PS-5

MRI-Based Transcranial Direct Current Stimulation Optimization for Post-Stroke Dysphagia: A Multi-Center Retrospective Study

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Background

Dysphagia is a common and debilitating consequence of stroke, affecting up to 50% of patients and leading to malnutrition, aspiration pneumonia, and prolonged hospitalization. Non-invasive brain stimulation (NIBS), particularly transcranial direct current stimulation (tDCS), has shown promise in enhancing swallowing recovery. Nevertheless, the efficacy of tDCS is highly dependent on electrode configuration, positioning, and individual anatomical variability, which influence current distribution and neuromodulatory outcomes.

Methods

We retrospectively analyzed MRI-based tDCS simulations in 50 patients with post-stroke dysphagia (PSD). Using a deep learning-based segmentation tool, we created individualized head models from each patient's MRI. Electric fields were estimated via finite element modeling with tissue-specific conductivity values. Two tDCS configurations were compared:

- Conventional tDCS: square (5×5 cm) vs. circular (1.5 cm radius) electrodes placed using the 10–20 EEG system
- Optimized tDCS: circular electrodes with grid-search optimized placement to maximize electric field strength in the swallowing cortex

Electric field strength and focality were calculated within a defined region of interest (ROI). Non-parametric statistics (Friedman and Wilcoxon signed-rank tests) were used due to non-normal data distributions.

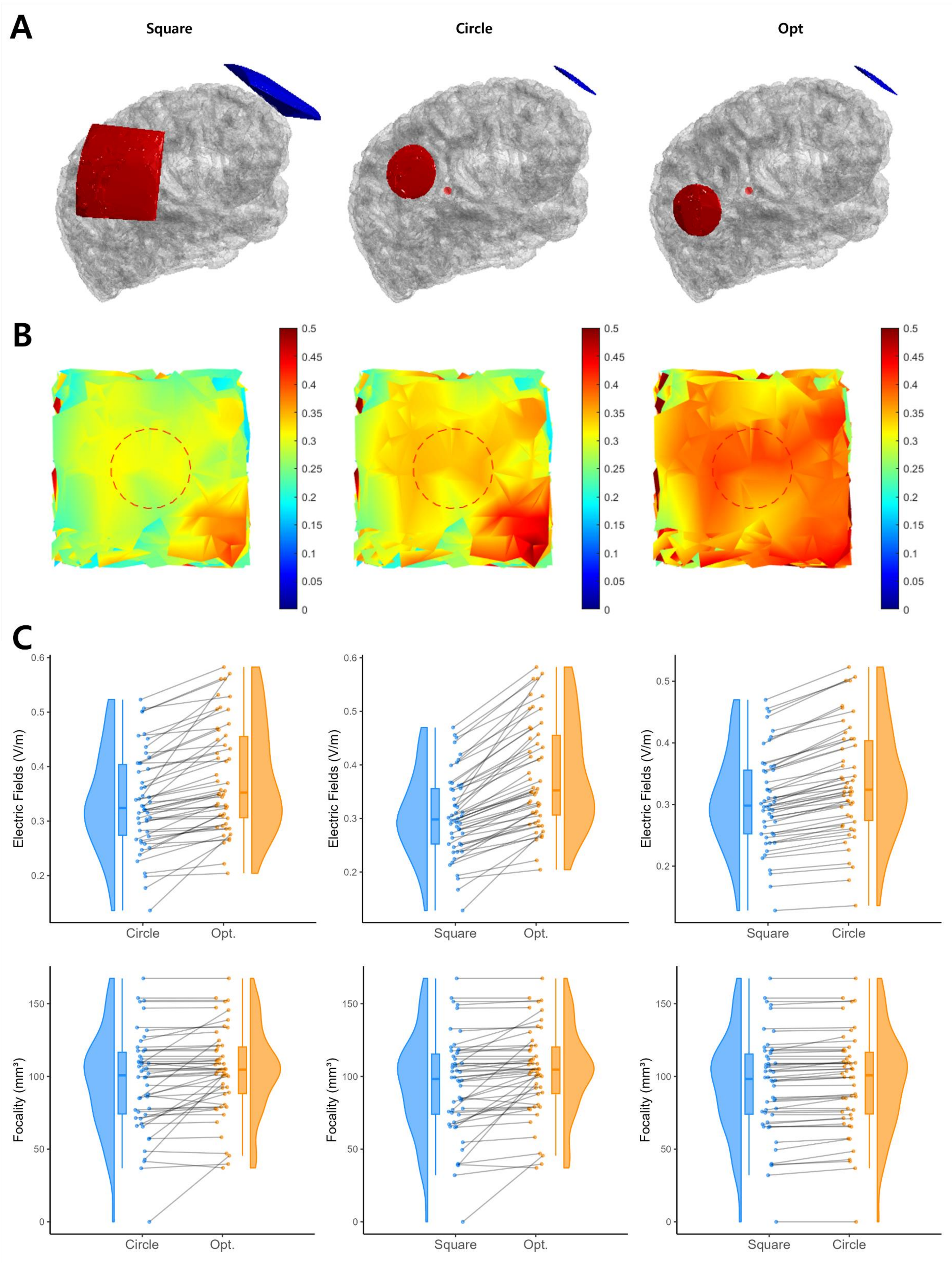
Figure A and B show representative electric field distributions for three tDCS configurations (left to right): conventional square electrode (5×5 cm), conventional circular electrode (1.5 cm radius), and optimized circular electrode (1.5 cm radius).
Figure C illustrates the electric field strength within the target region for each configuration in 50 stroke patients. Each circle represents an individual data point.

Results

Fifty patients with post-stroke dysphagia were included (54% male; median age: 76 years). The majority had left hemisphere lesions (62%).
A Friedman test showed significant differences in electric field strength and focality across three tDCS conditions:

- Optimized montage (Opt.)
- Conventional circular electrode (Circle)
- Conventional square electrode (Square)

Electric field strength was highest in the optimized montage (median: 0.3525 V/m), followed by Circle (0.3240 V/m), and lowest in Square (0.2982 V/m).
Focality was also highest in the optimized montage, with significant differences between all pairwise comparisons (all $p<.05$, Bonferroni-corrected). The optimized tDCS montage provided significantly stronger and more focused stimulation compared to conventional settings.



Conclusion

The findings underscore the significance of personalized electrode placement, more compact electrode designs, and the use of computational models to boost tDCS effectiveness. By implementing optimization techniques, researchers can enhance the focus and precision of current delivery, ultimately leading to more refined neuromodulatory approaches for treating dysphagia in post-stroke patients.