# Studying Botulinum toxin diffusion in spastic patients using high-density surface EMG: a clinical and electrophysiological perspective

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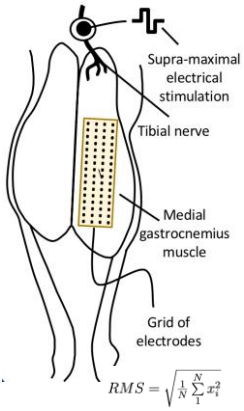
## Introduction

Botulinum neurotoxin (BoNT) is widely used in the management of spasticity *(1)*. Its clinical efficacy and safety is influenced by how it diffuses within the muscle tissue, although, methods to directly assess or model its distribution remain limited *(2)*. This study aims to assess whether high-density surface electromyography (HD-sEMG) can detect the effect of BoNT injections and identify its spatial diffusion within different regions of the treated muscle *(3)*. Additionally, clinical assessments and ultrasound measures were performed to evaluate the relationship between electrophysiological findings and patients' functional improvements.

*FIG1: CLINICAL SETTING*




## Methods

Twenty-two patients with unilateral spasticity involving the medial gastrocnemius treated with AbobotulinumtoxinA were included. Two 64-channel HD-sEMG grids were bilaterally placed over the target muscles *(fig1)*. M-waves were elicited via supramaximal stimulation of the posterior tibial nerve at two time points: baseline (T0) and 4 weeks post-injection (T1). RMS (Root Mean Square), variation of RMS (dRMS) and segmented channels (channels showing a >90% decrease in RMS amplitude compared to the maximum RMS value) were calculated. Clinical data (Modified Ashworth Scale, VAS, Penn Spasm scale, Quality of life scales) and ultrasound measurements (Heckmatt Scale, Muscle Tickness and pennation angle, *fig4*) were collected at all time points.

$DRMS_{(cs)} \geq 0.9 \times DRMAS_{Max}$

## Results

A significant reduction in M-wave RMS amplitude was observed at T1 on the BoNT-treated side compared to T0 *(fig3)*. RMS colormaps confirmed the spatial reduction in activity, consistent with the expected BoNT diffusion pattern *(fig2)*. Clinical parameters (dMAS) and ultrasound measaurments (Heckmatt Scale) significately correlated with the variation of RMS (dRMS) *(all $p<0.05$)*. Number of segmented channels signifcately correlated with the Heckmatt scale.

*TAB1: CLINICAL DATA*

| | T0 | T1 |
|---|---|---|
| MAS | 1.97±2.00 | 1.44±1.50 |
| Penn | 1.18±0.98 | 0.73±0.90 |
| VAS | 2.21±3.24 | 1.14±2.14 |
| Heckmatt Scale | 2.53±0.80 | 2.53±0.80 |
| Muscle Thickness | 14.6±3.3 | 14.7±2.6 |
| RMS | 1.53±0.75 | 1.03±0.37 |

*FIG2: RMS COLORMAP*

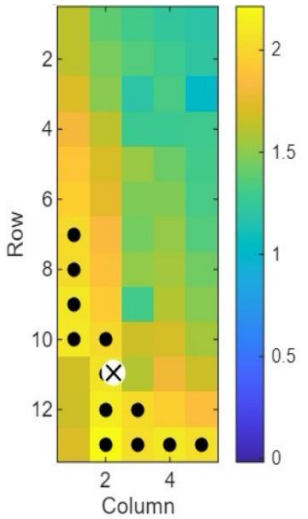



*FIG3: RAW M-WAVE DATA*

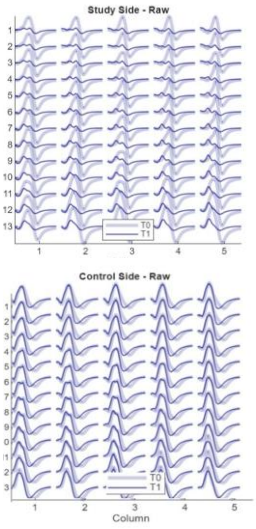
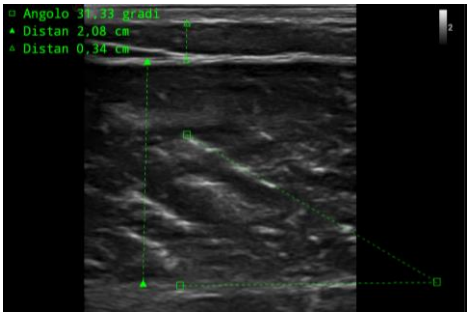



*FIG4: ULTRASOUND MEASURES*




## Conclusions

HD-sEMG is sensitive to the effects of BoNT and can provide spatial mapping of its diffusion. Electrophysiological data show a correlation wiith clinical outcomes and ultrasound measurements .

*REFERENCES: 1) O Brien et al, 2002 2) Picelli et al 2024 (3) Gayer et al 2001*