STRUCTURAL AND LUBRICATION PROPERTIES OF THE HYDRATION LAYER OF ARTICULAR CARTILAGE

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Biotribology ; Friction ; Everyday life tribology ; Articular cartilage

ABSTRACT
[Introduction]
Previous studies indicated that a hydration layer is formed an articular cartilage surface with proteoglycan molecules protruding from cartilage surface. The hydration layer contributes to excellent lubrication property of articular cartilage[1~3], but its detailed structure – function relation has not been clarified yet. In this study, we investigated structural and lubrication properties of the hydration layer to elucidate its lubrication mechanism.
[Method]
Cartilage specimens were harvested in a cylindrical shape from the load-bearing area of the distal femur of immature porcine knees. In addition to intact cartilage samples, rubbed cartilage samples were prepared in which the hydration layer of the samples was removed by rubbing against a flat glass plate with a friction distance of 60 m. Surface morphology of cartilage samples was observed using an amplitude-modulation atomic force microscope, and the cross-sectional imaging of hydration layer was conducted using a frequency-modulation atomic force microscope. Friction test was performed for the cartilage samples against an alumina ceramic ball of 3 mm in diameter with a friction speed of 0.5, 1.0, 5.0 and 10 mm/s. The load was 0.9 N (maximum surface pressure : 2.25 MPa), and the total friction distance was 1.0 m.
[Result and Discussion]
Surface morphology revealed that the hydration layer was removed with 60 m-rubbed cartilage. Cross-sectional imaging revealed that a hydration like layer with a thickness of approximately 6 μm was confirmed on intact cartilage surface (Fig. 1). The coefficient of dynamic friction of intact cartilage was lower than that of 60 m-rubbed cartilage, and the coefficient of dynamic friction of intact cartilage tended to decrease with the increase of friction speed (Fig. 2). These findings suggest that the hydration layer contributes to improvement of the lubrication property of articular cartilage.

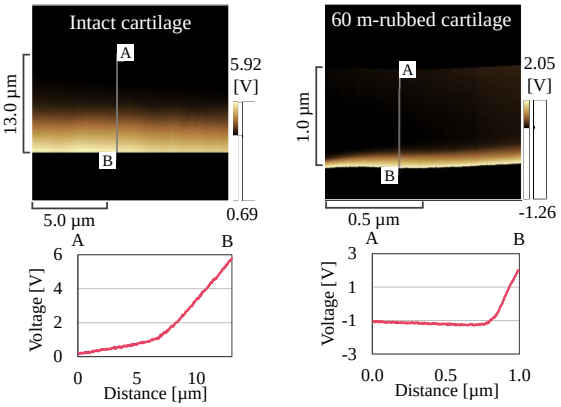

Fig. 1 Z-X mapping images (upper) and voltage profile in arbitrary section (lower) of hydration layer on cartilage

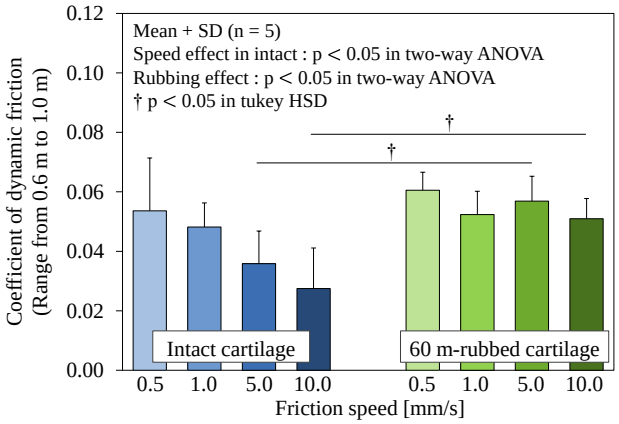

Fig. 2 Coefficient of dynamic friction of intact and 60 m rubbing cartilage

REFERENCES
[1] Walker, P. S., Charles C Thomas, 219, 1977.
[2] Sasada, T., Journal of Biomechanics, 21, 1999, 17.
[3] Kobayashi, T., Nakamura, R., Mitsui, H., Fujie, H., Abstracts of the 41 th annual meeting of the Japanese Society for Clinical Biomechanics, 2014, 156.