# In Silico Optogenetic Control of Spiral Waves in Focal and Diffuse Atrial Fibrotic Tissues

Kaiqi Liu, Heqing Zhan

College of Biomedical Information and Engineering, Hainan Medical University (Hainan Academy of Medical Sciences), Haikou, China

Atrial fibrosis, which causes an atrium to undergo structural remodeling and alters its electrophysiological characteristics, is a significant factor in inducing atrial fibrillation (AF). In recent years, optogenetics has been experimentally confirmed to effectively terminate AF in rodents, whereas its effectiveness in human AF cardioversion has not yet been clearly established due to considerations of experimental safety and technological challenges. As an important adjunct and necessary complement to clinical experimental research, computational modeling can provide both phenomenological simulation and mechanistic explanation for the occurrence and evolution of AF. This study used two-dimensional models of human atrium with focal fibrosis and diffuse fibrosis, respectively, to investigate the dynamic control of the expression pattern of Channelrhodopsin-2 (ChR2) and the frequency of sub-threshold illumination on spiral waves. Our results showed that with the same proportion of atrial fibrosis and gap-junctional conductance in both models, the spiral wave in focal fibrotic model was effectively terminated when ChR2 was expressed simultaneously in both atrial myocytes and fibroblasts, while in diffuse fibrotic model it was successfully discontinued by the sub-illumination which frequency was the same as the spiral wave. This study provides valuable mechanistic insights into the success or failure of optogenetic control of AF.