Caudal Zona Incerta/VOP Radiofrequency Lesioning Guided by Combined Stereotactic MRI and Microelectrode Recording for Posttraumatic Midbrain Resting-Kinetic Tremor

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OBJECTIVE: **Reporting the outcome of two patients who underwent unilateral ablative stereotactic surgery to treat pharmacologic resistant posttraumatic tremor (PTT).**

METHODS: **We present two patients (31 and 47 years old) with refractory PTT severely affecting their quality of life. Under stereotactic guidance, refined by T2-weighted magnetic resonance imaging and double-channel multi-unit microelectrode recording (MER), three sequential radiofrequency lesions were performed in the caudal zona incerta (cZi) up to the base of thalamus (VOP). Effects of cZi/VOP lesion were prospectively rated with a tremor rating scale.**

RESULTS: **Both patients demonstrated intraoperative tremor suppression with sustained results up to 18 months follow-up, with improvement of 92% and 84%, respectively, on the tremor rating scale. Tremor improvement was associated with enhancement functionality and quality of life for the patients. The patients returned to their work after the procedure. No adverse effects were observed up to the last follow-up.**

CONCLUSION: **Radiofrequency lesion of the cZi/VOP target was effective for posttraumatic tremor in both cases. The use of T2-weighted images and MER was found helpful in increasing the precision and safety of the procedure, because it leads the RF probe by relying on neighbor structures based on thalamus and subthalamic nucleus.**

INTRODUCTION

Tremor can sporadically occur secondary to brain trauma.[1] This condition is described as *posttraumatic tremor* (PTT), features a nonprogressive yet limiting condition that is mostly unresponsive to medication. PTT is hypothesized to appear secondary to a diffuse axonal injury (DAI) involving the midbrain; therefore, PTT may involve a pathophysiology similar to that of Holmes tremor. Both PTT and DAI may be differentiated only by the fact that Holmes tremor is secondary to etiologies of structural lesions of the brainstem, cerebellum, or thalamus different from DAI, such as stroke, vascular malformation, tumor, multiple sclerosis, or infection.[2,3]

Posttraumatic tremor is characterized by a combination of irregular resting, a postural and intention tremor of large amplitude, and slow frequency. Tremor is usually unilateral, predominantly affects the proximal upper extremities, and is markedly activated by goal-directed movements.[4] The initial manifestation of PTT and other symptoms can appear weeks to years after the precipitating event. It usually shows restricted responses to oral medication. Because of frequent resistance, a combination of pharmacologic agents is often tried, such as dopaminergic and

Key words
- Ablative radiofrequency surgery
- Deep brain stimulation
- Diffuse axonal injury
- Forel's fields
- Microelectrode recording
- Traumatic brain injury
- Tremor
- Zona incerta

Abbreviations and Acronyms
cZi: Caudal zona incerta
DAI: Diffuse axonal injury
DBS: Deep brain stimulation
MER: Microelectrode recording
MRI: Magnetic resonance imaging
PTT: Posttraumatic midbrain tremor
STN: Subthalamic nucleus
VOP: Ventral oral posterior nucleus of the thalamus
Zi: Zona incerta

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anticholinergic agents (attempting to control the resting component) and other agents such as carbamazepine and primidone (for the kinetic component).[2,5] For patients with severe, disabling, medication-refractory PTT, surgery is a reasonable treatment option. Ablative therapy through stereotactic thalamotomy was commonly performed.[6] In addition, chronic deep brain stimulation of the thalamus or ventral intermediate nucleus of the thalamus,[7] and more recently thalamus/VOP[8] and Globus Pallidus Internus,[9] have been addressed in bilateral tremor.

The present report emphasizes that PTT can be severe and disabling at the same time that it is often resistant to medication. Although deep brain stimulation is currently the leading technique for the treatment of movement disorders, nondegenerative conditions such as PTT can be treated by small lesions with presumable advantages. Caudal zona incerta (cZi) is an interesting target for the treatment of tremor overall, probably because of convergence of fiber bundle contained in this region. We show a fairly simple and reliable method for the targeting of this region using the combination of magnetic resonance imaging (MRI) and dual-channel microrecording technique in the stereotactic space. In addition, the results in two patients are reported.

METHODS

We report the outcome of two young patients with severely disabling PTT resistant to pharmacologic agents after a stereotactic radiofrequency ablative procedure. The procedures were performed using a stereotactic system (TMo3 Micromar/BMS-125E; Bramsys, São Paulo, Brazil) and planning software-based image guidance (MNPS-Mevis, São Paulo, Brazil). We used volumetric acquisition of a T1 gadolinium MRI sequence merged into the stereo computed tomography, mainly for the trajectory planning to avoid blood vessels, ventricles, and sulci from the tracks. In addition, T2-weighted MRI showing iron deposits refined the target definition.[10] These images show the hypointense (dark) regions in the upper midbrain marking the position of the subthalamic nucleus (STN) and the red nucleus. The target in the cZi was defined based on the axial MRI at the level of the transition of the midbrain and subthalamic region just over the mammillary bodies. The point between the red nucleus and the STN, 2 mm behind the Bejjani line,[11] was marked as the target. In the coronal plane, the line passing over the roof of the STN defined the inferior coordinate. In addition to the target based on the MRI, we used the microrecording technique to refine the targeting. The operations were performed using local anesthesia and consisted of routine steps, as described below. Through a precoronal burr hole marked on the planned trajectory, two rigid guide cannulas were inserted down to 10 mm above the target. Microelectrode recording was performed using two microelectrodes, one in the central and one in the lateral track of the micro drive (Inomed Medizintechnik, Freiburg, Germany; and Microtargeting FHC, Bowdoin, ME). The parallel recording started 10 mm above the target and advanced in 500-µm steps. As the desired target was medial and superiorly positioned related to the STN, the lateral microelectrode was intended to show STN neuronal activity 2 mm from the target, whereas the center channel remained roughly silent (target zone). The bottom target zone was marked directly over the point from which the STN activity emerged in the lateral microelectrode channel. Prior to "lesioning," test macrostimulation was performed in the point defined by the microelectrode targeting. We used either low (5 Hz, enhancing tremor) or high frequency (100–130 Hz, arresting tremor) and a 100-ìs pulse-width at currents up to 3.0 mA. ON the basis of electrophysiology confirmation of the target within a region that arrested tremor, the center electrode was switched by the RF probe (1.2 mm Ø and 2 mm exposed tip; Cosman, Burlington, VT) to produce an oval shaped lesion created by three sequential lesions 2 mm apart at 75°C during 60 seconds each. The lesion comprised the cZi up to the base of thalamus (VOP; **Figures 1, 2**).

Preoperative and postoperative statuses were assessed using the tremor rating scale, which classifies severity of tremor by body part involvement and amplitude (0 = none; 1 = slight; 2 = moderate amplitude; 3 = market amplitude; 4 = severe amplitude) in rest (RT), positional (PT) and intentional tremor (IT).

RESULTS

Case Number 1

A 31-year-old, right-handed man, had a long history of post-traumatic tremor that started 5 years after a traumatic brain injury and motivated total functional impairment of his right hand, becoming a left-handed person. Postural low-frequency and high-amplitude tremor was predominant, but there was associated intentional and resting tremor (RT = 3, PT = 4, IT = 3). No

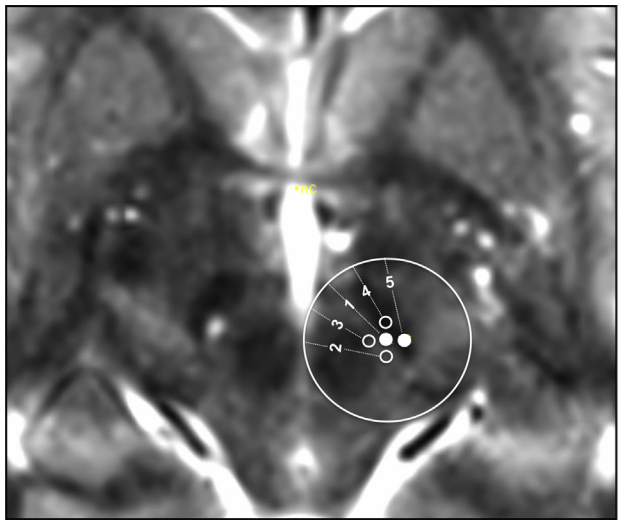

Figure 1. Axial T2-weighted magnetic resonance image at the level of the transition of the midbrain and the subthalamic region. The hypointense (*dark*) structures disclosed within the mesencephalic outlines in the center are the red nucleus and the subthalamic nucleus. The target zone is located between these two structures, behind the transversal line on the anterior border of the red nucleus. We included the outlines of the microdrive "Ben's Gun" in scale to illustrate the target at the channel 1 and the lateral track in the channel 5, intended to reach the medial portion of the subthalamic nucleus.