Multitarget deep brain stimulation

Deep brain stimulation (DBS) surgery for movement disorder treatments usually employs stimulation at a single site in one or both hemispheres. However, research has demonstrated that Multitarget deep brain stimulation shows some benefits over single target DBS.\(^1\)\(^2\)\(^3\).

Ding et al. proposed a novel stereotaxic system used for implanting a curved lead to any two targets of the brain, and used the theoretical “curved lead method”. First, a customized novel stereotaxic system was fabricated, and a solid cranial model with six fixed internal targets was made; second, CT scan was performed to locate the fixed internal targets; third, five curved leads were implanted to five selected pairs of targets, each following the calculated parameters of “curved lead pathway” with the novel stereotaxic system, respectively. Finally, CT scans were performed again to determine the exact locations of the curved leads.

Results: The five curved leads accurately passed through the five pairs of combined targets, respectively, and the average vector error of curved lead implantation was 0.70±0.24mm.

Comparison with existing method(s): In most situations, performing a multiple-target DBS procedure with the current stereotaxic systems means increased number of implanted leads, increased incidence of operative complications, and increased medical costs. However, the novel stereotaxic system could guide a single lead to reach two selected targets of the brain with high accuracy.

Conclusions: The novel stereotaxic system enables curved lead implantation with high accuracy, and can be considered as a useful complement to the current stereotaxic system.\(^4\).

Case series

Chang et al. reviewed patients who had undergone unilateral DBS targeting the GPi and ventralis oralis (Vo).

Five patients diagnosed with medically refractory upper extremity dystonia (focal or segmental) underwent DBS. Two DBS electrodes each were inserted unilaterally targeting the ipsilateral GPi and Vo. Clinical outcomes were evaluated using the Burke-Fahn-Marsden Dystonia Rating Scale (BFMDRS) and Disability Rating Scale.

BFMDRS scores decreased by 55% at 1-month, 56% at 3-month, 59% at 6-month, and 64% at 12-month follow up. Disability Rating Scale scores decreased 41% at 1-month, 47% at 3-month, 50% at 6-month, and 60% at 12-month follow up. At 1 month after surgery, stimulating both targets improved clinical scores better than targeting GPi or Vo alone.

Unilateral thalamic and pallidal dual electrode DBS may be as effective or even superior to DBS of a single target for dystonia. Although the number of patients was small, our results reflected favorable clinical outcomes.\(^5\).

Parker et al. report a series of cases: midbrain cavernoma hemorrhage with olivary hypertrophy, spinocerebellar ataxia-like disorder of probable genetic origin, Holmes tremor secondary to brainstem stroke, and hemiballismus due to traumatic thalamic hemorrhage, all treated by dual pallidal and thalamic DBS. All patients demonstrated robust benefit from DBS, maintained in long-term follow-up. This series demonstrates the flexibility and efficacy, but also the limitations, of dual thalamo-pallidal...
stimulation for managing axial and limb symptoms of tremors, dystonia, chorea, and hemiballismus in patients with complex movement disorders.

Kobayashi et al. implanted 2 DBS electrodes (one at the nucleus ventralis oralis/nucleus ventralis intermedius and the other at the SA) in 4 patients with HT. For more than 2 years after implantation, each patient's tremor was evaluated using a tremor rating scale under the following 4 conditions of stimulation: “on” for both thalamus and SA DBS; “off” for both thalamus and SA DBS; “on” for thalamus and “off” for SA DBS; and “on” for SA and “off” for thalamus DBS.

The tremor in all patients was improved for more than 2 years (mean 25.8 ± 3.5 months). Stimulation with 2 electrodes exerted greater effect on the tremor than did 1-electrode stimulation. Interestingly, in all patients progressive effects were observed, and in one patient treated with DBS for 1 year, tremor did not appear even while stimulation was temporarily switched off, suggesting irreversible improvement effects. The presence of both resting and intentional/action tremor implies combined destruction of the pallidothalamic and cerebellothalamic pathways in HT. A larger stimulation area may thus be required for HT patients. Multitarget, dual-lead stimulation permits coverage of the wide area needed to suppress the tremor without adverse effects of stimulation. Some reorganization of the neural network may be involved in the development of HT because the tremor appears several months after the primary insult. The mechanism underlying the absence of tremor while stimulation was temporarily off remains unclear, but the DBS may have normalized the abnormal neural network.

They successfully treated patients with severe HT by using dual-electrode DBS over a long period. Such DBS may offer an effective and safe treatment modality for intractable HT.

Case reports

A 33-year-old male PD patient with onset at the age of 12 years. The onset of the disease is presented with bradykinesia and progressively developed severe choreic dyskinesia with the use of medications. We then performed a thorough evaluation of the patient and decided to perform bilateral globus pallidus interna combined with subthalamic nucleus variable frequency DBS (bSGC-DBS) implantation, and after 2 years of follow-up the patient's bradykinesia and dyskinesia symptoms and quality of life improved significantly. Conclusions: This is the first case of bSCG-DBS in a PD patient with refractory dyskinesia, and the first report of encouraging results from this clinical condition. This important finding explores multi-electrode and multi-target stimulation for the treatment of dystonia disorders.


DBS leads were implanted in the GPi and Vim/Vop and each stimulation combination (GPi, Vim/Vop, and both) was tested for three months in a single patient. Burke-Fahn-Marsden Dystonia Rating Scale (BFMDRS) and Short-Form 36 (SF-36) were completed at the end of each trial period.
Results: Multitarget (Gpi+Vim/Vop) stimulation was clinically the most effective treatment and resulted in the most improvement in function and quality of life. The patient's hemidystonia improved by 25% as measured by the BFMDRS during the multitarget stimulation trial period and at the 6-month follow-up. The patient's quality of life improved by 86% and 59% during the multitarget stimulation trial period and at the 6 month follow-up respectively.

Conclusion: Multitarget thalamic and pallidal DBS proved to be the most effective therapy for this patient with secondary hemidystonia due to a putaminal stroke. A single-lead approach may not be sufficient in neuromodulating a highly disorganized motor network seen in hemidystonia. Multitarget DBS should be further explored in post-stroke dystonia and may offer improved outcome in other forms of secondary dystonia with limited response to Gpi DBS.  
