-test machine

Materials

【Cell sponge】

20 × 20mm (t=10mm)



To simulate the buffer performance of the soft tissue.⁽¹⁾

【Porcine muscle fiber】

20 × 20mm (t=10mm)



Mechanical properties equal to human soft tissue.⁽²⁾

【Urethane gel : Human skin gel (HSG)】

HSG5

20 × 20mm (t=10mm)

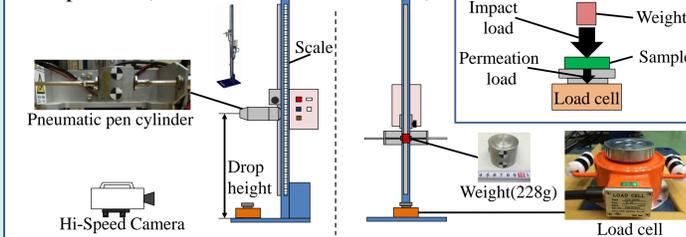
To simulate the texture (static compression property) of the soft tissue.⁽³⁾

	Hardness	Indication
HSG0	AO/0/1	Comparable to the abdomen
HSG5	AO/5/1	Comparable to the arm

※ Hardness conforms to ISO7619 (Type AO durometer)

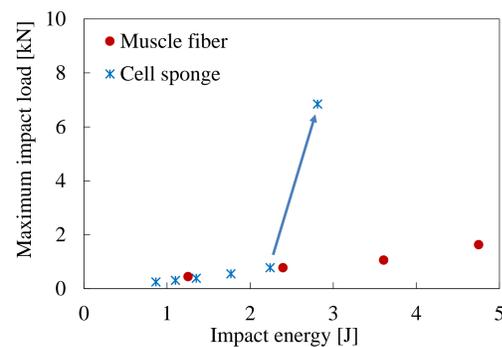
Methods

【Drop tester (DT-202 : YOSHIDA SEIKI)】

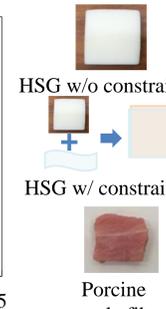
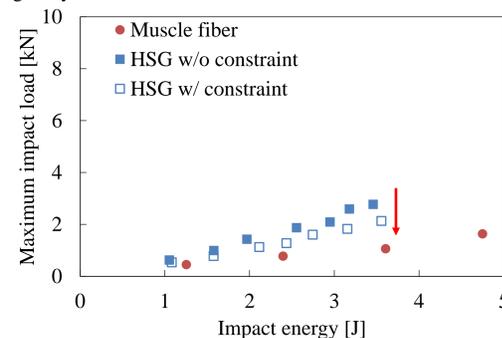


- The impact load is applied to the test piece by the dropping of a weight.
- Permeation load measurement using the load cell.

Results & Discussions



- Cell sponge can simulate Porcine muscle fiber in the low energy region.
- When the cell sponge exceeds a certain impact energy, the permeation load greatly increases.



- HSG can simulate porcine muscle fiber in a higher energy range than energy region where cell sponge can simulate porcine muscle fiber.
- By restraining the side of the HSG with a urethane film, it shows buffering performance similar to that of porcine muscle.

- Although the properties change when the cell sponge exceeds about 2.2J, it became clear that HSG has properties closer to porcine muscle fiber up to the higher energy range.
- It is thought that deformation behavior of soft tissue is also involved in shock-absorbing performance because it has been improved by constraining.

Dynamic viscoelasticity evaluation using rheometer

Materials

【Human arm】 【Human skin gel (HSG)】



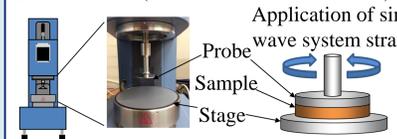
	Age	Gender	Weight (kg)	Height (cm)	Hardness
M20-1	25	Male	51.0	173	AO/2/1
M20-2	24	Male	55.0	169	AO/2/1
M20-3	21	Male	48.0	164	AO/1.3/1
M20-4	22	Male	62.1	166	AO/3/1
M20-5	22	Male	60.0	173	AO/1.7/1
M20-6	22	Male	60.8	163	AO/9.3/1
M20-7	22	Male	53.2	160	AO/4/1
M20-8	23	Male	83.5	173	AO2.7/1
M20-9	22	Male	55.8	168	AO/1.3/1
HSG15					AO/15/1

※ Hardness conforms to ISO7619 (Type AO durometer)

- The human arm is measured in the muscle relaxation state.

Methods

【Rheometer (AR550: TA Instruments)】

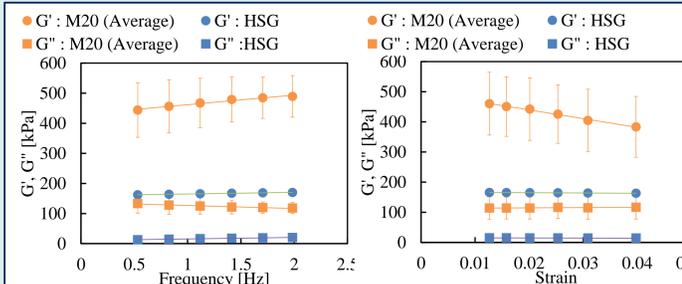


- Performing two measurements.

- Application of shear deformation to the sample by probe.
- Measuring the storage elastic modulus (elastic component: G') and loss elastic modulus (viscous component: G'') from the resistance of the shear deformation.

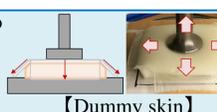
	Probe diameter (mm)	Strain	Frequency (Hz)	Probe pressing force(N)
Strain sweep	20	0.01~0.04	1	5.0
Frequency sweep		0.02	0.5~2	

Results & Discussions



- Dynamic viscoelastic properties of HSG and human arm (20s men) are largely different. (Human skin gel shows a considerably low value)
- Since human skin is always in a state of being extended by 5 to 30%⁽⁴⁾, it is considered that this skin elongation affects dynamic viscoelastic properties.

Therefore, the urethane film is given an elongation to make it a pseudo epidermis. Combine it with HSG and create dummy skin. (By using 2 sheets, elongation is made to 2 axes)



Conclusions

The main findings are as follows:

- In the impact performance evaluation, it became clear that urethane gel can be used as a dummy skin in a wider energy range than the conventionally used cell sponge.
- It was determined that both the form change and material are important as regards the shock-absorbing properties of soft tissue.
- In the dynamic viscoelasticity evaluation, it was possible to create a dummy skin simulating human skin (20s men).
- Dynamic viscoelastic properties of human skin are greatly different depending on age and gender, so it is necessary to prepare it for each age and gender.
- It was proposed that the urethane gel is useful as a dummy skin for human body damage evaluation by improving processing such as surface processing as a base.

Additional studies on the quantification of the static and dynamic mechanical properties of soft tissue are recommended.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number JP16H03134. I would like to thank the Japan Food Machinery Manufacturers' Association, which sponsored a part of this study and the Exseal Corporation for providing human skin gel of the test material. Advice and comments given by University of Yamagata Hospital doctor, Hiroshi Mitsui and a nurse, Kaori Sakuramoto, has been a great help in this study.

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