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Joints kinematics and ataxia of lower limbs during walking in essential tremor is differentially modulated by thalamic stimulation

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Introduction: Patients in advanced stages of Essential Tremor (ET) regularly exhibit gait ataxia, impaired balance control and imprecise foot placement resembling patients with cerebellar deficits.

Objectives: To elucidate the impact on cerebellar-like gait difficulties in ET patients of thalamic deep brain stimulation (thalamic DBS), a surgical therapy of otherwise intractable ET.

Methods: Eleven ET patients (five women; age 69.8 ± 3.9 ; disease duration 24.4 ± 11.2 years; follow-up after surgery 24.7 ± 20.3 months) were evaluated during the following conditions: stimulation off (STIM-OFF), stimulation on (STIM-ON), and supra-therapeutic stimulation (STIM-ST). Ten age-matched healthy controls (HC) served as comparison group. Locomotion was kinematically analysed using a three-dimensional opto-electronic motion analysis system. Established clinical and kinesiological measures of ataxia were computed.

Results: During STIM-OFF, the patients exhibited ataxia of foot trajectories and lower limb joints, which improved during STIM-ON and worsened again during STIM-ST. In the whole group, DBS improved ankle rotation and reduced leg stiffness (compensating the impaired dynamic stability). Moreover, in a subgroup of ET patients with more severe disease, thalamic DBS caused normalisation of kinematic variability and joint range of rotation, compared to STIM-OFF and STIM-ST. These improvements in ataxia were not a function of related to reduced tremor improvement in the lower limbs or torso.

Conclusion: Cerebellar dysfunction in ET patients can be differentially modulated with optimal versus supra-therapeutic stimulation. The cerebellar movement disorder of ET is due to a typical cerebellar deficit, not to trembling extremities. We hypothesize that DBS affects two major regulating circuits: the cortico-thalamo-cortical loop for tremor reduction and the cerebello-thalamo-cortical pathway for ataxia reduction (STIM-ON) and induction (STIM-ST).