Measurements of coherent scatter profiles over a range of momentum transfer values for normal and diseased breast tissue

Introduction

This study aims to aid the development of a system that will improve the process of examining biopsy samples, which in turn should ease the method of diagnosis of breast cancer. Once a lesion has been determined as suspicious a fine needle aspiration (FNA) or biopsy is performed. A histopathologist examines a stained slide and relies on skill and experience to make an accurate diagnosis. The process is open to interpretive problems. The unequivocal distinction between benign and malignant samples is not always possible. Some conditions have higher misinterpretation rates than others (Zakhour *et al* 1999) and may need additional cytological testing. The overall aim is to produce a unit that will remove operator dependency and ease the diagnosis of ambiguous samples. It would remove problems associated with the preparation and examination of the sample. Using a combination of x-ray techniques that rely on differences in tissue parameters, a reliable system can be designed to produce an accurate tissue classification.

There is evidence that sufficient differences between benign and malignant tissues exist to make distinguishing them using x-ray analysis a viable task. The concentration and arrangement of calcifications and trace element composition have been the subject of clinical studies, which indicate that these two parameters change with breast pathology (Galkin *et al* 1977, Geraki *et al* 2002). From a histopathological viewpoint the cellularity and cell-to-cell cohesion of these two tissue types are known to differ significantly; malignant cell populations consist of a uniform cell type, whereas benign lesions contain a mixture of cell types usually epithelial, myoepithelial and fragments of stroma cells (Zakhour *et al* 1999).

The coherent scattering distribution holds valuable information regarding the molecular structure of the material in question. It has been known for a long time that amorphous materials display a diffraction pattern, similar to that displayed by crystalline structures (Johns and Yaffe 1983). This is a consequence of interference of the coherent photons, and is therefore related to the interatomic and molecular forces within the material. Amorphous materials such as body tissues show an oscillatory pattern fading to the free electron case (i.e. the theoretical assumption that all electrons within the material are independent) at high scattering angles. As each material exhibits a different pattern, this pattern may be used to characterise tissue types, and because of this has been termed a scatter signature.

This pilot study aimed to investigate whether there are significant differences between benign and malignant scatter signatures. These measurements have not been performed to such a degree of accuracy before, or using a monochromatic synchrotron source.

Experimental Method

A small focussed beam (0.5 x 0.5 mm) was incident on the sample. The beam was tuned to an energy of 12keV. At this energy the flux is 10^{13} photons per second operating in single bunch mode. A scatter measurement was made over a range of 5.5° to 50°, with an angular resolution of 0.1°. Further measurements were made at an angular resolution of 0.02° in chosen areas of interest. The collimation of the scattered samples was achieved using slit collimators with the detector placed at the end a distance of approximately 1m from the sample. This gave excellent angular resolution and beam attenuation was minimised by evacuating the collimation. In order to improve the accuracy and reliability of data acquired a large number of tissues need to be examined. In this pilot study 12 tissues were examined, 6 malignant tumours and 6 benign. Hopefully further measurements will be made with a much larger number of samples.

Results

The data obtained for the twelve samples is shown in Figure 1 below.

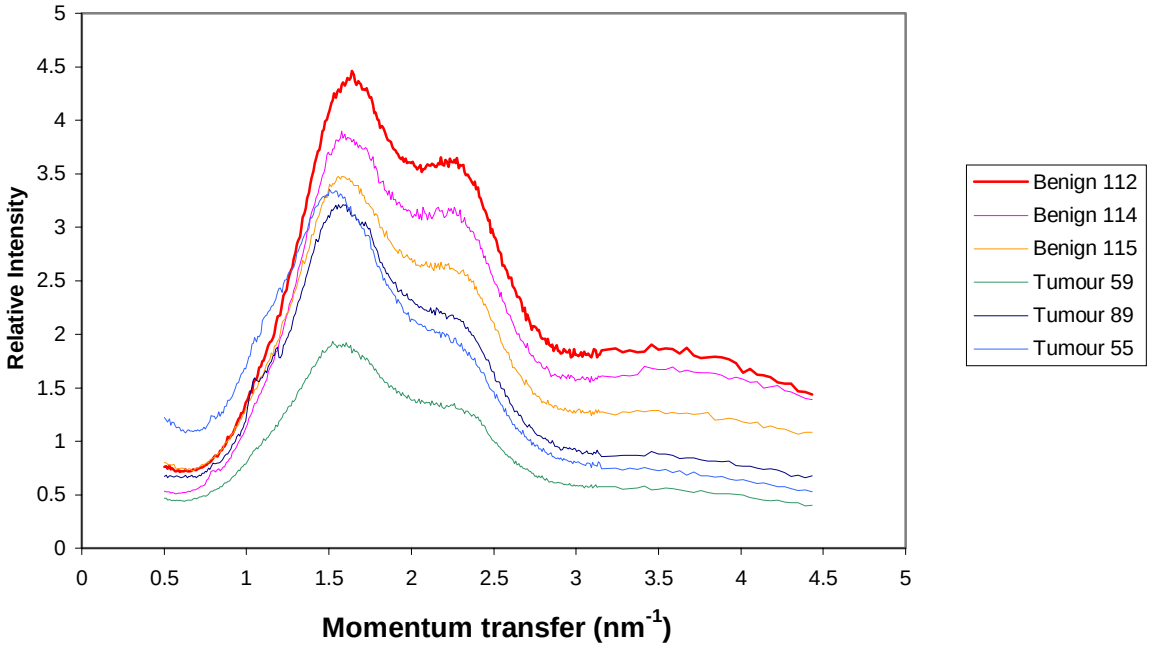

Figure 1. Data corrected for attenuation and volume effects

The data has been corrected to allow for the difference in sample thickness size between the samples. A correction has been applied to allow for the fact that different samples had a different volume of tissue within the scattering volume at each angle. An attenuation correction has also been applied to the data, to compensate for the different path lengths travelled in each sample by the beam. A graph of the averaged corrected data is shown in Figure 2. This figure also includes a scatter signature from an adipose tissue that was performed with the same set up.

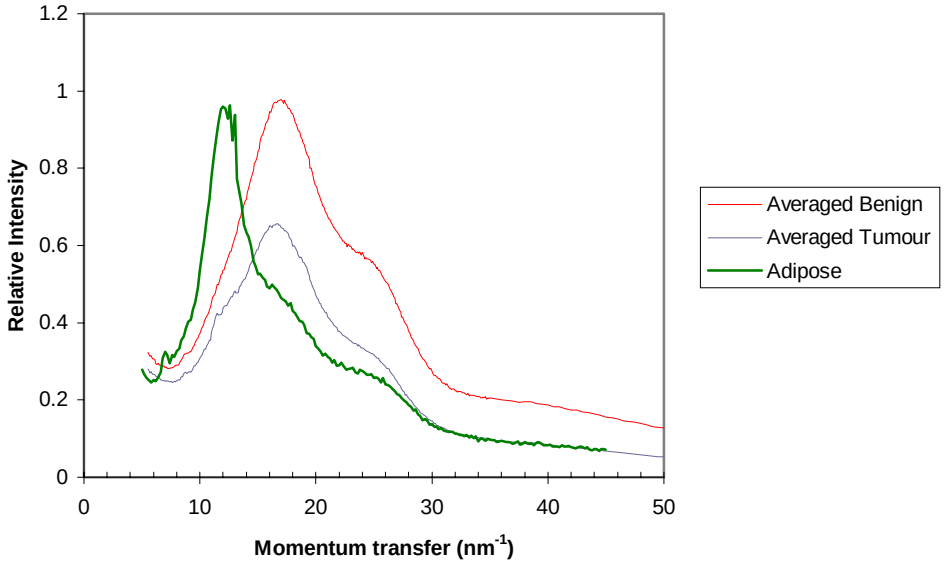

Figure 2. Averaged data for all tissue types

Conclusions

The results obtained show a definite difference in profile intensity and a slight difference in shape. This is being investigated further using Fourier analysis, which will show up any small differences in spectra shape. In order to be able to properly compare the tissue types a detailed knowledge of the tissue composition or density is needed. A method of determining the electron density of the tissue is currently being developed in the laboratory at City University.

In order to obtain a better data set the experiment needs to be repeated using a larger sample size, ensuring the samples are of a uniform thickness. This will eliminate differences due to volume and attenuation variability.

References

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