Mosquito-Inspired Insertion Guide Prevents Flexible Intracortical Microelectrodes from Buckling during Implantation

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Intracortical microelectrodes are essential tools in the rapidly growing brain-computer interface (BCI) and brain-machine interface (BMI) fields. The development of flexible intracortical microelectrodes has been a priority for researchers in efforts to increase biocompatibility and recording performance. A problem that arises, however, is that during implantation these flexible probes must remain stiff enough to penetrate the brain tissue without buckling. Looking to nature, the mechanics and principles behind the mosquito bite allow its fascicle, a flexible tube merely 30 microns in diameter, to be inserted into the human skin. This study details the development of a mosquito-inspired assistive insertion system which significantly increases the rate of successful implantation and drastically reduces buckling. Experimentation with laser-cut insertion guides in an agar gel model of the brain revealed that the guides enabled the insertion of flexible probes that otherwise buckled and/or deflected off the surface of the agar gel. In particular, successful insertion was achieved in 92% of the trials with the guide (versus 23% without). Buckling only occurred in 19% of the trials with the guide (versus 85% without). Furthermore, in vivo experimentation demonstrated the ability to implant a flexible microelectrode through the intact dura mater of the rat brain using the insertion guide. Finally, compression force testing demonstrated an approximately 300% increase in the critical buckling force of the microelectrodes when utilizing the guide. The results suggest the feasibility of the insertion guide to greatly increase the probability of successful implantation of flexible microelectrodes in brain tissue.

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