Study of Cell Elasticity

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Whole Cell Elasticity - AFM

The mechanical properties of cells, such as elasticity, are altered in some disease states, such as malaria, leukaemia and cancer.[1] In particular, evidence exists that cancer cells are more deformable than healthy cells and that metastatic cells are more deformable than non-metastatic cell.[2] In our group we study the elasticity of prostate cancer cells to determine the feasibility of using cell elasticity as diagnostic marker for prostate cancer and metastatic potential.

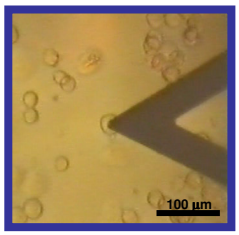

Fig. 1: AFM cantilever and cell.

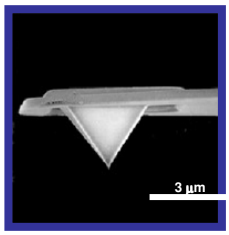

Fig. 2: SEM image of AFM tip on cantilever.[3]

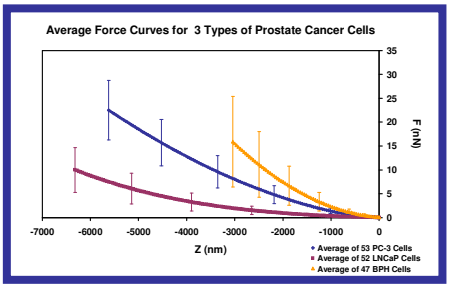

Fig. 3: Average force curves for BPH, LNCaP and PC-3.

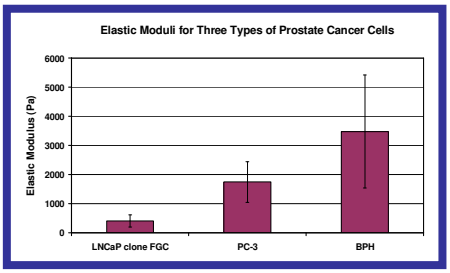

Fig. 4: Elastic modulus for BPH, LNCaP and PC-3 cells.

We have studied the elasticity of three different prostate cell types of varying invasiveness by pushing immobilised cells with an AFM cantilever (shown in Figs. 1 and 2) at 5.7 µm/s and determining the resulting force curves. The cells used were the primary cell line BPH (benign prostate hyperplasia cells, non-tumourigenic) and the established cell lines LNCaP (prostate cancer cells derived from lymph node metastasis, non-invasive) and PC-3 (prostate cancer cells derived from bone marrow metastasis, highly invasive).

Figure 3 shows the average force curves obtained for the three prostate cell types. The elastic moduli of the cells, which were determined using the Hertz model are shown in Fig 4. These results show that the three cell types have different elastic properties and thus can be discriminated using this characteristic. However, PC-3 were expected to be the most deformable and therefore have the lowest elastic modulus as they are the most invasive cells. However, this is not the case and further investigation is necessary to determine the reasons for this observation.

Cell Imaging

As well as studying the mechanical properties of cells the AFM can be used to image the cells and obtain a 3D topographical image. The 3D image of a prostate cancer cell is shown in Fig. 5.

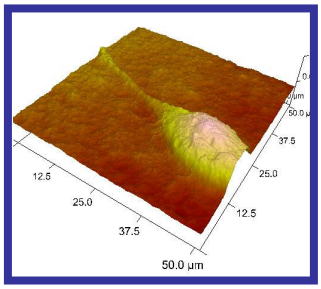

Fig. 5: AFM picture of a PC-3 cell.

Elasticity of the Cell Membrane – Laser Tweezers

The elasticity of the cell membrane is studied by attaching modified polystyrene microbeads to the cell membrane of immobilised cells and pulling the bead at known speed using laser tweezers (see Fig. 6 for setup used) which leads to the formation of a membrane tether between the bead and the cell. Using this method the Apparent Membrane Viscosity, the Membrane Bending Stiffness and the Membrane Tension can be determined.[4]

In our preliminary work we have succeeded in forming tethers between beads modified with BerEP4 and the three types of cells mentioned above, as is illustrated in Fig. 7. Further work is currently being carried out to study the mechanical properties of the membranes of the different cells.

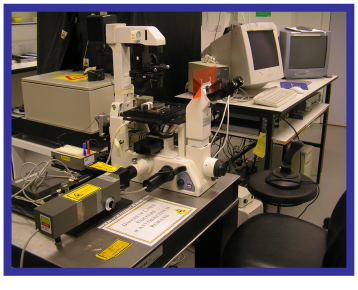

Fig. 6: Laser Tweezers Setup used.

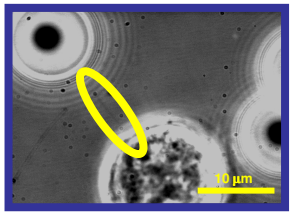

Fig. 7: Tether formation between polystyrene bead modified with BerEP4 and prostate cancer cell.

References

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