Video submissions

Practical video demonstration of the technique to identify the posterior superior insula orthogonal scalp projection without neuronavigation: the Fast-PSI

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ABSTRACT | BACKGROUND: The posterior-superior insula (PSI) has emerged as a potential target for non-invasive brain stimulation (NIBS) in the treatment of peripheral neuropathic pain. However, current methods for identifying the PSI require expensive and time-consuming brain imaging and neuronavigation. Here, we propose the Fast-PSI method, a novel approach based on craniometry and intracranial Euclidean distances proportions comparisons between scalp landmarks, to swiftly and accurately locate the PSI projection on the scalp. **METHODS:** Eleven healthy participants underwent identification of the PSI and cranial landmarks (CL) MNI152 coordinates using neuronavigation. Euclidean distances between nasion and PSI (N-sPSI), nasion and inion (N-I), vertex and PSI (Cz-sPSI), and vertex and tragus (Cz-T) were calculated. Craniometric-based Euclidean distances between PSI and CL were also measured. Correction factors were developed based on the proportionality of distances. **RESULTS:** Mean distances' proportions were consistent between stereotactic-based and craniometric-based measurements. Correction factors were determined as 0.67 for N-sPSI and 0.75 for Cz-sPSI. The Fast-PSI formula was established using these factors to swiftly locate the PSI projection on the scalp. Test-retest, intra- and inter-rater reliability coefficients were high, with no statistical difference compared to neuronavigated coordinates. The mean time for Fast-PSI determination was significantly shorter than traditional neuronavigation. **CONCLUSION:** The Fast-PSI method demonstrates high precision and reliability in identifying the PSI projection for NIBS in neuropathic pain treatment. Its rapid execution and accuracy make it a promising alternative to current techniques, potentially reducing time and resource burdens associated with neuronavigation. Further validation in clinical trials and everyday practice is warranted to assess its utility in clinical settings.

KEYWORDS: Insula. Neuronavigation. Transcranial Magnetic Stimulation. Frameless Neuronavigation. Euclidean Distance. Craniometry. Fiducial Points.

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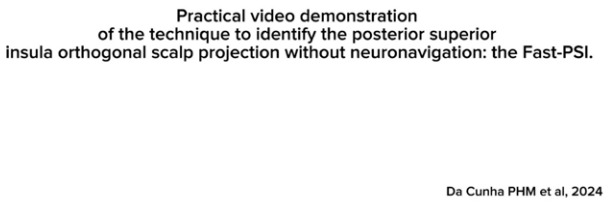
Figure 1. Practical video demonstration Fast PSI



Available from (Video 1): https://youtu.be/LeDONDEg9zA

1. Introduction

The PSI is a safe potential target for non-invasive brain stimulation (NIBS) in peripheral neuropathic pain (NeP) treatment.[1] Currently, its identification requires costly and time-consuming brain imaging and neuronavigation.[2] Knowing intracranial structure proportions are generally constant[3,4], using the standardization of the insular subdivisions' coordinates proposed by Faillenot et al. (2017)[5] and based on previous strategies to identify non-motor cortical neuromodulation targets[6], we proposed the FAST-PSI.[6]

We have recently developed and validated the "Fast-PSI": a novel method to identify the orthogonal scalp projection of the posterior-superior insula (sPSI) based on craniometry and intracranial Euclidian distance proportions comparisons between scalp landmarks.[7]

2. Methods

To perform it, eleven healthy participants (four females, 31.5 ± 9.5 years) had their sPSI and cranial landmarks MNI152 coordinates identified by neuronavigation and the Euclidean stereotactic distances between nasion and sPSI (N-sPSI), nasion and inion (N-I), vertex and sPSI (Cz-sPSI) and vertex and tragus (Cz-T) calculated: Euclidean distance formula $\sqrt{[(X1 - X2)^2 + (Y1 - Y2)^2 + (Z1 - Z2)^2]}$. The craniometric-based Euclidean distances between sPSI and cranial landmarks were measured with a pachymeter. Distances proportions (nasion-sPSI to nasion-inion distances and vertex-sPSI to vertex-tragus distances, assumed similar, were subsequently compared.

Two correction factors were developed (either calculated or measured Euclidian distances): 1) the proportion inside nasion-inion distance that corresponded to nasion-sPSI distance; and 2) the proportion inside vertex-tragus distance that corresponded to vertex-sPSI distance.

2.1 The Fast-PSI formula [7]

Identification of: the vertex (intersection of nasion-inion and tragus-tragus scalp distances); the Nasion–sPSI line: nasion-inion Euclidean distance x correction factor 1; the vertex-sPSI line: resulting from vertex-tragus Euclidean distance x correction factor 2.

Fast-PSI: the intersection points between nasion-sPSI and vertex-sPSI lines.

To validate the approach, two blinded raters assessed the Fast-PSI test-retest, intra- and inter-rater reliability coefficients in five different healthy volunteers (four women, 31.0 ± 4.0 years) (ten hemispheres' measurements). They were compared with the neuronavigated method and the mean time to perform the fast-PSI and the neuronavigation technique measured by a third researcher and compared.

3. Results

The mean stereotactic distances' proportions were: (N-sPSI)/(N-I) = 0.67±0.01 and (Cz-sPSI)/(Cz-T) = 0.75±0.02. The mean craniometric distances' proportions were: (a/b) = 0.67 ± 0.00 and (c/d) = 0.75 ± 0.02. There were no statistical differences between proportions (p= 0.635 and = 0.236 respectively). These proportions resulted in two correction factors*: correction factor 1 = 0.67; and correction factor 2 = 0.75*

The Fast-PSI formula: Nasion-sPSI line= nasion-inion Euclidian distance x 0.67 (correction factor 1) and vertex-sPSI line= vertex-tragus Euclidian distance x 0.75 (correction factor 2). Fast-PSI= intersection point between nasion-sPSI and vertex-sPSI lines.[7]

3.1 The Fast-PSI web-based version

A Fast-PSI electronic version was developed on Rstudio Shiny Server: available at https://juliocesar9999apps.shinyapps.io/fast_psi_app/.

There was no statistical difference between the intra-rater and inter-rater measurements, and Fast-PSI and neuronavigated coordinates. Cronbach's alpha was 0.91. The mean time to identify the PSI by neuronavigation was 41.2 ± 2.59 minutes (without MRI time). The mean time for the "Fast-PSI" determination was 1.33 ± 0.04 minutes.[7]

The technique was compared to the neuronavigated location method, showing very good precision and a good high intra- and inter-rater reliability (see numbers in original paper). These results support the reliability and accuracy of the Fast-PSI to perform PSI rTMS.[7]

4. Conclusion

Future studies comparing the utility of this framework in clinical trials and in daily practice will help in its establishment as a neuronavigation-free method to perform rTMS of the posterior insula.

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Authors contributions

The authors declare that they have made sufficient contributions to the work in terms of the conception or design of the research; the acquisition, analysis or interpretation of data for the work; and the writing or critical review for relevant intellectual content. All authors approved the final version to be published and agreed to take public responsibility for all aspects of the work.

Conflicts of interest

No financial, legal, or political conflicts involving third parties (government, private companies, and foundations, etc.) were declared for any aspect of the submitted work (including but not limited to grants and funding, advisory board participation, study design, manuscript preparation, statistical analysis, etc.).

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