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Paper Title: Validation of Temporal Interference Stimulation with Steamed Flour-Based Phantoms in Spinal Cord Neuromodulation

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Abstract

Combining epidural stimulation and temporal interference (TI) in spinal cord neuromodulation shows promising results. To investigate this success, electrical property-mimicking phantoms will be employed, with gel-based phantoms being one choice. However, gel-based phantoms may not securely attach electrodes for recording spatial positions because of their shrinkage. To address this limitation, a steamed flour-based two-layer concentric structure phantom was proposed, fabricated using the "steamed layer cake" method. Deionized water and 0.1 Molar saline were employed to mimic the electrical properties of the dura and spinal cord, respectively. The electrical conductivity of the phantoms was measured to validate their dielectric properties. To further assess various spatial electric field of TI stimulation, the finite element model simulation and phantom experiment were compared using normalized auto-correlation and R-square methods. Results demonstrate that deionized water-based and saline-based phantom closely approximate the electrical conductivity to dura and spinal cord tissues with conductivity value of 0.035 S/m and 0.72 S/m, respectively. Comparative finite element modeling shows a relatively agreement (R-square of 0.737) between TI patterns in the phantom experiment and simulation. In conclusion, the proposed steamed flour-based layer phantom provides an improved platform for validating and optimizing temporal interference in epidural spinal cord stimulation. Its accurate representation of electrical properties allows for more reliable and precise experimentation, advancing spinal cord neuromodulation research and potential therapeutic approaches.