Nanomechanical Properties of Engineered Cardiomyocytes Under Electrical Stimulation

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Engineered cardiomyocytes made of human-induced pluripotent stem cells (iPSC) present phenotypical characteristics similar to human fetal cardiomyocytes. There are different factors that are essential for engineered cardiomyocytes to be functional, one of them being that their mechanical properties must mimic those of adult cardiomyocytes. Techniques, such as electrical stimulation, have been used to improve the extracellular matrix's alignment and organization and improve the intracellular environment. Therefore, electrical stimulation could potentially be used to enhance the mechanical properties of engineered cardiac tissue. The goal of this study is to establish the effects of electrical stimulation on the elastic modulus of engineered cardiac tissue. Nanoindentation tests were performed on engineered cardiomyocyte constructs under seven days of electrical stimulation and engineered cardiomyocyte constructs without electrical stimulation. The tests were conducted using BioSoft™ In-Situ Indenter through displacement control mode with a 50 µm conospherical diamond fluid cell probe. The Hertzian fit model was used to analyze the data and obtain the elastic modulus for each construct. This study demonstrated that electrically stimulated cardiomyocytes (6.98 ± 0.04 kPa) present higher elastic modulus than cardiomyocytes without electrical stimulation (4.96 ± 0.29 kPa) at day 7 of maturation. These results confirm that electrical stimulation improves the maturation of cardiomyocytes. Through this study, an efficient nanoindentation method is demonstrated for engineered cardiomyocyte tissues, capable of capturing the nanomechanical differences between electrically stimulated and non-electrically stimulated cardiomyocytes.

Nanomechanical properties of electrically stimulated cardiomyocytes