



Somatosensory Cortical Plasticity and Brain Processing of Acupuncture Stimuli for Carpal Tunnel Syndrome



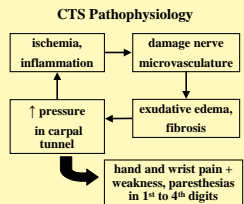
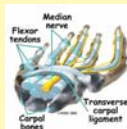
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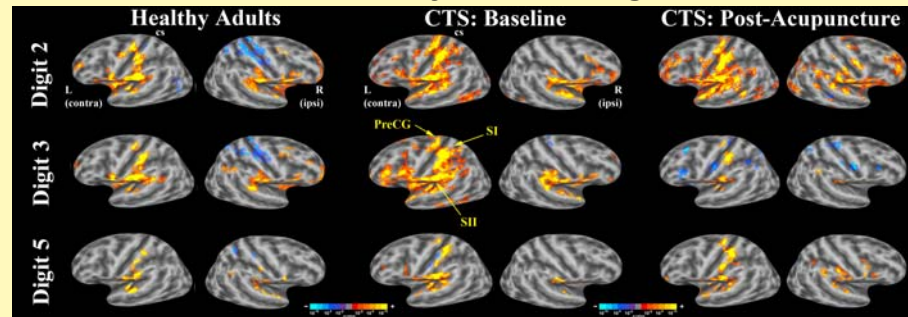


Introduction



- CTS doesn't just affect the wrist
- Tinazzi et al. reported abnormally amplified spinal, brainstem, and parietal SSEPs
- Tecchio et al. reported cortical amplification with MEG

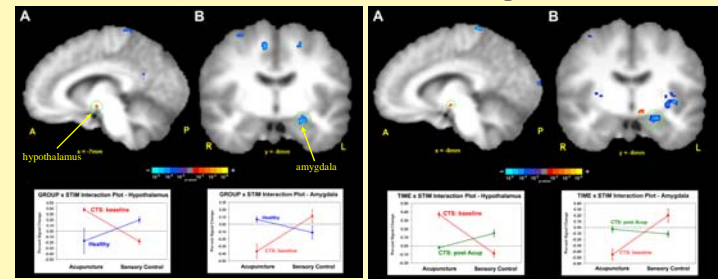
Somatosensory Processing Results



Group Brain Maps for Non-noxious Digit (2,3 and 5) Stimulation

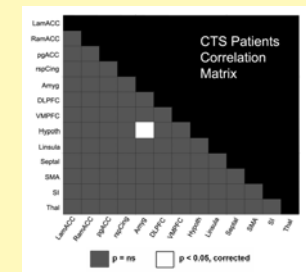
- Non-noxious stimulation leads to contra SMC hyperactivation & less ipsi deactivation for digits in CTS
- some evidence for normalization after acupuncture therapy [see D3 (above, right middle) in particular]

Acupuncture Processing Results



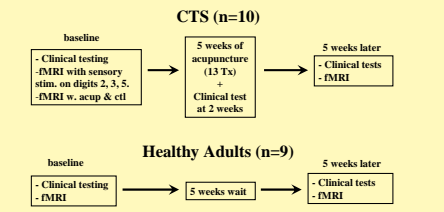
(Above) X-sectional Baseline and Longitudinal Analyses: X-sec = (CTSbase.acup - CTSbase.sham) - (Healthy.acup - Healthy.sham); Longitudinal CTS = (CTSbase.acup - CTSbase.sham) - (CTSpost.acup - CTSpost.sham). Both analyses found a positive ANOVA interaction in the hypothalamus, and a negative interaction in the amygdala. Interaction plots demonstrated that the subgroup with the largest response for both analyses was: CTS patients at baseline with acupuncture stimulation

Functional Connectivity: correlated fMRI response in the hypothalamus and amygdala



(Left) Functional connectivity was explored by calculating the percent signal change correlation matrix for CTS patients at baseline responding to verum acupuncture stimulation. Potential brain regions (13) were drawn from those demonstrating a significant cross-sectional ANOVA interaction. The only two regions which demonstrated a significant correlation were the amygdala and hypothalamus.

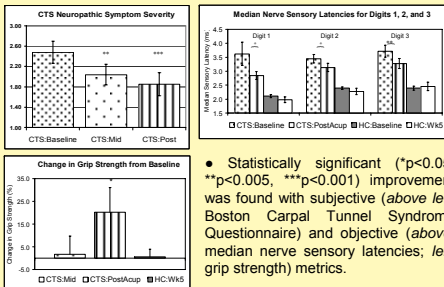
Methods



- Finger Cortical Mapping and Somatotopy fMRI Stimulation: 100Hz electro-stimulation on digits 2, 3, and 5 (pseudo-random order); just below pain threshold.
- Acupuncture fMRI Protocol fMRI Stimulation: (verum) manual acupuncture at LI-4 (1Hz twisting stimulation with 0.2x30mm pure silver needle) OR (sham) somatosensory/cognitive control 1Hz stimulation with 5.88 von Frey monofilament.

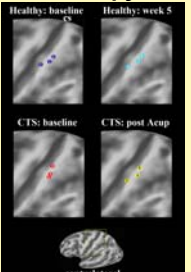
- Data Analysis - Single subject GLM analysis performed with FEAT, FSL (motion correction with FLIRT; spatial smoothing, FWHM=5mm) - Surface-based analyses performed with FreeSurfer & SUMA (AFNI) -> group & difference maps thresholded at p<0.05 FDR corrected and minimum cluster size of 5 voxels. - Acupuncture neuroimaging: Two 2x2 ANOVA interactions with factors GROUP and STIM (x-sec), and factors STIM and TIME (longitudinal).

Clinical Results



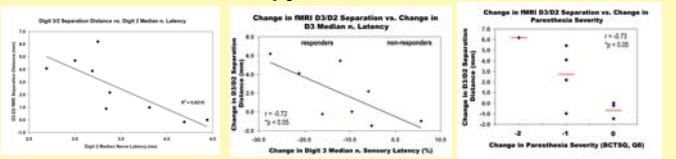
- Statistically significant (*p<0.05, **p<0.005, ***p<0.001) improvement was found with subjective (above left, Boston Carpal Tunnel Syndrome Questionnaire) and objective (above, median nerve sensory latencies; left, grip strength) metrics.

Somatotopy



(Above) In CTS, median n. innervated D2 and D3 had closer SI representations (group cluster center-of-mass & ROI). Improvement was seen after acupuncture therapy.

Correlation of Somatotopy with Clinical Variables



(Above Left) At baseline, D2/D3 separation distance in CTS patients correlated with sensory latency - the worse the pathology, the smaller the separation distance. (Above Middle) After acupuncture therapy, the change in D2/D3 separation distance correlated with the change in sensory latency - the more improvement in sensory latency, the more D2 and D3 spread apart in their SI representation. (Above Right) The change in D2/D3 separation distance with acupuncture therapy correlated with the improvement in paresthesias

Conclusions

- fMRI can be used to probe central dysfunction in CTS and response to therapy.
- CTS leads to contra- and ipsilateral sensorimotor disinhibition and blurred digit representations.
- Improvement in CTS peripheral nerve function correlates with improved central somatotopy.
- Diffuse multi-digit paresthesias produce afference with greater than normal temporal coherence. This temporal synchrony leads to Hebbian mechanisms of synaptic strengthening and cortical reorganization, leading to decreased separation in cortical representation fields of affected digits.
- Acupuncture may improve not only CTS symptomatology, but also cortical somatotopy.
- Patients with CTS respond to acupuncture with more pronounced fMRI signal decrease in the amygdala and signal increase in the hypothalamus, compared to healthy subjects - these regions may be an important component of the mechanism by which acupuncture benefits CTS patients.

Acknowledgements

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