Novel Spinal Cord Stimulation Technique Using Non-Invasive Temporally Interfering Electric Fields

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INTRODUCTION: Temporal Interference (TI) is an innovative, non-invasive technique used to stimulate brain and peripheral nerves in humans and animal models. This method applies two high-frequency electric fields (>1 kHz) that intersect at a focal point, stimulating tissue at a differential frequency (Δf). Neuronal responses at Δf have been documented in both brain and peripheral nerves. Despite its potential, TI has not yet been applied to spinal cord stimulation, which could be transformative in rehabilitation following traumatic injuries. This study aims to evaluate the efficacy of TI in spinal cord stimulation in mice, building on established effects observed in peripheral nerve stimulation.

METHODS:

We conducted seven trials stimulating the spinal cords of anesthetized mice (isoflurane) using two pairs of skin electrodes. Initially, we replicated peripheral nerve stimulation on the sciatic nerve (n=4) based on previous studies (Botzanowski et al., 2022), followed by spinal stimulation at the L4-L5 vertebrae (n=3). We gradually increased Δf and assessed the induced leg movements to determine whether spinal cord stimulation responds at the Δf frequency and if the resultant movement amplitudes are comparable to those of peripheral nerve stimulation. Movement frequency and amplitude were quantified using ImageJ with a motion tracking plugin.

RESULTS: Our findings demonstrate that spinal cord stimulation via TI induces movements with frequencies and amplitudes similar to those observed in sciatic nerve stimulation (P-value from Kruskal-Wallis Test: 0.339311), indicating no significant differences between the two stimulation sites.

DISCUSSION AND CONCLUSION:

This study is the first to show that spinal stimulation via TI can induce controlled movements, confirming that the effects observed in peripheral nerve stimulation are due to TI rather than muscular responses to electrode contact. Additionally, to confirm neuronal engagement, future studies will include c-fos staining, providing essential validation of TI's stimulatory effects. This will provide corroborative evidence that the neural pathways are being activated in a manner analogous to that observed in brain tissues. Finally, these results have significant implications for rehabilitation therapies for patients with nerve damage or traumatic injuries and may provide a non-invasive alternative to deep brain stimulation systems for Parkinson's disease patients.