Parkinsonism and Related Disorders 19 (2013) 1100–1105

Contents lists available at ScienceDirect

Parkinsonism and Related Disorders

journal homepage: www.elsevier.com/locate/parkreldis

Treating post-traumatic tremor with deep brain stimulation: Report of five cases

Neil M. Issar [a], Peter Hedera [b], Fenna T. Phibbs [b], Peter E. Konrad [c], Joseph S. Neimat [c,*]

[a] School of Medicine, Vanderbilt University, Nashville, TN, USA
[b] Department of Neurology, Vanderbilt University Medical Center, Nashville, TN, USA
[c] Department of Neurosurgery, Vanderbilt University Medical Center, Nashville, TN 37232, USA

ARTICLE INFO

Article history:
Received 1 November 2012
Received in revised form
2 July 2013
Accepted 19 July 2013

Keywords:
Tremor
Post-traumatic
Deep brain stimulation
Ventral intermediate nucleus
Globus pallidus internus

ABSTRACT

Background: Post-traumatic tremor is one of the most common movement disorders resulting from severe head trauma. However, literature regarding successful deep brain stimulation (DBS) treatment is scarce, resulting in ambiguity regarding the optimal lead location. Most cases support the ventral intermediate nucleus, but there is evidence to defend DBS of the zona incerta, ventral oralis anterior/posterior, and/or a combination of these targets. We report five patients with disabling post-traumatic tremor treated with DBS of the ventral intermediate nucleus and of the globus pallidus internus.

Methods: Patients were referred to the Vanderbilt Movement Disorders Division, and surgical intervention was determined by a DBS Multidisciplinary Committee. Standard DBS procedure was followed.

Results: Patients 1–4 sustained severe diffuse axonal injuries. Patients 1–3 underwent unilateral ventral intermediate nucleus DBS for contralateral tremor, while Patient 4 underwent bilateral ventral intermediate nucleus DBS. Patients 1–3 experienced good tremor reduction, while Patient 4 experienced moderate tremor reduction with some dystonic posturing of the hands. Patient 5 had dystonic posturing of the right upper extremity with tremor of the left upper extremity. He was treated with bilateral DBS of the globus pallidus internus and showed good tremor reduction at follow-up.

Conclusion: Unilateral or bilateral DBS of the ventral intermediate nucleus and bilateral DBS of the globus pallidus internus may be effective and safe treatment modalities for intractable post-traumatic tremor. Further studies are needed to clarify the optimal target for surgical treatment of post-traumatic tremor.

Published by Elsevier Ltd.

1. Background

Various forms of tremor have been observed following traumatic brain injury [1]. In many such cases, medications are ineffective, or beneficial responses are limited by side effects. Stereotactic surgical treatments, such as deep brain stimulation (DBS), targeting regions of the thalamus have been attempted in some patients with variable effectiveness. Post-traumatic tremor is one of the most common movement disorders resulting from severe head trauma. It can occur within a month or years after the trauma incident, and can include resting, postural, kinetic, and intention tremor. A survey of 289 severely head-injured children showed 45% developed significant tremor, 36% of which remained unchanged or progressively worsened for a period of up to three years after the injury [1]. Similarly, a survey of 221 patients who were admitted with a Glasgow Coma Scale (GCS) score of 8 or less after they sustained a head trauma showed 19% developed tremor, with highly significant associations between generalized brain edema and the occurrence of kinetic tremor and between focal cerebral lesions and the occurrence of kinetic tremor [2]. Successful pharmacological treatment of post-traumatic tremors [3–8] is quite rare, and treatment by surgical intervention has proven more difficult than the treatment of essential or parkinsonian tremor. Additional concerns have complicated the surgical treatment of post-traumatic tremor. These include the presence of symptoms that might limit the benefit of DBS, such as psychological and cognitive deficits, ataxia, dysarthria, paresis, and oculomotor deficits [9].

Below, we report successful surgical treatment of five patients with disabling post-traumatic tremor with Vim DBS and DBS of the globus pallidus internus (GPi). We further review the extant literature on the treatment of post-traumatic tremor and address some of its challenges.

* Corresponding author.
E-mail address: jneimat@gmail.com (J.S. Neimat).

1353-8020/$ – see front matter Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.parkreldis.2013.07.022

2. Methods

We performed a retrospective analysis of all patients with post-traumatic tremor treated by our DBS group in the past four years. A thorough chart review was conducted. All patients had been referred to the Vanderbilt Movement Disorders Division. Their work up included an evaluation by a movement disorders neurologist and standardized tremor assessment with the Fahn–Tolosa–Marin (FTM) [7] or WHIGET [8] tremor rating scale. After assessment, the patients' cases were presented to a multidisciplinary committee that included neurologists, neurosurgeons, neuropsychologists, and neurophysiologists. Patients determined by consensus to be candidates for DBS were offered appropriate surgeries as outlined in Table 1.

The DBS procedure was performed under local anesthesia to allow intraoperative assessment of tremor response. We used the Starfix™ microtargeting stereotactic platform in all cases. Targeting was performed using a combination of AC–PC coordinates and adjustments based on direct imaging relative to MRI visible structures. After incision and burr hole placement under local anesthesia, we advanced microelectrodes and recorded in multiple parallel tracts from 10 mm above target to the bottom of the physiologically defined target. Stimulation mapping along the tracts was then conducted in the presence of the patient's movement disorders neurologist to determine the efficacy and any side effects of each tract in treating tremor. Final Medtronic 3387 electrodes were placed and secured in the optimal location. Patients returned one week later for placement of an internal pulse generator (IPG). Electrode locations were subsequently confirmed several weeks after surgery with volumetric CT scanning registered to the preoperative MRI. Patients were first programmed by their neurologist approximately one month after their procedure, and returned for secondary adjustments as necessary. Final electrode locations and most recent efficacious DBS settings are presented in Table 3.

3. Results

We treated five patients with post-traumatic tremor over a period of four years (Table 1). All patients were male. Their ages ranged from 12 to 26 at the time of their injury, and from 18 to 49 at the time of their surgeries. Patients 2, 3, and 4 had surgeries performed an average of 43 months after the emergence of tremor symptoms, while Patients 1 and 5 had long-standing tremor and did not receive surgery until 22.3 and 17.8 years after the emergence of symptoms, respectively.

Patients 1, 2, and 3 underwent unilateral Vim DBS for symptoms of unilateral tremor; Patients 1 and 3 were cases of left handed action and postural tremors, and Patient 2 was a case of right handed action tremor. The patients' FTM tremor rating scale [18] scores are reported in Table 1. The findings from post-trauma computed tomography (CT), cerebral magnetic resonance imaging (MRI) with gadolinium, and electroencephalogram (EEG) are reported in Table 2. In all three cases, tremor progressed to the point of disability, complicated by varying degrees of hemiparesis.

Patient 4 underwent bilateral Vim DBS for the treatment of cerebellar and rubral tremors in both upper extremities, with the right side worse than the left. Tremor deteriorated in the months following the trauma, eventually preventing him from feeding himself. The patient's head CTs on the day of and day after the accident, as well as brain MRI results, are reported in Table 2. The patient's FTM tremor rating scale scores [18] are reported in Table 1.

Patient 5 underwent bilateral GPi DBS for severe tremor of the left upper extremity, tremor of the right upper extremity that occurred upon writing, head tremor, and dystonic posturing of the right hand. Findings from a head CT on the day of the trauma are reported in Table 2, while the patient's WHIGET rating scale [19] scores are reported in Table 1. For all patients, coordinates of each Medtronic 3387 lead (based on the center of the four-contact array) and the most recent stimulator settings are listed in Table 3.

Surgical outcomes ranged from near complete reduction of visible tremor without side effects to moderate tremor reduction with some persistence of dystonic symptoms. Percentage change in tremor rating scale scores was available for three of the five patients, and ranged from 14.3% to 56.5%. All of the patients' clinical global impression (CGI) ranged from 2 to 3. Patient 5 showed significant tremor reduction with bilateral GPi DBS at 7 month follow-up as well as considerable improvement in his contralateral dystonia, though noticeable improvement in his WHIGET rating scale scores was only noted unilaterally. For all patients, stimulation-associated side effects included some dystonic movements of the upper extremities, gait instability, balance difficulties, paresthesias, ataxia while walking, and slurred speech. Patient 3 had a second electrode placed intraoperatively in the ZI, but intraoperative ZI stimulation caused pyramidal tract problems, including left foot pulling and pain, dizziness, apprehension, and facial contracture. Conversely, Vim stimulation alone resulted in 80% reduction of his tremor with minimal side effects, resulting in removal of the ZI lead and leaving only the Vim lead.

Delayed complications included decreased tremor control and increased impedance in Patients 2, 3, and 4 between 6 and 33 months after DBS. Patients 3 and 4 underwent exploration and interrogation of their DBS systems with replacement of the extension wires, which resulted in significantly improved tremor reduction, though Patient 4 continued to have some dystonic posturing of both hands while performing fine motor tasks. Patient 2 had his stimulator settings adjusted, after which he experienced slightly better tremor control despite paresthesias. Future follow-ups are necessary to determine if long-term tremor reduction can be achieved.

4. Discussion

Post-traumatic tremor is a significant complication of traumatic brain injury and can represent a challenging clinical dilemma. The relative success of medical and surgical therapies is much more limited than the use of similar therapies in the treatment of essential tremor or Parkinson's tremor [9–15].

Currently, there are only a few reports describing DBS for post-traumatic tremor (or similar movement disorders), and uncertainty regarding the optimal lead location persists. Prominent and/or relevant case reports and studies are listed in Table 4. Of note,

Table 1
Patient and DBS data.

Patient	Age	Gender	Date of surgery	DBS target	Tremor rating scale	Pre-op score			Post-op score			Clinical global impression (CGI)	Tremor reduction (%)
						Date	Right	Left	Date	Right	Left		
1	53	M	04/22/2008	Right Vim	FTM [18]	01/30/2008	0	16	07/15/2011	0	7 (On stimulation) 9 (Off stimulation)	2	56.3
2	21	M	07/09/2008	Left Vim	FTM [18]	02/04/2008	19	0	N/A	N/A	N/A	3	N/A
3	20	M	05/20/2009	Right Vim	FTM [18]	02/04/2009	0	23	10/17/2011	0	10 (On stimulation) 22 (Off stimulation)	2	56.5
4	22	M	11/04/2008	Bilateral Vim	FTM [18]	07/21/2008	22	18	N/A	N/A	N/A	3	N/A
5	39	M	05/11/2011	Bilateral GPi	WHIGET [19]	03/01/2011	5	16	12/08/2011	3	15	2	14.3