PTSD Treatment: The Pros and Cons of Deep Brain Stimulation versus Transcranial Magnetic Stimulation

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Abstract

Post-traumatic stress disorder (PTSD) is a disorder developed in patients who have gone through a traumatic experience and cannot control the memory that then overpowers them. Patients with this disease commonly suffer a variant of depression, anxiety, and heightened reactions to events that trigger the memory. Although the current treatment for PTSD is psychotherapy, scientists are looking into deep brain stimulation (DBS) and transcranial magnetic stimulation (TMS) as more permanent treatments. TMS targets the prefrontal cortex using magnets, whereas DBS targets the amygdala using surgically implanted electrodes, making it a much more invasive procedure. However, once the electrodes are implanted in the brain they are permanent and the patient does not have to return for follow up treatments. Both treatments show promise for the future of PTSD victims, but lack of human studies in DBS and the uncertainty of long-term side effects in both procedures bring up ethical issues that are slowing progress. Further research into these two procedures is needed before these treatments can be publicly available.

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Advances in medical technology have enabled neuroscientists to decode intricate spatial and temporal maps of neural activity. In parallel with these discoveries, treatments for previously troubling neurological disorders are becoming more commonplace through better understanding. Posttraumatic stress disorder (PTSD), one of these problematic disorders, is prevalent in every generation, and will continue to be diagnosed into the foreseeable future. Through the use of neurological treatments such as deep brain stimulation (DBS) and transcranial magnetic stimulation (TMS), posttraumatic stress disorder could be mitigated in diagnosed victims whose disorder is unresponsive to pharmacological or psychotherapeutic interventions.

Posttraumatic stress disorder develops when an individual goes through a traumatic experience, such as war, abuse, or losing a loved one and when the memory remains prevalent instead of fading over time. The amygdala, a small, specialized region of the brain’s temporal lobe, is responsible for encoding certain memories that correspond to survival techniques and fear (Miller, 2004). PTSD arises when a memory in the amygdala is overpowering and becomes consistently present in the conscious mind, during which the survival response is not necessary. The suppression of the same memories, which is carried out through conscious action, is present in the dorsolateral prefrontal cortex of the brain (Miller, 2004). Survival memories are suppressed, because in everyday life an individual does not need to worry about being beaten at work or fleeing from a gunfight. The prefrontal cortex is also responsible for anxiety, avoidance, and the adjusting of reactions, functions that the majority of PTSD victims struggle with for an extended period of time. In 95% of lifetime PTSD patients, varying forms of depression are seen (Shalev et al., 1998). Such high correlation between PTSD and depression in chronic patients not only leaves these individuals living an empty and scared lifestyle, but also makes acquiring and holding a job arduous.

The current methods for treating PTSD involve various forms of psychotherapy (Henry, Fishman, & Youngner, 2007), but none are consistently effective and can take years to work (Kent, Coplan, & Gorman, 1998; Leichsenring, Rabung, & Leibing, 2004). Due to modern day medical improvements, correctional treatments to alleviate some of the symptoms are now potential options.

Deep brain stimulation is a considerably invasive yet effective way of targeting the amygdala through electrode implantation into the brain. The procedure involves drilling a miniscule hole into a certain area of the head in order to insert needle-like electrodes through the brain into the amygdala. Once the electrodes are placed, a brain pacemaker is then wired to the ends of the electrodes and installed in the body cavity around the clavicle region. In patients with PTSD, MRI scans have confirmed that the amygdala is hyperactive (Langevin, De Salles, Kosoyan, & Krahl, 2010). By emitting electrical impulses inside of the amygdala scientists plan to inhibit some of the activity, reducing symptoms in the patient.

Tests of DBS for traumatic memories have been conducted in non-human animal models. In one such experiment, researchers induced fearful memories in rats; once memory had been encoded in the amygdala, half the rats were surgically implanted with the electrodes to reduce the symptoms. The rats positively responded to the treatment, demonstrating trauma symptoms nearly restored to normal levels (Langevin et al., 2010). Through this well-structured experiment, scientists were able to demonstrate that suppression of amygdala function affects the expression of PTSD related symptoms.

Although deep brain stimulation of the amygdala is effective in normalizing activity in rats, the invasiveness of the procedure and lack of human testing poses complications to the future of this neurological treatment. Due to the invasiveness of DBS, the ethical principle of beneficence and non-maleficence must be considered (Illes & Bird, 2006). Although there is short-term harm from the surgical insertion of the electrodes, the benefits of reducing PTSD symptoms far outweigh the costs of receiving local anesthetics and a minimal wound to the skull. The potential issue of this type of stimulation comes from the lack of knowledge regarding long-term effects of having a metal rod inserted in the brain, along with the effects of repeated electrical delivered to a localized region of the brain. One of the more difficult barriers to cross in medicine is the progression from animal testing to human clinical studies. Most mammalian brains are similar in function and structure, yet it cannot be said with certainty that DBS of the amygdala will demonstrate the same results in humans versus rats.

Transcranial magnetic stimulation (TMS), a less invasive procedure than DBS, involves the use of a magnet to stimulate superficial brain regions, such as the dorsolateral prefrontal cortex in PTSD patients. The TMS procedure consists of holding a magnet against the outside of the cranium and then emitting magnetic fields into the first few centimeters of the brain (Glannon, 2005—better to cite an original study here). The process can be a single treatment, or repeated waves of magnetic fields. In PTSD, symptoms can be modulated by using frequencies that stimulate cortical neurons (Glannon, 2005—same here). In case studies involving PTSD patients, TMS is stimulated bilaterally in order to target two different regions of the pre-frontal cortex; the left lending to improvement of mood, and the right leading to reduction of anxiety (Boggio et al., 2010; Grisaru, Amir, Cohen, & Kaplan, 1997). Through stimulation of the pre-frontal cortex scientists are able to improve conscious control of these memories, temporarily allowing the patient to relax and enjoy his or her life.

TMS presents as a safe, human tested alternative to DBS, but it lacks support for the longevity of each individual treatment session, as well as the permanence of treatment effects. There are also possible concerns with TMS regarding detrimental long-term effects and unintended consequences (Farah, 2005). Although it is safer than DBS, TMS will require more data confirming the safety of this process beyond a couple of years post-treatment. Chronic exposure to magnetic fields could lead to a dependency on them in order to function, leaving the patient in constant need of more treatment. However, in the few controlled studies that have been conducted, patients who returned for 3-month follow up appointmentsstill retained the effects of the treatment (Boggio et al., 2010). However, there is a lack of evidence supporting longer-term efficacy of this treatment. Uncertainty and lack of support from scientists does not currently allow TMS to be deemed a sustainable method of treatment. This is not to say that within the next decade if research permits and supports, TMS could potentially be the preferable brain stimulation method for reducing PTSD symptoms.

Neurologic medical advancements, such as TMS and DBS, have provided PTSD victims with potential hope for reducing anxiety, depression, stress, and insomnia in the near future. With the benefits of these practices outweighing the harms, these procedures are medically sound but are still confronted by certain ethical issues. The lack of human testing, especially in DBS treatments, and the unknown long-term effects of both methods, pose an issue to regulatory agencies and ethical boards that would need to approve of TMS and DBS before they could be publically available. Further research into this issues is needed in order for brain stimulation to be widely considered as a feasible treatment for PTSD patients.

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