The History of Deep Brain Stimulation

The story of DBS is a fascinating example of the interplay between basic and clinical science as a two-way process. A chance clinical observations related to drug abuse led to the creation of a monkey model for PD, and intensive investigation of this model led within four years to a practical approach in PD patients. Some the milestones in this particular development were:

1983 The compound MPTP was discovered to be the source of Parksinson-like symptoms in young designer-drug addicts [Langston JW, Ballard P, Tetrud JW, Irwin I. (1983) Chronic Parkinsonism in humans due to a product of meperidine-analog synthesis. Science, 219:979-80].

1983 Injection of MPTP into monkeys caused a Parkinson-like state [Burns RS, Chieuh CC, Markey SP, Eberet MH, Jacobwitz DM and Kopin IJ (1983) A primate model of parkinsonism: selective destruction of dopaminergic neurons in the pars compacta of the substantia nigra by MPTP. PNAS 80, 4546-4550]

1983-1990 Recordings in the basal ganglia of both normal and MPTP-treated monkeys helped to define the operational principles of basal ganglia-thalamocortical loops, and showed for the first time pronounced over-activity in a part of the basal ganglia called the subthalamic nucleus (STN). These papers have provided the conceptual framework for much of work on the basal ganglia and movement disorders over the past decade or so. They relied on both recordings from single neurons in awake, behaving monkeys, but also used metabolic markers to map areas of over- and under-activity. [Mitchell IJ, Jackson A, Sambrook MA & Crossman AR. (1989) The role of subthalamic nucleus in experimental chorea-evidence from 2-deoxyglucose metabolic mapping and horseradish-peroxidase tracing studies. Brain 112: 1533-1548.
Alexander GE, Crutcher MD & DeLong MR. (1990) Basal ganglia-thalmocortical circuits: parallel substrates for motor, oculomotor, prefrontal and limbic functions. Progress in Brain Research 85: 119-146]

1990 Lesions of STN in monkeys were shown to completely and permanently reverse the effects of MPTP [Bergman H, Wichmann T, DeLong M. (1990) Reversal of experimental parkinsonism by lesions of the subthalamic nucleus. Science 249: 1436-1438. Aziz TZ, Peggs D, Sambrook MA & Crossman AR. (1991) Lesion of the subthalamic nucleus for the alleviation of 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP)-induced parkinsonism in the primate. Movement Disorders 6: 288-292]

1993 The first report from Benabid's clinic of the use of DBS in the STN to treat Parkinson's Disease. Benabid's group had first used DBS in the thalamus as early as 1987. This was carried out in three patients, with DBS electrodes implanted on both sides of the brain, which is now the standard approach in PD patients [Limousin P, Pollak P, Benazzouz A, Hoffmann D, Le Bas JF, Broussolle E, Perret JE, Benabid AL (1995).
Effect of parkinsonian signs and symptoms of bilateral subthalamic nucleus stimulation. Lancet, 345, 91-95].

1997 FDA approval given for DBS in the thalamus.

2001 FDA approval given for DBS in the STN.

(387 citations from 2001-2003)

It is noticeable that in this example, both the conceptual framework and the experimental evidence to support clinical trials in PD patients came from the animal model . Much of this experimental work was done in the UK (Alan Crossman, Tipu Aziz and colleagues in Manchester were pioneers).

The clinical picture now

The treatment of PD by DBS is now used world-wide. Current estimates are that approximately 20,000 patients with movement disorders have been treated with DBS. DBS is also being used to treat other disorders including dystonia, a much rarer disease than PD, but one which affects children. Again, reports of long-term beneficial outcomes have appeared [P Coubes, A Roubertie, N Vayssiere, S Hemm, B Echenne (2000) Treatment of DYT1-generalized dystonia by stimulation of the internal globus pallidus
Lancet 355:2220-2221]. DBS has long been used for the relief of chronic pain [Richardson, D. (1995) Deep brain stimulation for the relief of chronic pain. Neurosurg Clin N Am 6:135-44].

Despite the large number of PD patients treated with DBS, there is a surprisingly small number of randomised clinical trials [Stowe RL, Wheatley K, Clarke CE, Ives NJ, Hills RK, Williams AC, Daniels JP, Gray R (2003) Surgery for Parkinson's disease: lack of reliable clinical trial evidence. J Neurol Neurosurg Psychiatry 74:519-521]. Currently a randomized clinical trial of DBS is being carried out by the MRC [http://www.mrc.ac.uk/prn/index/public-interest/public- press_office/public-press_releases_2001/public-25_july_2001.html].

The longest surviving patients have had stimulators in for around 8 years without untoward side-effects. In most patients batteries need to replaced every 5 years. Despite its major impact on PD, DBS treatment is available in only a limited number of centres in the UK. This is partly due to the high cost of the treatment, including the stimulators and electrodes, which are very expensive. There is a virtual monopoly of DBS electrodes and stimulators by Medtronic Inc. [http://www.medtronic.com/hic/tremor.html].

Current estimates are that the cost of DBS treatment will be recouped in around five years