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DIFFERENCE OF ELECTRICAL IMPEDANCE BETWEEN TYPICAL BENIGN PROSTATIC HYPERPLASIA TISSUES AND BEACH BALLS RETRIEVED AFTER HOLMIUM LASER ENUCLEATION OF THE PROSTATE

Hypothesis / aims of study

Different pathologic features between typical benign prostatic hyperplasia (BPH) tissues and beach balls which are retrieved after Holmium Laser Enucleation of the Prostate (HoLEP) [1] may affect the electrophysiological characteristics of the two types of the tissues. To investigate the difference of electrical impedance between the two types of prostatic tissues, our group has developed a needle sensor device by incorporating electrical impedance spectroscopy (EIS) sensor on a tip of a hypodermic needle.

Study design, materials and methods

Prostatic tissue samples from 10 patients who presented beach balls during morcellation after HoLEP were collected. A total of 10 respective pieces of typical BPH tissues and beach balls were prepared for the study by randomly selecting one piece of each type of tissues from each patients. The needle device with EIS sensor was fabricated by using the microelectromechanical system technology (Fig. 1a–1c) and was connected to an impedance analyzer to measure the impedance of the tissues [2]. The impedance of the samples was measured at the frequency range from 100 Hz to 1 MHz by inserting the EIS needle device at the depth of 2 mm into the tissues. Once the impedance of the samples were measured, they were pathologically investigated. The mean magnitude of impedance between typical BPH tissues and beach balls at each frequencies between 100 Hz and 1 MHz were compared, and the degree of correlation between the magnitude and frequency in each type of tissues were evaluated. Also, the variations of magnitude according to the frequency were compared between the two types of prostatic tissues.

Results

The mean magnitude of the beach balls were tended to be larger than that of the typical BPH tissues at all frequencies from 100 Hz to 1 MHz (Fig 1d). Notably, significantly larger mean magnitudes were measured in the beach balls compared to the typical BPH tissues at the frequencies higher than 15.9 kHz ($p \leq 0.02$ at all frequencies higher than 15.9 kHz). Also, a significant negative correlation was presented between the measured magnitudes and frequencies in beach balls ($p < 0.001$) and typical BPH tissues ($p < 0.001$) which the correlation coefficient (*r*) was calculated as –0.28 and –0.29, respectively. When the measured magnitude of the tissues were log-transformed, the variation of mean log-transformed magnitudes according to the frequency was significantly different between the two types of prostatic tissues ($p < 0.001$). The pathologic features of the beach balls presented pure stromal nodule of nodular hyperplasia (consisted of only stroma) while the typical BPH tissues presented mixed epithelial-stromal nodule of nodular hyperplasia (composed of stroma + epithelium).

Interpretation of results

Electrical impedance represents a measure of total resistance to alternating current, and is defined in the frequency domain (Hz) [13]. The EIS sensor could differentiate between the two types of the prostatic tissues by comparing not only their magnitude of impedance, but also their variation of log-transformed magnitude according to the frequency. The significant difference regarding the magnitude of impedance between the typical BPH tissues and beach balls is assumed to be affected by the difference of their pathological characteristics. Since the beach balls have more abundant stromal content compared to the typical BPH tissues, its larger mean magnitude of impedance is likely to be attributed by a larger amount of stroma contained in the tissues. Such results imply that the amount of stromal content affects the absolute value of impedance among the same type of tissues.

Concluding message

The needle device with EIS sensor could effectively discriminate between the typical BPH tissues and the beach balls by measuring their electrical impedance. The difference of impedance between the two types of prostatic tissues is assumed to be attributed by the amount of stromal content in the tissues.

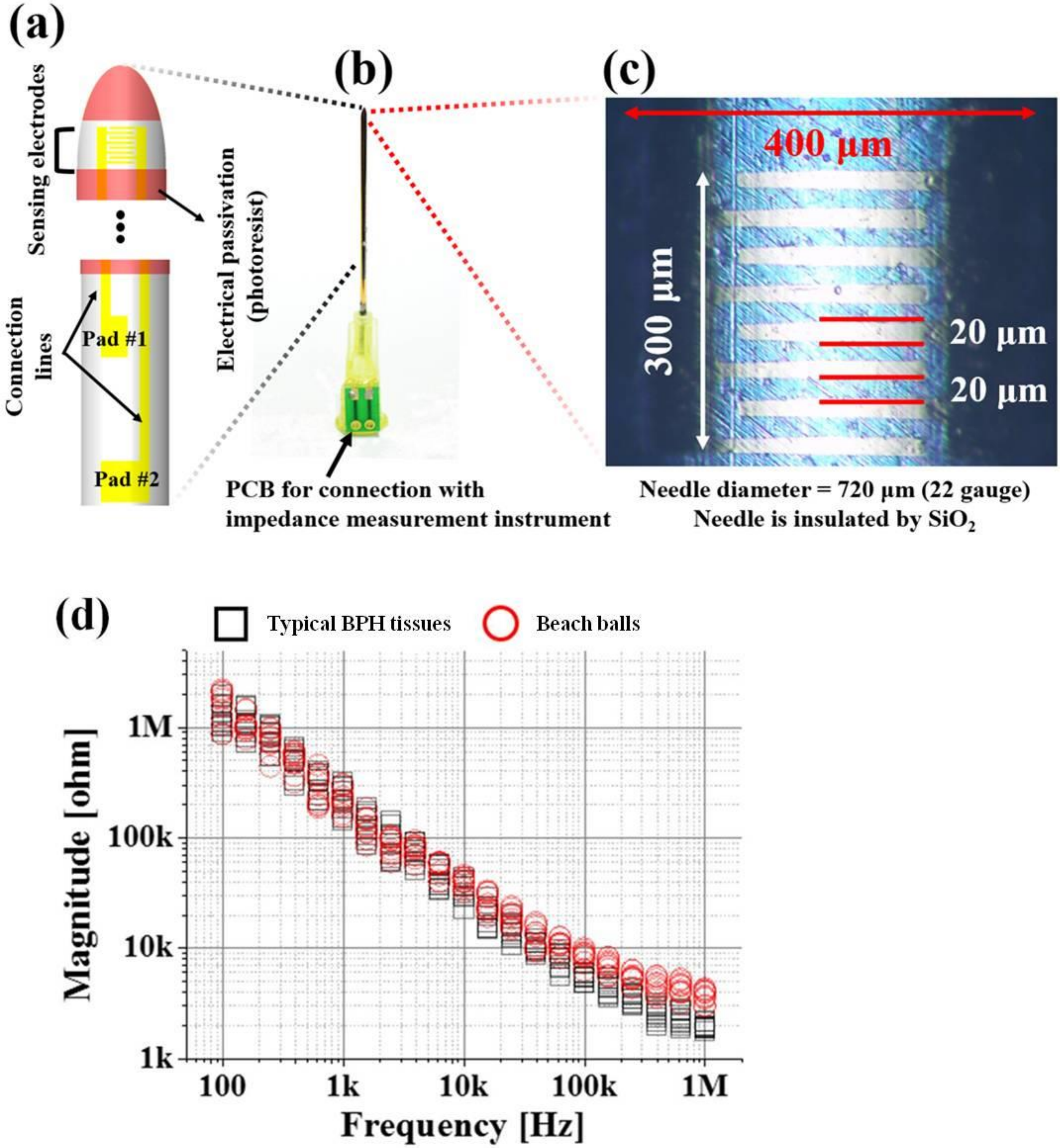

Fig 1. (a) Schematic design of the needle sensor, (b) needle sensor assembled for experiments, (c) fine sensing electrodes at the end of the hypodermic needle (diameter: 720 µm), and (d) magnitude of impedance measured from the typical BPH tissues (n = 10) and the beach balls (n = 10) in the frequency domain (100 Hz – 1 MHz).

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