**EVALUATION OF THE INTERNAL STRUCTURE CHANGE OF ARTICULAR CARTILAGE WITH WEIGHT-BEARING IN TERMS OF ¹H-NMR RELAXATION BEHAVIOR**

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**Introduction:** Articular cartilage plays an extremely important role in absorption and dispersion of external force with load. Major solid components of articular cartilage are collagen fiber and proteoglycan. Collagen fiber is considered to work as a flexible skeleton in the cartilage tissue. The cartilage tissue is 60 - 80 % water by wet weight due to highly hydrophilic proteoglycan existing in gaps among the collagen fibers. When a weight load is given, the articular cartilage is deformed to gradually release the water, and this absorbs as well as disperses the weight load. Moreover, the water squeezed out from the cartilage contributes to lubrication during articular movements. In the present study, I analyzed a change of articular cartilage internal structure with load by the proton nuclear magnetic resonance method (¹H-NMR method).

**Materials and Methods:** Materials were obtained from 15 freshly prepared bovine femoral condyles. Two cylinder shaped articular cartilage specimens with underlying cancellous bone (7 mm in diameter) were obtained from weightbearing and non-weightbearing regions of a medial femoral condyle. These materials were subjected to NMR measurements with static load (0.15, 0.3, 0.5, and 1.0 MPa) by using the compression device. The ¹H longitudinal (T₁) and transverse (T₂) relaxation times were measured by fast-inversion-recovery method and multi-spin-echo method, respectively. The ¹H DQF MR images were measured by changing the creation time (t) from 0.3ms to 10.0 ms. NMR measurements were recorded on an AMX-300wb Bruker NMR spectrometers. All the experiments went in room temperature (about 25 degrees Celsius).

**Results:** The stress-strain curve provided from thickness of the articular cartilage which was measured with a GRE image did not recognize the statistically significant difference between in cartilage of weightbearing and non-weightbearing regions. T₁ relaxation time at the layer directly below the cartilage surface decreased remarkably with weight load on the articular cartilage in both loaded and unloaded regions. The reduction rate of T₁ at the layer directly below the cartilage surface was 59.7 % in loaded and 57.9 % in unloaded region under 1.0 MPa of weight load. On the other hand, the deep parts of the articular cartilage within 0.1 mm from the deepest layer showed relatively small changes of T₁ relaxation time. These tendencies were remarkable at the loaded region of the cartilage samples. With 1.0 MPa of weight load, T₁ relaxation time distributed nearly uniformly in the cartilage (Fig. 1). T₂ relaxation time at the layer directly below the surface greatly shortened with weight load in the loaded region. T₂ relaxation time at the middle layers showed relatively short values before the weight was loaded, and not greatly changed with weight load. T₂ relaxation time at the deep layers of articular cartilage was as long as 30 ms before weight was loaded, but became shorter with weight load (Fig. 2).

**Discussions:** Depending on weight load, the tension of articular cartilage increased. This change presents that articular cartilage supports an external force in accordance with the Donnan’s formula by an increased swelling pressure that is induced by an increased amount of water squeezed-out by the weight load. It was found that the distribution of water content in articular cartilage is drastically changed at this moment (Fig. 1). As the T₁ relaxation time, water transfer by an external force is largest at transitional zone, so that the water is suggested to contribute to viscosity for absorbing external forces. Moreover, the water squeezed out from this zone can easily effuse to the sliding surface via the top layer of the articular cartilage, thereby playing an important role in lubricating the joint. T₁ relaxation time and a ¹H-DQF MR image have the information of orientation of collagen fiber. Because of a result of T₁ relaxation time and a ¹H-DQF MR image, the collagen fiber which was randomly aligned in non weight load at the surface layer and the intermediate layer increased the orientation by weight load, and the collagen fiber which oriented perpendicularly at the deep layer thought that the orientation decreased by maximum load.

**Conclusions:** With weight load, water begins to flow from intermediate layer, and articular cartilage absorbs weight load. In addition, orientation enhanced collagen fiber in arthrosis collagen fiber in superficial layer, and it became clear at the depths that orientation decreased.

**Fig. 1-a, b:** Effects of external load on the T₁ profiles from the bottom to the surface layer of the articular cartilage obtained from weight bearing (a) and non-weight bearing (b) regions.

**Fig. 2-a, b:** Effects of external load on the T₁ profiles from the bottom to the surface layer of the articular cartilage obtained from weight bearing (a) and non-weight bearing (b) regions.

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