Development of a New RFA Heating Applicator using a Bimetal

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Radiofrequency ablation, which is an attractive cancer treatment, is a minimally invasive technique that provides favorable clinical outcomes. In the treatment, a needle electrode is inserted into the tumor and radiofrequency energy is supplied to necrotize the cancer. However, the conventional method has a narrow heating area, and various ingenuities have been proposed to expand the heating area. In the clinic, needles that can be manually deployed to expand the heating area have been used. On the other hand, these devices are not custom-made for each patient and it might cause thermal damage to surrounding tissues on incomplete heating. To address these problems, we developed a new needle electrode using a bimetal.

Bimetals possess the property of curving, i.e., bending when heated. By changing the dimensions of the bimetal, it is possible to control displacement. We validate the possibility of extending the heating area by bimetal curvature during heating. The experimental procedure was as follows. First, a tissue is prepared to mimic agar phantom (0.3 % (w/w)) and the Young's modulus is measured according to the Hertz theory [1]. Consequently, the Young's modulus was found to be 2.5 kPa, which is equivalent to that of a biological soft tissue. Second, we optimized the bimetal dimensions (30 mm × 2 mm × 0.13 mm) to achieve a large displacement. Finally, the bimetal needle electrode is inserted into the agar phantom and heated with a Radiofrequency power generator. During the heating experiment, a picture is clicked every 5 min when the power is increased by 5 W. The temperature is also measured simultaneously. The output is increased from 0 W to 20 W. Figure 1 shows the comparison of the tip of the bimetal before and after heating. The maximum displacement was 7.7 mm at 67 °C. Figure 2 shows the relationship between temperature rise and displacement. We verified the consistency of theoretical values with experimental values. As the Young's modulus of agar phantom was small, we ignored the modulus, and assumed the bimetal electrode as a cantilever beam. Equation (1) shows the relationship between temperature rise and displacement.

By comparing the theoretical and experimental values, we found that the larger the increase in temperature, larger the difference in displacement. Moreover, these results indicate the practicality in terms of extending the heating area.

$$D_{max} = \frac{K \Delta T l^2}{t}, (1)$$

where D is the displacement (mm), K is the specific deflection of bimetal (°C^{-1}), ΔT is the increase in temperature (˚C), l is the length of the bimetal (mm), and t is the thickness of the bimetal (mm).

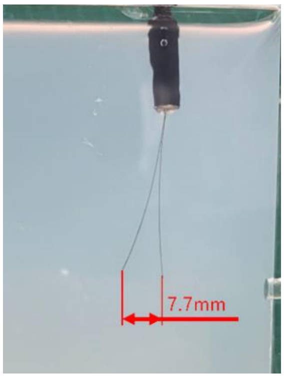

Figure. 1 Overlapping image showing the tip of the bimetal before and after heating

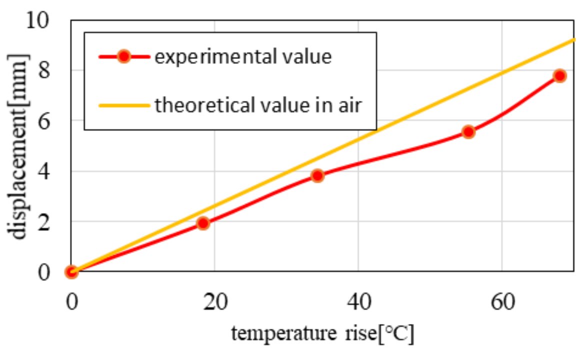

Figure. 2 Relationship between temperature increase and displacement.

References

[1] Kazuhiro Doi, Masahito Miki and Masafumi Morita, "Evaluation of Young's modulus of skin tissue by indentation test based on modified Hertz contact theory" *Trans. of the JSME*, **82**, 833, March 2015.