

Deep Brain Stimulation: an underused panacea?

Authors



Erick Pereira is a Specialty Registrar in Neurosurgery at the John Radcliffe, Oxford. He studied natural sciences at Trinity College Cambridge before qualifying in medicine at Oxford. His clinical research, which recently won the British Neurosurgical Research Group prize, investigates novel surgical techniques and clinical applications in stereotactic surgery including pain, psychiatric and autonomic disorders with Alex Green, Clinical Lecturer in Neurosurgery at Oxford.



Dipankar Nandi is a Consultant Neurosurgeon at Charing Cross Hospital and Honorary Senior Lecturer at Imperial College London. He studied medicine and completed residencies in general surgery and neurosurgery in the All India Institute of Medical Sciences, New Delhi, before undertaking higher neurosurgical training in Oxford. His DPhil research at Oxford helped establish the pedunculo-pontine nucleus as a surgical target for parkinsonian akinesia. Current interests include stereotactic neurosurgery, deep brain stimulation and brain tumours.



Tipu Aziz is Professor of Neurosurgery at the University of Oxford and a Consultant Neurosurgeon at the John Radcliffe, Oxford. He studied physiology at University College London then medicine at King's College London. His MD research in Manchester established the subthalamic nucleus as a surgical target for Parkinson's disease. At Oxford he also advanced neurosurgery for dystonia, multiple sclerosis and chronic pain. His clinical experience includes over 1,000 deep brain surgical procedures and over a decade implanting deep brain stimulators.

Correspondence to:
Dr Erick AC Pereira,
Oxford Functional Neurosurgery,
Nuffield Department of Surgery,
Oxford University and Department of
Neurological Surgery, The West Wing,
The John Radcliffe Hospital,
Oxford, OX3 9DU.
Email: eacp@eacp.co.uk
Tel: +44 (0) 1865 234605
Fax: +44 (0) 1865 231885

Summary

Deep brain stimulation (DBS) enables structures in the brain to be stimulated electrically by an implanted pacemaker after a minimally invasive neurosurgical procedure and has become the treatment of choice for Parkinson's disease refractory to or complicated by drug therapy. Many clinical indications for DBS now exist including dystonia and tremor in movement disorders; depression, obsessive-compulsive disorder and Tourette's syndrome in psychiatry; epilepsy, cluster headache and chronic pain. DBS is a standard and widely accepted treatment for Parkinson's disease after two decades of experience, but for most other clinical indications it remains restricted to a handful of experienced, specialist centres. Current challenges highlighted include consideration of referral for DBS by clinicians and the securing of funding for its use from National Health Service healthcare providers.

Deep brain stimulation (DBS) is neurosurgery that enables brain structures to be stimulated electrically by a pacemaker implanted under the skin. In the 1980s, over a decade after its first use in pain,¹ implantable DBS of the thalamus was performed to suppress tremor in Parkinson's Disease (PD) refractory to drug treatments.² Primate-based research soon afterwards identified the subthalamic nucleus, a basal ganglia structure, as a putative brain target for both ablation and DBS.^{3,4} Alongside the resurgence of thalamic DBS and basal ganglia lesional surgery^{5,6} and improvements in neurostimulator technology, scientific discoveries from primate research cultivated a renaissance in neurosurgery for PD in the 1990s resulting in increasing use of DBS over the last decade. Its efficacy in PD has been demonstrated robustly by clinical trials with multiple novel brain targets having been discovered recently. Several other indications for DBS now exist such as tremor and dystonia in movement disorders; psychiatric disorders like obsessive-compulsive disorder (OCD), depression and Tourette's syndrome; cluster headache, epilepsy and chronic pain.⁷

Devices

At present, only one commercial manufacturer (Medtronic Inc, Minneapolis, MN, USA) produces deep brain electrodes widely used for DBS. Two models are currently available - the 3387 and the 3389. Both are quadripolar electrodes, having four electrical contacts with the brain.

Several stimulation parameters can be altered in DBS, in particular voltage, frequency and pulse

width. Stimulation can be monopolar or bipolar over any combination of the four contacts of each electrode and multiple contacts can be specified as anodes or cathodes. The DBS electrode is secured to the skull and connected to a lead tunneled to the chest or abdomen where a pulse generator (pacemaker) is implanted under the skin. Recent developments include commercially available transcutaneously rechargeable pulse generators, which will be included in a new DBS platform being introduced by Medtronic, and the potential entry of other device manufacturers from related fields like spinal cord stimulation. Detailed device issues are described elsewhere.^{8,9}

Efficacy

As several decades of clinical experience with established drug treatments have accrued so patient subgroups refractory to medical therapies have been identified, not just in PD, chronic pain and epilepsy, but also in other movement disorders including dystonias, tremor, Tourette's syndrome, psychiatric disorders of depression and obsessive-compulsive disorder (OCD) and cluster headache. These disorders have all been successfully treated by DBS after failed drug treatment (Table 1).⁷ Each is summarised below.

Parkinson's disease

PD is a slowly progressive, neurodegenerative disease characterised by tremor, rigidity, bradykinesia and postural instability. It is common in middle or late life with prevalence rising to 1% in people over 60

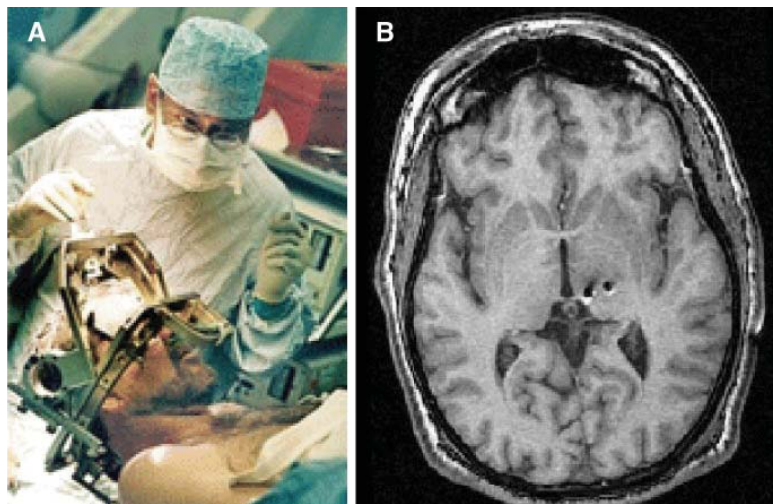


Figure 1: (A) Intra-operative awake deep brain stimulation; (B) axial MRI of deep brain stimulators for pain in situ.