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Interactions among biotic and abiotic factors affect the reliability of tungsten microneedles puncturing in vitro and in vivo peripheral nerves: A hybrid computational approach.

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Abstract

Tungsten is an elective material to produce slender and stiff microneedles able to enter soft tissues and minimize puncture wounds. In particular, tungsten microneedles are used to puncture peripheral nerves and insert neural interfaces, bridging the gap between the nervous system and robotic devices (e.g., hand prostheses). Unfortunately, microneedles fail during the puncture process and this failure is not dependent on stiffness or fracture toughness of the constituent material. In addition, the microneedles' performances decrease during in vivo trials with respect to the in vitro ones. This further effect is independent on internal biotic effects, while it seems to be related to external biotic causes. Since the exact synergy of phenomena decreasing the in vivo reliability is still not known, this work explored the connection between in vitro and in vivo behavior of tungsten microneedles through the study of interactions between biotic and abiotic factors. A hybrid computational approach, simultaneously using theoretical relationships and in silico models of nerves, was implemented to model the change of reliability varying the microneedle diameter, and to predict in vivo performances by using in vitro reliability and local differences between in vivo and in vitro mechanical response of nerves.

KEYWORDS:

Adiabatic invariants; Biotic and abiotic factors; In vivo reliability of tungsten microneedles; Local interactions; Peripheral nerves

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