

Thalamic stimulation for choreiform movement disorders in children

Report of two cases

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✓ Surgery for movement disorders is most commonly performed in patients with dyskinesia and tremor associated with Parkinson's disease or in those with essential tremor. The role of ablative surgery or deep brain stimulation in patients with choreiform movements is poorly defined.

The authors placed thalamic stimulation systems in two children with disabling choreiform disorders due to intracerebral hemorrhage or cerebral palsy. Each patient displayed choreiform movements in the upper extremities both at rest and with intention, which interfered with daily activities and socialization. Both children obtained significant improvement in their choreiform movements, and their upper extremity function improved with no incidence of morbidity. Thalamic stimulation appears to be a promising and nonablative approach for children with choreiform movement disorders.

KEY WORDS • cerebral palsy • chorea • deep brain stimulation • tremor

SURGERY for movement disorders is most commonly performed in patients with dyskinesia and tremor associated with Parkinson's disease or in those with essential tremor. Increasingly, cerebral stimulation is used to achieve similar results, while avoiding the creation of a destructive lesion. Patients with spastic and dystonic cerebral palsy often benefit from dorsal rhizotomies and implanted intrathecal baclofen pumps; however, these interventions do not improve chorea or athetosis. The goal of each of these procedures is to remove the disabling symptoms of the disease, allowing improvement in motor function. In addition, oral medications are generally ineffective in treating chorea. We report on two patients—one with choreiform cerebral palsy and another with posthemorrhagic chorea—both of whom experienced dramatic improvement in their symptoms in response to thalamic stimulation.

Case Reports

Case 1

History. This 15-year-old boy had cerebral palsy and a mild developmental delay resulting from a cerebral hemorrhage that occurred at birth. He was born at 30 weeks gestation, weighing 2 lbs, 6 oz. Details of his birth history are not well documented because he is one of two adopted siblings. The boy's perinatal period included

a 4-month-long hospitalization, three respiratory distress events requiring resuscitation, and a seizure.

Magnetic resonance imaging performed 1 year before our examination revealed a large cavum septum pellucidum and mild enlargement of the ventricles. The inferior cerebellum and brainstem appeared hypoplastic. The basal ganglia were unremarkable.

The patient's chief complaint was "tremors" that interfered with his eating. His family members stated that it was increasingly difficult for him to eat independently because of the tremors, which had worsened over the past 2 years to the point that he was unable to feed himself. The tremors affected both upper extremities, the right more than the left. He was able to brush his teeth and hair without assistance. Baclofen, primidone (Mysoline), and propranolol had not improved his movements.

Examination. On examination, the patient was awake, alert, fully oriented, and attentive. The cranial nerves were intact and strength was normal in all extremities. His muscle tone according to the Ashworth scale was normal in all extremities. He had no clonus, but exhibited hyperreflexia on the left side. Choreiform movements were observed in the upper extremities. We did not believe that the movements in his upper extremities were tremors because they were not rhythmic in nature. He was unable to perform rapid alternating movements with either hand. He was able to ambulate, but with mild ataxia.

The patient was reevaluated 1 year later. His parents stated that his abnormal movements seemed to be worse. Because he was older, they believed that the movement disorder was significantly interfering with his function-

Abbreviations used in this paper: AC = anterior commissure; DBS = deep brain stimulation; MR = magnetic resonance; PC = posterior commissure.

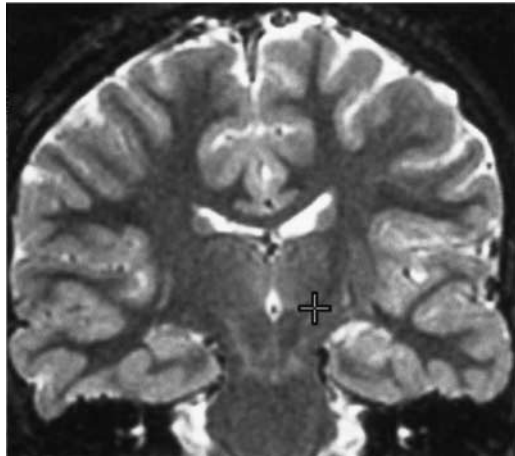


FIG. 1. Case 1. Planning MR image used for placement of the left thalamic stimulator revealing the proximity of the target to the internal capsule.

al ability and his socialization, particularly at meal times. The patient and his parents elected to pursue a trial of DBS.

Operation. On the day of surgery, a Leksell G frame was placed on the patient's head following induction of mild sedation by intravenous injection of 50 μ g fentanyl and 0.5 mg midazolam. Care was taken to align the base ring of the frame with the zygomatic arch in an attempt to place both the AC and PC in the same axial plane. We obtained contrast-enhanced MR images in both axial and coronal planes. The axial MR image was a volume-acquisition image with 1-mm slices. The coronal images were obtained using a fast spin gradient-echo technique to achieve the best visualization of the thalamus and basal ganglia. Stereotactic coordinates for localizing the nucleus ventralis intermedialis were used for initial planning (three twelfths of the AC-PC line distance anterior to the PC, one half the third ventricle width plus 11 mm lateral). Coronal and sagittal views were used to plan the entry point and trajectory, avoiding sulcal arteries (Fig. 1). The stimulating electrode (model 3387; Medtronic, Inc., Minneapolis, MN) was passed to the left nucleus ventralis intermedialis target through a 14-mm burr hole following dural puncture. Microelectrode recording was not performed. Rather, stimulation and observation of the patient's clinical response were used to guide electrode placement. Test stimulation beginning with 130 Hz from 0 to 2 V induced a moderate diminution in the patient's jerking movements. When the setting of 180 Hz at 2 V was used, the patient exhibited prompt elimination of his choreiform movements; he was able to write better and hold a cup of water without spilling. The result was reproducible. The electrode was tunneled a short distance subcutaneously for a 2- to 3-day trial period and left externalized. The stimulator was initially programmed at the following settings: 2.5 V, pulse width 120 μ sec, and rate 185 Hz. Lead 0 (the most distal lead) and Lead 2 were off, Lead 1 was negative, and Lead 3 was positive.

After the procedure, there was a marked reduction in the patient's choreiform movements. Initially he reported facial paresthesias. On the 3rd trial day, the patient

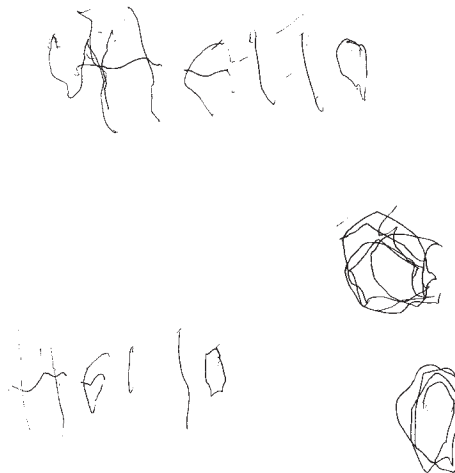


FIG. 2. Case 1. Handwriting samples obtained with the stimulator off (upper) and with the stimulator on (lower) demonstrating a marked improvement in motor control during stimulation.

returned to the operating room and the stimulator was placed internally.

Postoperative Course and Treatment. In the immediate postoperative period, the patient believed that the effect of the stimulation was not as beneficial as he had experienced during the trial. Ten days later, he stated that the improvement in his chorea was "major." He continued to complain of mild paresthesias in his right face and arm. Virtually no chorea was present in the right arm. Voltage was decreased from 2.5 to 2 V with no increase in aberrant movements. Six weeks later, the patient reported that his movements were still improved, but had increased slightly 2 days after reducing the voltage. Three months postoperatively without further change in the stimulator settings, the patient and his parents expressed satisfaction with the stimulator response. It was much easier for the patient to eat with a fork. Both patient and parents believed that his eating behavior was much more socially acceptable, and he was no longer flinging food. The stimulator was used an average of 14 hours per day and was turned on and off by the patient. When the stimulator was left on overnight, the patient believed that it did not work as well on the following day. He remains well 18 months postimplantation and is satisfied with the relief of his movements. The stimulator has had a more profound effect on his ability to eat and to write on a blackboard (using gross motor movements) than on his handwriting. Samples of his handwriting are shown with the stimulator on and off (Fig. 2). Chorea in the left upper extremity has been unaffected by the DBS. Because of the effectiveness of DBS in treating the patient's right extremities, we are considering placement of a contralateral thalamic stimulator in the future.

Case 2

History. This 11-year-old girl had sustained a left thalamic hemorrhage 4 years before presentation in our clinic. The hemorrhage caused an initial hemiparesis that recovered markedly. She retained significant right-sided hypesthesia and hypalgesia and, subsequently, a profound

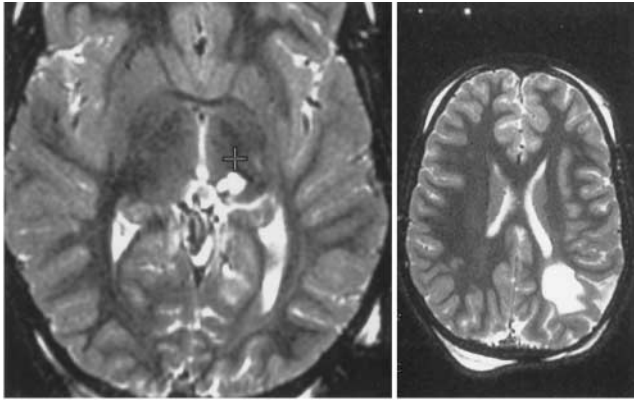


FIG. 3. Case 2. Axial MR image obtained 4 years after the patient sustained a hemorrhagic infarction, demonstrating T₂ signal changes in the thalamus (*left*) and cortex (*right*). The planning MR image (*left*) shows the target for the deep brain stimulator.

movement disorder developed that limited use of her upper extremity for any functional activity. An evaluation at that time found no evidence of vasculitis, arteriovenous malformation, or tumor. Trials of clonazepam, phenytoin, carbamazepine, and baclofen proved to be ineffective. At the time of our evaluation, the patient was taking 240 mg of propranolol and 18 mg of trihexphenidyl daily, without improvement in her symptoms.

Examination. On examination, the patient exhibited normal mentation and a normal cranial nerve function except for facial sensation. There was marked hypesthesia and hypalgesia on the right side of her face, body, and extremities. Strength was normal in all extremities. Intentional movements of the right upper extremity were unsuccessful

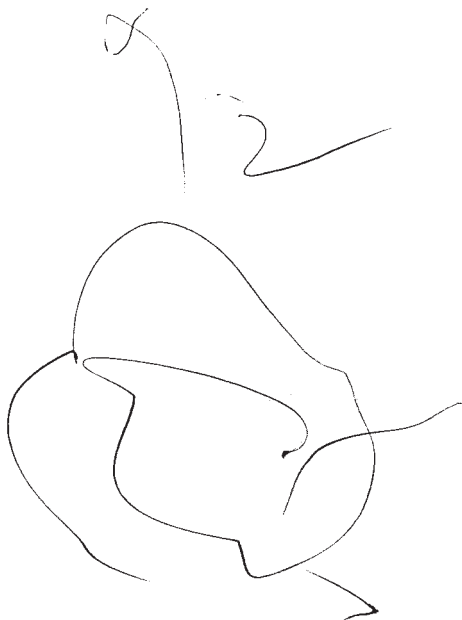


FIG. 4. Case 2. Handwriting samples obtained before surgery using only the right hand to draw a circle (*upper*) and 4 months postoperatively, without stimulation, allowing the left hand to stabilize the right arm (*lower*).

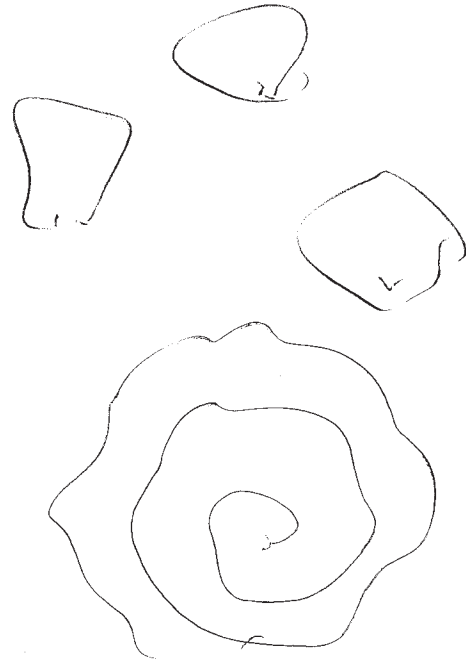


FIG. 5. Case 2. Handwriting samples obtained during stimulation, 4 months postoperatively. Using only the right hand, the patient drew simple circles, but could not draw an Archimedes spiral (*upper*). Using the left hand to stabilize the right arm, she drew this spiral (*lower*).

because of involuntary nonrhythmic and unpatterned movements. The patient was able to grasp a pencil, but was not able to make contact with a writing surface. In attempting to perform finger-to-nose tasks, the patient would forcefully strike her face. She could not hold a cup or utensils. The patient's lower extremity was not as severely affected. She walked, but displayed an altered gait.

Magnetic resonance imaging revealed an area of encephalomalacia in the left posteroinferior thalamus, with a wedge of cortical atrophy (Fig. 3). Contrast-enhanced images did not reveal any evidence of tumor or vascular malformation. There were no other abnormalities in the brain.

Operation. The patient underwent imaging and placement of the left thalamic stimulating electrode, as described for Case 1. Microelectrode recording was not performed. As the stimulator was advanced to the target, the patient's movement disorder improved without stimulation. She was able to perform finger-to-nose testing without striking her face. Greater improvement was achieved with stimulation greater than 1.5 V. Test stimulation up to 3 V did not induce any paresthesias, but induced mild dysarthria that resolved after stimulation. Repeated testing with the stimulating electrode alternating between the on and off settings confirmed the clinical benefit of stimulation. The stimulator was placed internally at the same sitting after induction of general anesthesia. The following morning, the stimulator was activated at 2.6 V, with a pulse width of 120 μ sec and a rate of 170 Hz. The leads were adjusted to the following settings: 0 = negative, 1 = off, 2 = positive, and 3 = off. The patient and her family noted a marked improvement in motor control on the

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right side of her body. The patient continued to do well over the 1st month, at the same stimulator settings (Fig. 4).

The patient's medication regimen was tapered. With cessation of all medicine 3 months postoperatively, the patient reported that the improvement in her right upper extremity had lessened, but was still better than her preoperative status. Function was still better than preoperatively, but not as good as the initial result. She continued to use the stimulator throughout the day, turning it off at night.

When the patient was evaluated 4 months postoperatively, she reiterated that arm function was improved enough that she no longer wanted her arm to be removed, a wish she had expressed preoperatively. Her arm was useful postoperatively for tying shoes, holding books, and holding a cup. The patient reported improved self-esteem as a consequence of improved arm control. The stimulator was adjusted to 3.2 V, with a pulse width of 150 μ sec and a rate of 180 Hz. Leads were set at: 0 = off, 1 = off, 2 = negative, and 3 = positive. With these new settings, the patient was able to perform motor tasks with greater control (Fig. 5).

Discussion

Chorea is a term used to describe brief irregular involuntary muscle contractions that are nonrhythmic and unpatterned and have variable timing.⁵ Chorea is associated with a number of degenerative diseases such as Huntington's disease, ataxia telangiectasia, and Wilson's disease. Chorea can also be a secondary symptom of infection or autoimmune disease (Sydenham's chorea or systemic lupus erythematosus), drug side effects (from use of levodopa, anticholinergic agents, or antipsychotic medications), metabolic disorders (due to hyperthyroidism, oral contraceptives, or pregnancy), or vascular lesions, or it may be idiopathic. There is no well-established medical or surgical therapy for chorea. Before 1960, both pallidotomy and thalamotomy were attempted in patients with chorea and athetosis, but with poor results.¹⁰ Spiegel and Wycis^{7,8} found improvements in three of nine patients with chorea who had been treated by pallidotomy and in one of three patients who had been treated with medical thalamotomy. Narabayashi and Okuma^{2,3} effectively treated two patients with chorea by chemopallidotomy.

Deep brain stimulation has been used for more than 20 years for the relief of chronic pain. More recently, use of DBS has been extended to functional neurosurgery, including stimulation of the thalamus, globus pallidus, and subthalamic nucleus as treatment for Parkinson's disease, tremor, and dystonia. Deep brain stimulation has the advantage of avoiding a permanent lesion and allowing multiple variations of current frequency and bandwidth between a combination of four electrodes, each 1.5 mm in length and separated by 1.5 mm. Its effectiveness without resorting to creation of a lesion and its potential to vary the stimulation parameters make DBS an ideal way to treat children.

Although the exact mechanism of benefit remains unclear, it has been postulated that DBS creates an electrical

field that physiologically alters cellular function or axonal transmission. At frequencies higher than 100 Hz, DBS appears to create a functional physiological lesion. Deep brain stimulation may activate or inactivate neurons and axons within the electrical field.^{4,6,9} The effect on axons may be relayed to either the neuron of origin or the end target. Long-term DBS may lead to remodeling of the cerebral cortex.¹

Conclusions

Treatment of children with cerebral palsy or posthemorrhagic movement disorders pose numerous diagnostic and therapeutic difficulties. Our patients and their families were motivated to seek supportive aids and interventions that would allow their children to achieve the highest level of function. Their initial evaluation in our Spasticity and Movement Disorders Clinic was intended to determine the possible role of intrathecal baclofen for spasticity. Although the first patient misclassified his choreoathetosis as a "tremor," he correctly identified the source of his greatest functional disability. These cases represent the first use of successful DBS in children with choreiform disorders. This report will hopefully encourage others to continue to investigate therapeutic interventions for children with movement disorders.

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