



Evaluation of electrical impedance related to matrix composition of articular cartilage using the two-electrodes impedance measurement

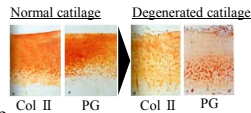
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Introduction

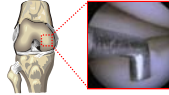
Degeneration of articular cartilage

- Loss of proteoglycan and collagen
- Decreased biomechanical properties



Diagnosis for articular cartilage

- It is important to diagnose a degeneration of the articular cartilage at an initial stage.



Conventional hand-held medical device

- Ultrasound method
- Indentation method
- Streaming potential method

Problems

- Difficulty of the adjustment of the device in a narrow joint cavity
- Damage of the detected tissue due to the pushed probe

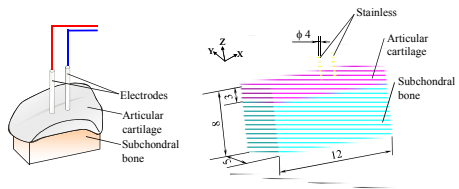
The hand-held device which can evaluate quantitatively degeneration of articular cartilage is needed for clinical use.

The purpose

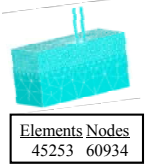
Develop the measuring system using an electrical impedance method to evaluate electrical properties of articular cartilage related to the difference in matrix composition.

Electric field analysis

Analysis model



Symmetry model

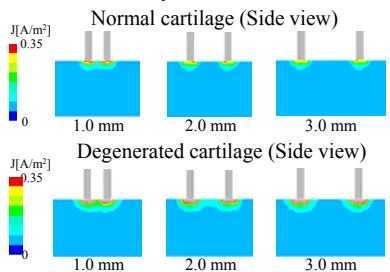


Analysis condition

- Normal cartilage
- Degenerated cartilage

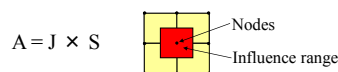
	Electrical resistivity ($\Omega \cdot m$)	Amplitude	10 m Vrms
Articular cartilage	5.56	Frequency	10^4 Hz
Degenerating cartilage	2.78	Electrodes	1.0, 2.0,
Subchondral bone	16.7	distance	3.0 mm
Stainless	7.20×10^{-7}		

Electric field analysis



Calculation method of the measurement range

Calculation of the current value



Current values were calculated using the influence range and the current density.

Comparison with 10 nA of minimum current value for potentiostat

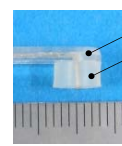
Calculation of the measurement range

Electrodes distance	The measurement range of the depth	
	Model.1	Model.2
1.0 mm	0.6 mm	0.8 mm
2.0 mm	0.65 mm	0.9 mm
3.0 mm	0.7 mm	1.0 mm

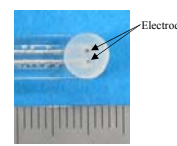
- Since the difference between the measurement range of the normal cartilage and the measurement range of the degenerated cartilage is minimum in the case for 1.0 mm, the measurement range was in the thickness of the articular cartilage.

Fabrication of the probe

Side view



Top view



The diameter of wound opened by operation in osteoarthritis is about 6 mm.

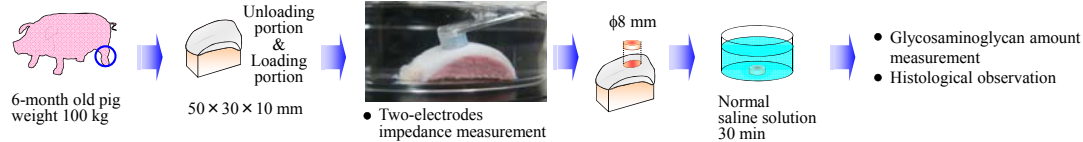
The height and width of the whole electrode was designed to 6 mm.

Materials

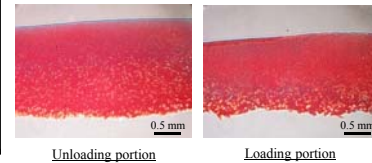
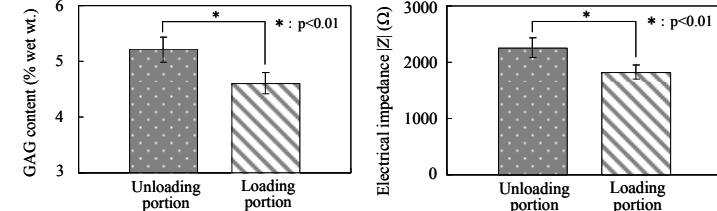
- Polycarbonate
- Silicon
- Stainless

Validation of measurement method

Material and method



Experimental result



- The electrical impedance related to the differences in matrix composition of articular cartilage can be evaluated by the two-electrode impedance method with the probe.
- The developed impedance measurement can be a minimally invasive technique and suitable for in vivo quantitative examination under arthroscopy.

Conclusion

The electrical impedance of articular cartilage depended on the amount of GAG, and the difference in the electrical impedance between the loading and the unloading portion was evaluated by the developed two-electrode impedance measurement.