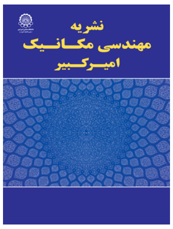

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Experimental Extraction of Young's Modulus of MCF-7 Breast Cancer Cell Using Spherical Contact Models

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ABSTRACT: Breast cancer is one of the most important cancers in the field of medicine due to its high prevalence. Understanding the mechanical properties of cellular tissue, including Young's modulus, and comparing the differences created after the onset of the disease, lead to the development of new methods in recognizing, controlling, and treating the disease. Nanomanipulation is one of the processes used in the field of nanotechnology, which explores the properties of cellular tissues. An atomic force microscope is a tool used during this process that examines the properties of cellular tissue by measuring the movement of the cantilevers and the changes due to displacement and force. In this study, nanomanipulation of MCF-7 breast cancer cells was performed experimentally using an atomic force microscope with the aim of finding the Young modulus of cell tissue. After extracting the experimental results, modeling and calculating the critical force and time by considering different contact models including the Hertz contact model, PT, and COS, has been done. According to the comparison of experimental and simulation results, Young's modulus of MCF-7 breast cancer cells was obtained in the range of 800 Pa. Also, the COS contact model was more in line with the experimental results.

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1. INTRODUCTION

One of the important indicators for diagnosing and understanding the activity and progression of cancer cells is the relationship between the mechanical properties and biological function of the cell. Among the limitations of working with biological particles and obtaining cellular properties are methods and tools for measuring properties. For this purpose, properties measurement methods such as the nanomanipulation method based on Atomic Force Microscopy (AFM) in the field of Nano are used.

Iturri et al. [1] examined the changes in the MCF-7 breast cancer cell using an atomic force microscope with a fluorescence microscope. They used the cell indentation method to determine simultaneous changes in Young's modulus, maximum adhesion force. Korayem et al. [2] studied the elastic and viscoelastic mechanical properties of the MCF-7 breast cancer cell using atomic force microscopy. They also calculated the modulus of elasticity of the cell using Hertz and Dimitriadis theories. Heydarian et al. [3] compared the viscoelasticity of healthy human breast cells with MCF-10 with MCF-7 cancer cells. They also compared cell stiffness under both static and dynamic conditions.

Therefore, in this research, as a general innovation, an attempt has been made to extract both the force and the critical time of manipulation, in order to ensure that no tissue damage occurs during the experiment. The mechanical properties of MCF-7 breast cancer cells have been extracted from Hertz, PT, and COS contact models. The cancer cell was examined experimentally and the necessary images and information were extracted by atomic force microscopy.

2. MODELING

In this paper, an atomic force microscope is used to model the MCF-7 breast cancer tissue manipulation. The equations of the contact models are derived from Ref. [4] and due to the contact in the two areas of probe-cell tissue and cell tissue-surface, in three contact models Hertz, PT, and COS have been developed. Also, the cell tissue after preparation and placement on the slide was examined by atomic force microscope and the results of this imaging were extracted.

3. RESULTS AND DISCUSSION

In order to determine the exact shape of the breast cancer cell, as shown in Fig. 1, the geometry of the cancer cell is estimated by defining specific ranges. According to the obtained results, spherical geometry for cell tissue is considered in the simulation using different contact models.

Other results of this study include the extraction of modulus of MCF-7 breast cancer cells. In order to achieve this, force-depth indentation diagrams have been drawn by considering three contact models of Hertz, PT, COS, and experimental results. By considering different yang

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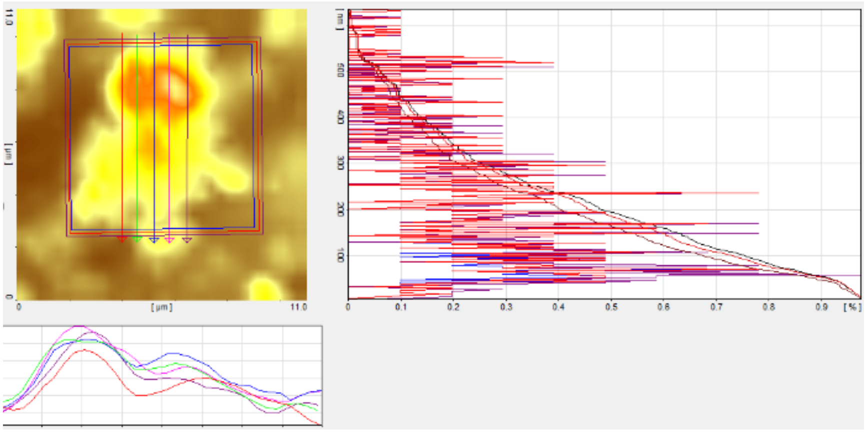


Fig. 1. Estimation of MCF-7 breast cancer cell geometry

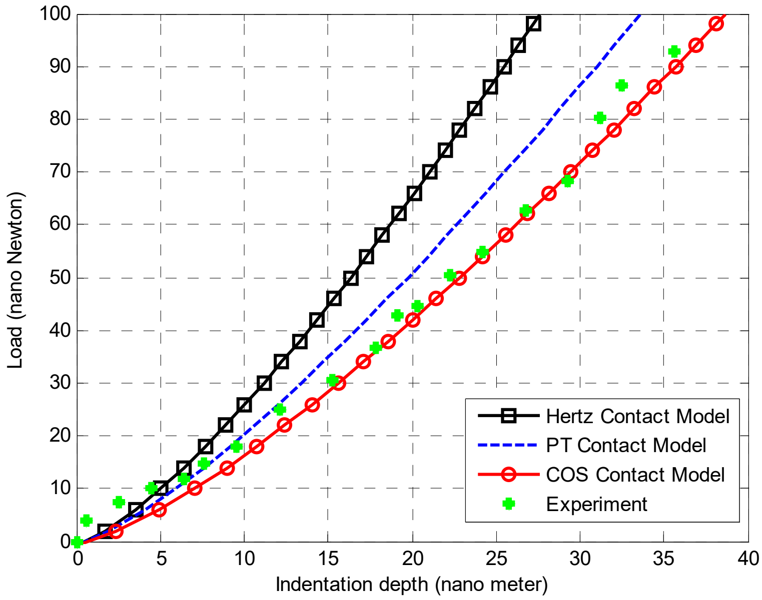


Fig. 2. Experimental and theoretical comparison, Young's modulus of breast cancer cells

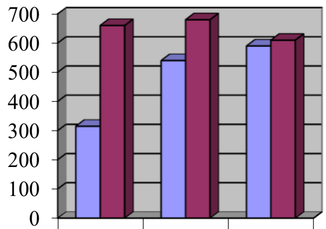
modules, the theoretical results of different contact models change. Finally, by considering the Young modulus of 800 Pa for MCF-7 breast cancer cells, the theoretical results are close to the experimental results. As you can see in Fig. 2, the experimental results are more in line with the theoretical results of the COS contact model. It is also observed that at certain penetration depths, the load in the COS contact model is less than other models and causes less damage to the cancer cell tissue.

4. VALIDATION

In order to verify the accuracy of the values obtained in this paper, Refs. [5, 6] have been examined. The considered contact model is Hertz's theory. Atomic force microscopy has been used in all results. Fig. 3, compares the minimum and maximum values of Young's modulus of breast cancer tissue with other references. As can be seen, the values obtained in this study were in the range of previous studies.

5. CONCLUSION

In this study, due to the importance of recognizing the characteristics of cancer cells, the Young modulus of breast cancer cells is considered an important mechanical property and has been extracted by atomic force microscopy during the nanomanipulation process. In all the simulations performed, Hertz, PT, and COS contact models were applied. By estimating the theoretical results and comparing them with the results of experimental work, Young's modulus of breast cancer cell tissue MCF-7 in the range of 800 Pa has been obtained. Also, in the depth of constant indentation, it has given less load in the COS contact model, which is of great importance due to less damage to the cancer cell. Also, in future works, using other contact models such as MD, DMT, Sun, and Tatara can be used in this field.



	[5]	[6]	article
MIN	314.77	540	590
MAX	660.11	680	610

Fig. 3. Validation

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