Transcranial MEP Threshold Voltages and Current Densities Simulated with Finite Element Modelling

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Objective: The aim of this study was to compare stimulation thresholds and current densities in the brain for transcranial motor evoked potentials (tcMEPs) from the hands and feet with linked quadripolar (LQP), M3-M4 and C1-C2 electrode montages.

Methods: **25** patients underwent cerebral vascular surgery with tcMEP monitoring. tcMEP voltage thresholds were compared between LQP (C1, M3, C2, M4), C1-C2, and M3-M4 montages. In a finite element model (FEM), hand, arm, and leg regions of interest (ROIs) on the cortical motor homunculus were segmented. Current densities in these ROIs at tcMEP thresholds were compared across tcMEP electrode montages.

Results: LQP tcMEP thresholds were 61.5 volts for hands and 95.2 volts for feet. Thresholds were higher for M3-M4 (hands, 89.4 V; feet, 141.3 V) and C1-C2 (hands: 137.3 V; feet: 194.7 V). Total current at threshold voltage was greater for LQP (hands, 210.9 mA; feet, 311.3 mA) compared to M3-M4 (hands, 166.8 mA; feet, 256.6 mA), but similar to C1-C2 (hands, 246.7 mA; feet, 341.1 mA). In FEM simulations, current density and local current density topography in the hand ROI at threshold were very similar for LQP, M3-M4 and C1-C2.

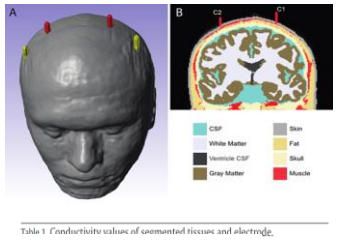
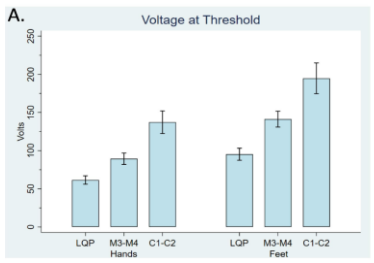
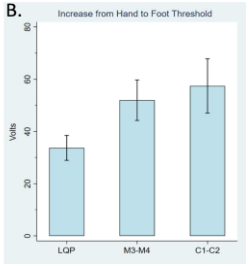
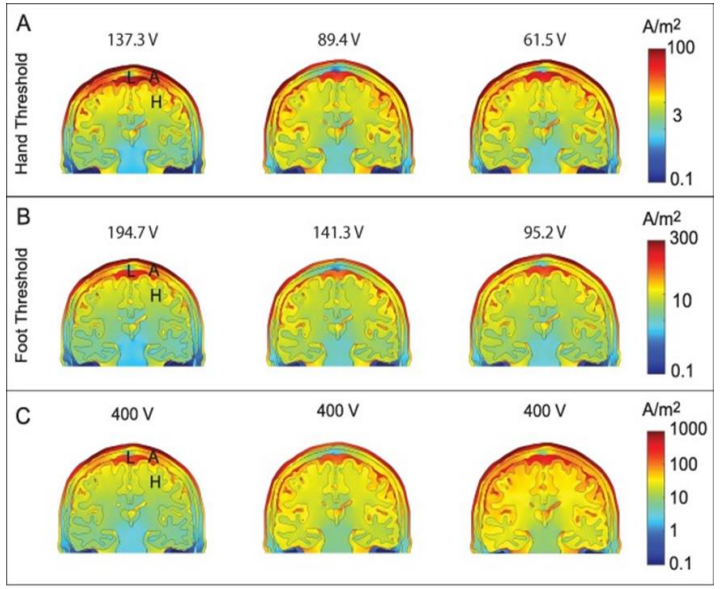


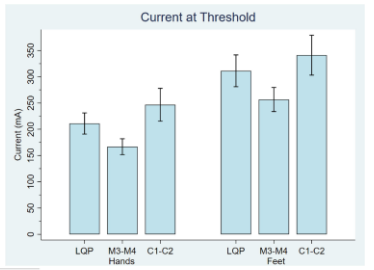
Table 1: Conductivity values of segmented tissues and electrode.

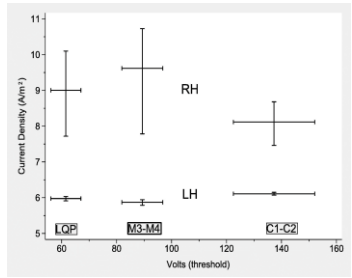
Tissue compartment	Conductivity values (S/m)
Ventricle, External CSF	1.79
White matter	0.15
Gray matter	0.33
Eye	0.50
Blood vessel	0.70
Air	$1x10^{-10}$
Skull	0.01
Fat	0.024
Muscle	0.16
Skin	0.43
Electrode	1

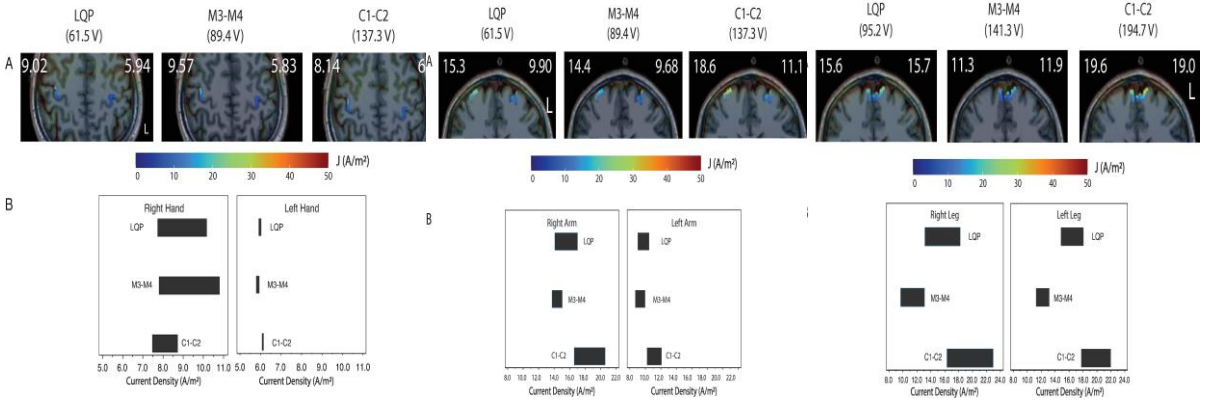


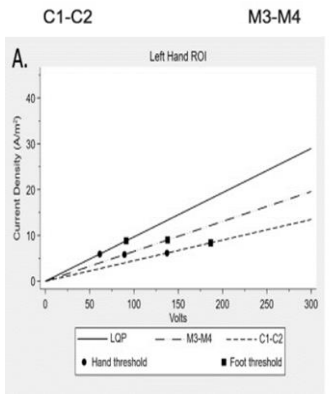












Conclusion: Conclusion: LQP voltage thresholds were least for LQP, and lesser for M3-M4 compared to C1-C2. In FEM simulations, resistance to current to hand ROI was ordered the same (LQP<M3-M4<C1-C2). The local distribution of current density in motor cortex with tcMEP was mainly determined by cortical geometry.

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