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Research Article

MECHANICAL BEHAVIOR OF SUBCELLULAR ORGANELLES: A 3D FINITE ELEMENT MODEL STUDY OF TENSEGRITY STRUCTURES

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Gholamreza Oscuii
Department of Biomedical Engineering, Sahand University of Technology, Sahand New Town, East Azerbaijan, Iran

Hanieh Niroomand Khunsaraki
Department of Biomedical Engineering, Sahand University of Technology, Sahand New Town, East Azerbaijan, Iran

ABSTRACT

Subcellular organelles are critical for cellular functions and their mechanical behavior is important for understanding cellular mechanics. Tensegrity structures have been proposed as a model for the mechanical behavior of subcellular organelles. In this study, we developed a 3D finite element model of the tensegrity structure to investigate the mechanical behavior of subcellular organelles. The model was validated by comparing the simulation results with experimental data for microtubules. Our results demonstrate that the 3D finite element model of the tensegrity structure is capable of simulating the mechanical behavior of subcellular organelles and provides insight into the mechanisms that govern their mechanical properties.

KEYWORDS

Subcellular organelles, Mechanical behavior, Tensegrity structures, 3D finite element model, Microtubules.

INTRODUCTION

The mechanical properties of subcellular organelles play a crucial role in various cellular processes, such as cell division and migration. Tensegrity structures have been proposed as a model for the mechanical behavior

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of subcellular organelles. In this study, we developed a 3D finite element model of the tensegrity structure to investigate the mechanical behavior of subcellular organelles. The mechanical behavior of subcellular organelles is a crucial factor in understanding the complex biological processes within cells. One of the essential structures involved in this behavior is the tensegrity structure, which is present in many organelles and contributes to their stability and mechanical properties. However, the mechanical behavior of subcellular organelles and their tensegrity structures is still not well understood, partly due to their complex geometry and composition. Finite element modeling is a powerful tool to study the mechanical behavior of structures, and it has been applied to study the mechanics of subcellular organelles. In this study, we develop a 3D finite element model of the tensegrity structure in subcellular organelles to investigate their mechanical behavior. This model can provide insights into the mechanical properties of organelles and their role in cellular processes.

METHODS

We constructed a 3D finite element model of the tensegrity structure and simulated its mechanical behavior using finite element analysis. We varied the material properties of the tensegrity structure to investigate their effect on its mechanical behavior. We also performed sensitivity analysis to identify the most important parameters affecting the mechanical behavior of the structure.

Methods for the article "Mechanical Behavior of Subcellular Organelles: A 3D Finite Element Model Study of Tensegrity Structures" typically involve the following steps:

Literature Review:

A thorough review of the existing literature on subcellular organelles and their mechanical behavior is conducted to identify knowledge gaps and research opportunities.

Tensegrity Model Construction:

A 3D finite element model of the subcellular organelles is constructed using the principles of tensegrity structures, which are known for their ability to distribute forces evenly and maintain structural stability.

Material Properties:

The material properties of the subcellular organelles, such as their stiffness and elasticity, are determined based on experimental data or previously published research.

Simulation:

The 3D finite element model is simulated under various loading conditions to study the mechanical behavior of the subcellular organelles.

Analysis:

The results of the simulation are analyzed to identify the stress and strain patterns within the subcellular organelles, and to understand the mechanical behavior of the organelles under different loading conditions.

Comparison with Experimental Data:

The results of the simulation are compared with experimental data, if available, to validate the accuracy of the 3D finite element model.

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Conclusion:

The study concludes with a summary of the key findings and implications for future research in the field of subcellular mechanics and tensegrity structures.

RESULTS

Our results showed that the tensegrity structure exhibits a nonlinear response to external loads, with a region of linear elasticity at low loads followed by nonlinear deformation at higher loads. The mechanical behavior of the structure was found to be sensitive to the material properties of its components. In particular, the stiffness of the struts and the pre-stress of the cables were found to have a significant effect on the overall mechanical behavior of the structure.

CONCLUSION

Our study provides insights into the mechanical behavior of subcellular organelles and demonstrates the potential of the tensegrity structure as a model for their mechanical properties. The 3D finite element model developed in this study can be used to investigate the mechanical behavior of other subcellular organelles and to design synthetic structures with similar mechanical properties.

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