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ARTICLE

Psychosurgery: A History from Prefrontal Lobotomy to Deep Brain Stimulation

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ABSTRACT

Neurosurgical treatment for psychiatric disorders features a long and controversial history. This article explores a "spectrum of psychosurgery", describing how old-fashioned and controversial prefrontal lobotomy gradually evolved into modern day, mainstream scientific deep brain stimulation (DBS). We focus on the rise, fall and possible re-emergence of psychosurgery as a therapeutic intervention today. We journey through historic indiscriminate use of prefrontal lobotomy, which evoked stern criticism from both public and professionals, through to the development of modern day DBS - performed for patients suffering from severe, treatment resistant symptoms of obsessive-compulsive disorder (OCD), epilepsy and movement disorders. We hope this article will provide a basis for understanding the availability of existing treatment options and potential future opportunities, whilst simultaneously challenging any public/professional preconceptions of psychosurgery, which may indirectly be obstructing patient care. Additionally, we carried out a qualitative survey displayed in WordCloud Format, capturing the intellection of 38 mental health professionals working for North West Boroughs NHS Healthcare Foundation Trust, on "psychosurgery", "prefrontal lobotomy" and "DBS", which may well reflect wider public opinion. In summary, the article provides a brief, yet comprehensive overview of the controversial history of psychosurgery, present-day practice, and future trends of neurosurgery for psychiatric disorders.

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1. Introduction

Psychosurgery...what comes to your mind when you hear this word?

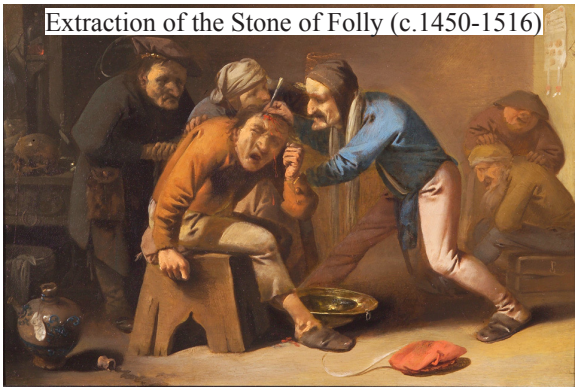

Figure 1. Extracting the Stone of Madness [45]

Does it bear resemblance to this portrayed image? Do words like "barbaric", "zombie" or "inhumane" spring to mind? Or perhaps the idea that it is useless and illegal?

Neurosurgery for psychiatric disorders has relished enthusiastic support as well as facing scorn throughout human history. Any discussion unvaryingly evokes controversy due to its indiscriminate use in the mid-twentieth century, resulting in profound ethical implications that remain to this day. Currently, the standard therapeutic approach to most psychiatric diseases involves either (or a combination of) psychotherapy, pharmacotherapy, and electroconvulsive therapy (ECT) in some cases. Despite these treatment methods, many patients still fail to respond effectively and continue to remain severely disabled. Most patients and their families are unaware that such "last-resort" options like psychosurgery still exist. In intractable cases, surgical intervention may be considered suitable if the therapeutic result and overall level of functioning could be enhanced [3].

Interestingly there is evidence of brain surgery successfully treating "organic" disorders such as epilepsy. According to a survey by physicians at Henry Ford Hospital, brain surgery for otherwise hard to treat epilepsy was found be an effective treatment for up to 15 years. Most prior studies had solely looked at seizure control and psychosocial outcomes at 2-5 years post-surgery [42].

Such procedures for "organic" brain disorders are just as invasive and associated with similar risks as psychosurgical techniques for "functional" illnesses, however we suspect that its evolution has been far less controversial - why?

This article explores a "spectrum of psychosurgery", describing how old-fashioned and controversial prefrontal lobotomy gradually evolved into modern day, mainstream scientific deep brain stimulation. It also explores the perceptions of medical professionals on psychosurgery, which may reflect wider public opinion and stigma. To explore this we asked a group of 38 psychiatrists and psychiatry trainees working for North West Boroughs NHS Healthcare Foundation Trust, to write down 3 words reflective of their intellection about "psychosurgery (Figure 4), prefrontal lobotomy (Figure 2), and deep brain stimulation (Figure 10)". We have displayed their responses visually as word clouds below, embedded into sections of relevant discussion, with the size of the font directly corresponding with the frequency of responses.

2. A Spectrum of Psychosurgery from Prefrontal Lobotomy to DBS

2.1 Prefrontal Lobotomy Word Cloud

Figure 2. NWBH 38 psychiatrists "3 word" response to "Prefrontal lobotomy" [46]

The earliest evidence of psychosurgery has its roots in the Neolithic era of the stone age (around 5100 BC) [4]. During this period, numerous skulls were identified with areas of trephination and evidence of proper healing. The estimated long lifespan of these individuals, suggests that these early procedures were likely performed with therapeutic intent, rather than a traumatic origin of the wound [5]. It has been hypothesized that early trephination was performed for ritualistic or spiritual purposes, with intent to treat manifestations of headaches, epilepsy, and mental illness [6].

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Bronze Age skull from Jericho, Palestine, 2200-2000 BC
This skull shows four separate holes made by the ancient surgical process of trephination

Figure 3. Skull showing holes made by trephination process - clearly begun to heal, suggesting that although highly dangerous, the procedure was by no means fatal [47]

In the early 1800s, new insights into functional neuroanatomy and neurophysiology stimulated renewed interest into psychosurgery. In 1819, Franz Joseph Gall published his treatise on phrenology, which suggested that the brain possessed discrete functional regions [7]. He divided the brain into sections that corresponded to certain behaviours and traits that he called fundamental faculties. He based his structure-function association primarily on cranial differences between men and women [8].

Despite the idea of phrenology being flawed and eventually disgraced, Paul Broca and Carl Wernicke stretched the idea of neurological functions having an anatomical link in seminar work. This notion was further expanded by work of Gustav Fritsch, Eduard Hitzig, and David Ferrier on localization of the motor cortex [6].

When discussing traumatic brain injury, it is pertinent to recall the famous case of Phineas Gage, an American railroad construction worker, who developed personality changes (aggressive and impulsive behaviour, along with the defect in rational decision making and emotions processing) following an accidental penetrating injury to his left frontal lobe [9].

A Swiss psychiatrist named Gottlieb Burckhardt, performed the first psychosurgical procedures as early as 1888, after gaining inspiration from Phineas Gage's case findings. He conducted these procedures on six chronic schizophrenic patients and excised their cerebral cortices, which was thought to be responsible for aggression, agitation and hallucinations. Most patients showed improvement and became easier to manage, although one patient died from the procedure and some had aphasia or seizures [10]. He published his findings in 1891 in a scholarly paper; however, his approach outraged the medical community, calling him ruthless and irresponsible. This led to cessation of his academic endeavours [11]. The research and quest of psychosurgery became invisible until 1935, when Yale psychologists John Fulton and Carlyle Jacobsen presented a study on frontal lobectomy in primates and described the role of the frontal lobe in short term memory, anxiety and aggression [12].

2.2 Psychosurgery Word Cloud

Figure 4. 38 psychiatrists "3 word" response to "Psychosurgery" [48]

Egas Moniz, a Portuguese neurologist, along with neurosurgeon Almeida Lima developed a procedure called leucotomy (lobotomy) for the treatment of psychiatric patients with prominent depression, anxiety or aggression. The first lobotomy was performed on November 12th, 1935 by Almeida Lima, on the orders of Egas Moniz [13]. Their patient was a psychotic woman in her sixties, and Lima treated her by piercing her skull with a bone drill and killing frontal lobe brain tissue with an injection of alcohol. Moniz called this procedure a "prefrontal leucotomy" [14]. Between November 1935 and February 1936, Moniz and Lima performed lobotomies on nineteen more patients [15]. During this time, they revised their surgical technique and began using an instrument called a leucotome to destroy tissue in the frontal lobes [16]. Leucotomy had the best results on patients with agitated depression and involutional melancholia, the majority of whom Moniz classed as "greatly improved" [17]. Moniz and Lima also discovered that the procedure did not remove the symptoms of psychosis or improve obsessive-compulsive symptoms, much like other therapies. However, Moniz considered the operation to be an overall success, since patients became calm and were often discharged from hospital [18].

Leucotomy was introduced into the United States in 1936 by the neurologist Walter Freeman and the neurosurgeon James Watts [19]. They performed their first operation on September 14th, 1936. The patient, "A.H.", was a

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middle-aged woman with severe agitated depression [20]. Although Freeman noted that the long-term effects of frontal lobe damage were unknown, the patient was "relieved" of her agitation and depression. Freeman and Watts originally used Moniz's leucotomy technique before altering it to develop the standard lobotomy. This was a blind procedure which involved drilling into the skull near the top of the forehead, and then using a cannula (a sharp-ended tube) and leucotome to make "sweeping motions" and "stab incisions". This was done on both sides of the head with the patient potentially still awake [21,22]. This advanced procedure was termed the prefrontal lobotomy. Minimal lobotomies were mainly performed for the treatment of affective symptomatology, while radical lobotomies were for schizophrenic patients or those with refractory symptoms [23].

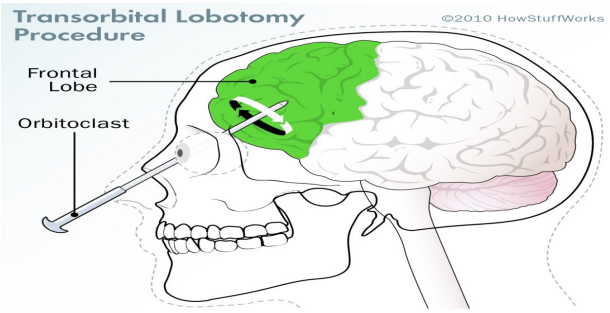

Figure 5. Transorbital Lobotomy Procedure [49]

Between January and March of 1946, Freeman began performing "transorbital" or "ice-pick" lobotomies. This process involved destroying frontal lobe tissue by moving around a cannula that was inserted into the brain through the bony orbit above the eye (Figure 5) [24]. Transorbital lobotomy destroyed less total brain tissue than the standard prefrontal leucotomy, and, according to Freeman, did not produce any "significant intellectual or personality deficits". Freeman promoted the transorbital approach as a "safe, simple, and quick" minor operation that merely required electroshock therapy for sedation. Hence psychiatrists could perform this without a neurosurgeon, anaesthetist or even proper sterile technique [25]. By 1952, when anti-psychotic drugs were introduced as a psychiatric treatment, Freeman and Watts had performed over 600 surgeries [26].

Figure 6. Lobotomy Tool Set consisting of a Hammer and Orbitoclast [50]

Figure 7. Dr Walter Freeman performing a transorbital lobotomy [51,52]

Leucotomy was gradually introduced in Britain in 1941 and was used more rapidly after World War II. By November 1961, 15,000 or more patients had reportedly received the operation [27]. Even before the introduction of chemical treatments in the early 1950s, leucotomy numbers slowed down nationally, possibly due to adverse side effects [28].

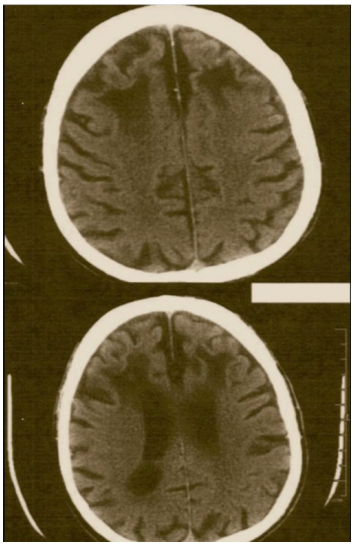

Figure 8. A CAT scan of a brain after leucotomy. The hypodense areas at eleven and one o'clock show the damage [53]

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Ultimately, the opinion of professionals and public turned against the lobotomy owing to the link of morbidity and mortality becoming more obvious [22]. A number of patients developed symptoms like apathy, emotional blunting, and disinhibition; which was jointly named as "post-leucotomy syndrome". Consequently, the medical association instigated to obtain further scientifically rigorous surgical methodologies, which were focused on hypothesis-driven targeting, with less hostile wounds and resections.

Due to the early enthusiasm for frontal lobe lobotomy and its widespread social acceptance, the non-neurosurgeons started performing this procedure in inappropriate settings. This sparked professional criticism regarding the substantial underreported adverse events, along with the lack of scientific rigor [29]. Additionally, the public became conscious of the objectionable consequences of lobotomies; and social attitudes were moulded by damaging portrayals in literature and film, including noteworthy examples such as *One Flew Over the Cuckoo's Nest*. It also came to the light that some institutionalized or incapacitated patients had lobotomies done without their informed consent, and that it may have been performed on prisoners to tackle dysfunctional behaviour rather for treating mental illness [23].

Ultimately, it was the growth of pharmacotherapy that turned the tide against psychosurgery, predominantly with the arrival of lithium [30] and chlorpromazine [31]. Although, electroconvulsive therapy (ECT) was also initiated before the arrival of psychotropics, and was documented as being efficacious in the treatment of psychiatric disorders, its use had also dramatically shrunken before 1980s, due to its side effects on cognition and memory [32].

However despite psychotropics, psychotherapies and ECT interventions, it became clear that a significant number of patients were not responding to these treatments, and psychosurgery was either being overlooked or not considered at all.

The success of the cardiac pacemaker, gave the public "the notion of an implantable device legitimacy and appeal" [43], and the subsequent development of present-day deep brain stimulation (DBS) is largely attributed to Alim Benabid. In the late 1980s, he discovered that the symptoms of Parkinson's disease improve massively following electrical stimulation of basal ganglia [33]. This neurosurgical procedure involved the placement of a neurostimulator (sometimes referred to as a "brain pacemaker"), which sent high-frequency electrical impulses through implanted electrodes deep in the brain, to specific brain areas responsible for the symptoms of each disorder [34].

Deep brain stimulation emerged as a neurosurgical treatment modality from ablative stereotactic neurosurgery. It nearly became extinct following the introduction of antipsychotics for psychiatric disorders and levodopa for Parkinson's disease. However, it soon became clear that a suggestive number of patients either had intolerable side effects or inadequate response to pharmacotherapy, which gave credence for consideration of invasive surgical interventions like deep brain stimulation in patients suffering significant functional impairment.

A patient's tremor is tested in the operating room during DBS surgery.

Figure 9. Deep Brain Stimulation procedure [54]

Today DBS is used in a variety of conditions. It is currently approved by the U.S. Food and Drug Administration (FDA) to treat refractory Parkinson's disease, primary dystonia, intractable seizures, essential tremors and chronic cluster headaches [35]. The use of DBS in Parkinson's disease and essential tremor has proved so effective that it has been licensed as a treatment option [36]. This well-known procedure has now been used for more than 20 years, and despite the invasive nature, it is linked with minimal adverse effects.

DBS has also successfully treated patients suffering from various intractable psychiatric disorders. Severe, treatment-resistant obsessive-compulsive disorder (OCD) is a chronic, incapacitating disorder, imposing substantial suffering and significantly impairing affected individuals' ability to work, interact socially, or live independently. DBS drastically reduces the symptoms of severe OCD, by stimulating either Ventral Capsule (VC) or anteromedial subthalamic nucleus (amSTN), according to a study in Biological Psychiatry [38].

Furthermore, DBS has emerged as a prospective option for select Tourette syndrome patients whose motor and/or vocal tics impact the quality of life ominously, despite maximal use of other treatment options. The implantation of electrodes in three target areas (nucleus accumbens as part of the ventral striatum, globus pallidus internus and thalamus), all of which have proved effective [39].

An interesting study was published in the American Journal of Psychiatry on Friday October 4 2019, which found that deep brain stimulation of subcallosal cingulate

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(SCC) area in the brain provides a robust antidepressant effect, that is sustained over a long period of time in patients with treatment-resistant depression [40]. New findings were made by a team of researchers led by Dr. Andres Lozano at the Krembil Neuroscience Centre (KNC) of Toronto Western Hospital (TWH). They provided further insight into the effects of Deep Brain Stimulation in the treatment of Alzheimer's disease [41].

3. Deep Brain Stimulation WordCloud

Figure 10. 38 psychiatrists "3 word" response to "Deep Brain Stimulation" [55]

4. Qualitative Survery of North West Boroughs Healthcare (NWBH) professionals regarding "Psychosurgery", "Prefrontal lobotomy" and "Deep Brain Stimulation"

We conducted a survey at NWBH NHS healthcare foundation trust, capturing the intellection of 38 mental health professionals. The survey was done in joint academic round, and 3 separate survey papers were distributed, with professionals asked to write 3 words that come to their minds when they heard the terms "psychosurgery", "prefrontal lobotomy" and "deep brain stimulation". Two minutes were provided, in order for instinctive conscious/unconscious responses to be recorded. The survey papers were then collected, and the results are displayed using word cloud format (Figure 4,2 & 10). The larger the font, the more popular that word response was.

5. Conclusion

The results of our survey demonstrated that 38 NWBH professionals commonly viewed Psychosurgery as "barbaric, controversial, extreme", and prefrontal lobotomy as "barbaric, cruel and outdated", amongst other responses.

Deep Brain Stimulation was viewed in a somewhat more favourable positive light, with common responses being "innovative, futuristic and associated with treatment for depressive and Parkinson's disease".

Why was this?

Was it because the clinicians thought that the emergence of better scientific evidence and neuroimaging techniques to guide such procedures makes DBS safer?

We found these results interesting, as DBS is still a significantly invasive procedure. DBS still involves drilling holes into to the skull, with invasive electrodes being implanted on (usually) both sides of the brain. Such procedures are no less likely to cause complications such as bleeding and/or infection.

We also suspect that the use of brain surgery for "organic" brain disease has been far less controversial than for "functional" brain disorders? If so, then why?

The NHS Commissioning Board (NHS CB) commissions Deep Brain Stimulation for patients with Parkinson's disease, tremor and dystonia in accordance with the eligibility criteria [44]. Presently, we don't see this happening for functional disorders. Why is this? These are the questions which began surfacing in our minds whilst writing this article.

Our take home message is that as clinicians we must examine, unpick and confront any possible preconceptions and cognitive bias in our conscious/unconscious minds regarding psychosurgery, as we are potentially denying patients suffering from distressing intractable symptoms a viable treatment option.

Conflict of Interest

Authors report no conflict of interest.

MCQ's

1. Burckhardt performed the first psychosurgical procedures on patients suffering from which psychiatric disorder?

(1) Depression
(2) Obsessive Compulsive Disorder
(3) Schizophrenia
(4) Epilepsy

2. The first prefrontal leucotomy technique was carried out by which technique?

(1) Killing frontal lobe tissue with an injection of alcohol
(2) Killing frontal lobe tissue with a leucotome instrument
(3) Killing frontal lobe tissue with an ice pick
(4) Killing frontal lobe tissue with an injection of acid.

3. Which noteworthy film may have contributed to moulding of social attitudes to lobotomies?

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(1) A Beautiful Mind
(2) Shutter Island
(3) The Snake Pit
(4) One Flew Over The Cuckoo's Nest.

4. The arrival of which two drugs turned the tide against psychosurgery?

(1) Haloperidol and Promazine
(2) Lithium and Chlorpromazine
(3) Imipramine and Thorazine
(4) Valium and Prozac

5. Which of the following conditions is Deep Brain Stimulation (DBS) not approved by the US FDA (Food & Drug Administration) for ?

(1) Parkinson's disease tremor
(2) Chronic Cluster headache
(3) Intractable Epilepsy
(4) Borderline Personality Disorder

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