# Investigations Concerning the Dielectric Properties of Breast Tumors
## Method and Results of ex-vivo-Measurements

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**Abstract: Women's breast cancer is one of the most frequent neoplasmatic diseases today. An equipment is described for in vivo measuring of the passive electrical properties of biological tissue. A rectangle voltage pulse with constant current is applied via a dual needle electrode to the mammary tissue. The deformation of the pulse is registered with an oscilloscope and can be fitted with the parameters, i.e. resistance and capacitance, of an equivalent circuit. Taking into account the rather tricky problem of electrode polarization the error for the estimation of these parameters is about 10%.**

**Nevertheless, it is possible to differentiate between normal and altered tissue. The pathological results for benign and malignant tumors from 46 women were compared with the dielectric properties of the probes.**

**Malign tumors show an increase of tissue impedance in general, whereas the decrease of the capacitive resistance is compensated by a higher value for the ohmic part. On the other hand, the parameters for benign tumours are less changed in a significant manner.**

INTRODUCTION

Attempts to determine the dignity of mammary tumors by means of passive electric methods trace back to the year 1926 [1]. By measuring the electrical properties of both the normal and the tumors tissue of one and the same probe, it might well be possible to obtain statements on the dignity. In this way, highly specific differences between normal tissue, benign and malignant neoplasias are found [2-5].

MATERIAL AND METHOD

In the paper presented, dielectric measurements were carried out on n=47 tumors from n=46 female patients. The mean age of the test persons was 45.6 ± 15.6 years, where the youngest patient was 19, the eldest 80 years of age. First, a macroscopic obvious tumor tissue was examined, after which inconspicuous gland tissue was investigated.

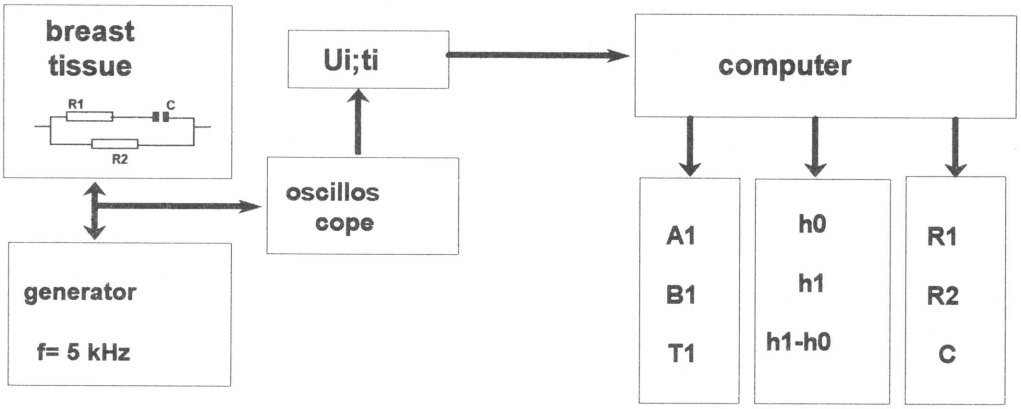


Fig. 1: Representation of the measuring arrangement for the determination of passive electrical properties of mammary tissue, along with the equivalent circuit.

The applied rectangular pulse (a principle method proposed in 1946 [6]) of a basic frequency of 5 kHz was generated by a battery powered digital generator with high internal resistance. This pulse of constant current reached a two-needle puncture electrode via a short feed wire (l=0.5m). This needle electrode was devised in such a way that only the tips were electrically conducting. Hereby it is possible to measure tumors even when they are surrounded by normal tissue.

The deformation of the rectangular pulses that is given rise by the tumor or normal tissue was measured in the form of value pairs ti;Ui, and was further analyzed

by means of a continuous curve fitting with an exponential function.

In this way it succeeds to describe mathematically the curve pretty exactly and to obtain the parameters of the equivalent circuit for the biological tissue R1, R2 and C according to Fig. 1.

As well known problem in the determination of passive electrical properties of biological matter is the electrode polarization. It depends on the electrode material, its surface content, its shape, and the frequency spectrum that is used. As these quantities were kept constant during the presented measurements, in a sequence of measurements the signal of the probe itself was determined more exactly.

The measurements on breast gland tissue were carried out immediately after the removal of the tumors and were finished at least 5 minutes later. It was demonstrated by earlier experiments that the passive electrical properties remain stable for 30 minutes after the tissue removal, so that the much more extensive measuring equipment during surgery was avoided.

## RESULTS

The evaluation of the results of measurement yields the values for the elements in the equivalent circuit. They are displayed in Fig. 2. The assignment of the tumor dignities was carried out after the presence of microscopic examinations. The test of the significance behavior according to the Students t-test yields highly significant differences when comparing carcinomas and mastopathy forms. These differences are not detectable in the comparison of normal tissue and fibroadenomae.

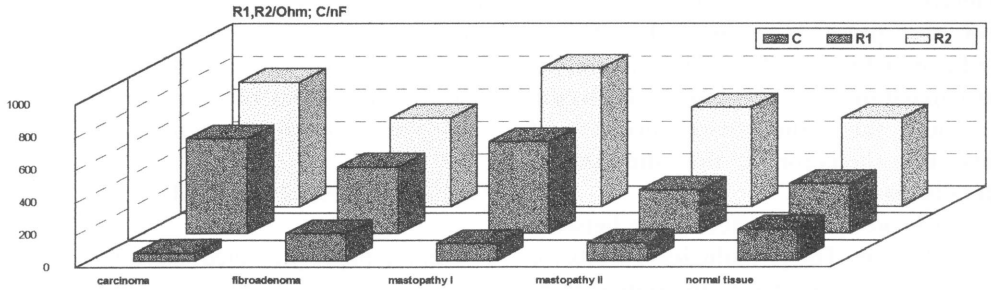


**Fig. 2: Parameter of the equivalent circuit of normal and tumor tissue of different dignity on the basis of n=47 tumors.**

## DISCUSSION

On the measurement of solutions at different K+ concentrations, the variance of the polarization effect dominates in the range of very low electrolyte concentrations [7]. From this one can conclude that in solutions which posses a concentration of $K^+$ higher than 100 mmol/l one can find comparatively stable polarization effects, which means that changes in the complex resistance are caused by the probe itself. Considering tissue, the extracellular part can be considered very small in comparison to the intracellular contribution.

The results of the measurements at the tumors that were removed from the body allow a unique classification into different qualities. The differences become more obvious if only the RC-component, which describes mainly the intracellular space, is taken into consideration. On the other hand, R2 is mainly responsible for describing the extracellular space [8].

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