Investigating the Role of Water Content on the Terahertz Properties of Rat Liver Cirrhosis

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***Abstract*—Existing studies terahertz pulsed imaging and spectroscopy to be safe techniques for biomedical applications. Coherent detection in terahertz pulsed imaging enable it to probe a wide range of information of unknown objects in both time and frequency domains. These distinctive features have recently spurred numerous research into human and animal tissues. We previously reported the dielectric properties of normal and diseased rat liver tissues by terahertz pulsed imaging. In this study, further experiments were carried out to understand the observed differences in the optical parameters by looking into the water contents of the normal and cirrhotic specimen.**

I. Introduction and Background

In our previous work, we employed Terahertz Pulsed Imaging (TPI^{TM}) to characterize the dielectric properties of cirrhotic and normal liver samples [1]. Results showed that both the refractive index and absorption coefficient of the cirrhotic liver samples were consistently higher than those of the normal samples from 0.2 to 1.5 THz. After the samples were fixed in formalin solution for 24 hours, differences in the refractive index and absorption coefficient were still seen. These results reveal the sensitivity of TPI to soft tissue also show the potential of TPI for being able to a new clinical imaging technique.

In this work, after quantifying the refractive index and absorption coefficient of the tissues, further experiments were designed to calculate the water content in the samples as one of the main characteristics of TPI is highly sensitive to water. With this study we aim to get a better understanding of the differences observed in the terahertz region.

II. Materials And Method

A terahertz probe system was used to determine the complex refractive index[1, 2]. The specific optical setup is described in reference [3]. Normal and cirrhotic liver specimens were measured three times by the terahertz probe. In the first step the liver tissues were measured shortly after their excision and then they were fixed in 10% formalin solution. The second and third measurements were taken after 24 and 48 hours' formalin fixation respectively. After every TPI measurement, a microwave oven would be used for dehydrating all the water content inside the specimen. Also, every time before and after the dehydration a high performance electronic scale was used for the purpose of weight measurements. By the calculation (1) and recording the weight of the samples before and after the dehydration procedure, the water content of the tissues was calculated.

$$Water\ Content = \frac{W_b - W_a}{W_b} * 100\% \quad \ldots (1)$$

W_b: sample weight before the dehydration
W_a: sample weight after the dehydration

III. RESULTS

Figure 1 shows the absorption coefficients, α of the cirrhotic and normal groups, indicated by the bold and thin lines respectively. The solid and dashed lines represent results of the fresh samples and those after formalin fixation respectively.

Before fixing in formalin, we can see that the absorption coefficient in the control group is clearly lower than the cirrhotic group which is caused by the difference in water content between normal liver and cirrhotic liver [4]. After fixing in formalin, all the samples would be dehydrated therefore lower absorption coefficients can be seen both in normal and cirrhotic tissues in the Fig 1. Although the difference between the control group and cirrhotic group after the fixing became smaller comparing with the one before fixing, we can still be able to distinguish both of them. Since the water levels in these two kinds of tissues are expected to be similar after fixation, this slight difference may be due to the differences in the tissue structure and composition.

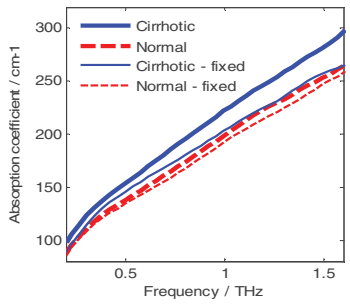

Fig. 1. Mean absorption coefficients of the tissue samples

The water contents from the wet and dehydrated samples in different groups are summarized in Table 1. It can be seen that

in the fresh group, water content in cirrhotic areas is much higher, which could account for greater absorption coefficients. After formalin fixation of 48 hours, the water contents in both the groups are found to be reasonably similar as the water inside are expected to be replaced by the formalin solution. This suggests that the difference after fixation could be due to factors (e.g., component and structure difference) other than water content.

	Fresh	*After formalin fxation 24 hours*	*After formalin fxation 48 hours*
Normal	*69.8%*	*80.0%*	*82.6%*
Cirrhotic	*80.2%*	*82.7%*	*82.5%*

Table 1. Calculated water content of the tissue

IV. CONCLUSION

In conclusion, we have calculated the *ex vivo* frequency dependant absorption coefficient in both of normal and cirrhotic liver tissues before and after the formalin fixing. In order to explore more relationships between the water content and the optical parameters, we conducted the dehydration and weight measurement processes on the specimen in this study. The cirrhotic liver was found to have a higher absorption coefficient in comparison with the control group. This relationship was still seen after fixation in formalin despite some decrease in the values. But by comparing the water content between the normal group and cirrhotic sample after 24hrs fixing in table 1, we can notice that they are quite similar which suggests that TPI can differentiate liver with cirrhosis from normal liver not only by the water content but also by the inner structure and composition.

ACKNOWLEDGMENT

The authors gratefully acknowledge partial financial support for this work from the Research Grants Council of the Hong Kong Government, the Shun Hing Institute of Advanced Engineering, Hong Kong and the 973 Project Fund (2010CB732606) in China.

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