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"NEURO PROTHESES" – IMPROVEMENTS IN NEUROLOGY

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ABSTRACT :

Neuroscience is an essential field of investigation that reveals the identity of human beings, with a comprehensive understanding of advanced mental activities, through the study of neurobiological structures and functions. The idea of treating neurologic disorders with chronic stimulation began to emerge in the 1960s, Ever since Fritsch & Hitzig's (1870) classical demonstration of the localized electrical excitability of the motor cortex, electrical stimulation of the brain has played a major role in investigations of brain function. Deep brain stimulation (DBS) has provided remarkable benefits for people with a variety of neurologic conditions . "Neuro prostheses" technically understood as Brain implants are mechanical devices that electrically stimulate, block or record (or both record and stimulate simultaneously) signals from single neurons or groups of neurons (biological neural networks) in the brain. One of the most established clinical uses of neural implants is in a treatment called deep brain stimulation, or DBS. A common purpose of modern brain implants and the focus of much current research is establishing a biomedical prosthesis circumventing areas in the brain that have become dysfunctional after a stroke or other head injuries.

Key words: Neuro prostheses, DBS (Deep brain stimulation), Parkinson's disease, neuromodulation, electroceuticals.

INTRODUCTION:

"Anything that the nervous system does could be helped or healed by an electrically active intervention—if we knew how to do it," says Gene Civillico, a neuroscientist at the NIH, who runs the agency's peripheral nerve stimulation funding program SPARC.

Neuroscience is an essential field of investigation that reveals the identity of human beings, with a comprehensive understanding of advanced mental activities, through the study of neurobiological structures and functions. Fully understanding the neurotransmission system that allows for connectivity among neuronal circuits has paved the way for the development of treatments for neurodegenerative diseases such as Parkinson's disease, Alzheimer's disease, and depression.

Deep brain stimulation (DBS) has provided remarkable benefits for people with a variety of neurologic conditions. It is seen that studies show stimulation of the ventral intermediate nucleus of the thalamus can dramatically relieve tremor associated with essential tremor or Parkinson disease (PD). Similarly, stimulation of the subthalamic nucleus or the internal segment of the globus pallidus can substantially reduce bradykinesia, rigidity, tremor, and gait difficulties in people with PD. Multiple groups are attempting to extend this mode of treatment to other conditions. Yet, the precise mechanism of action of DBS remains uncertain. Such studies have importance that extends beyond clinical therapeutics. Investigations of the mechanisms of action of DBS have the potential to clarify fundamental issues such as the functional anatomy of selected brain circuits and the relationship between activity in those circuits and behavior. Although studies reviewed the relevant clinical issues, it is emphasized on the importance of current and future investigations on these concerns. One such contribution or seen as a innovation is brain implants technically named as Neuro prostheses.

History of brain stimulation?

The idea of treating neurologic disorders with chronic stimulation began to emerge in the 1960s, ever since Fritsch & Hitzig's (1870) classical demonstration of the localized electrical excitability of the motor cortex, electrical stimulation of the brain has played a major role in investigations of brain function. The first report of human cortical stimulation appeared four years later (Bartholow 1874). Although electrical stimulation was used to map cortical function in the 1930s (Penfield & Boldrey 1937), it was not until human stereotaxic devices were developed that neurosurgeons could begin to investigate the effects of stimulating deeper structures (Spiegel et al. 1947). By the early 1950s, intraoperative stimulation was used to identify deep structures such as the corticospinal tract prior to lesioning the globus pallidus or thalamus (Spiegel & Wycis 1952). Most reports in the 1950s focused on positive phenomena that were elicited by stimulation. In the early 1960s, it was reported that high-frequency (100-Hz) stimulation of the ventrolateral thalamus could diminish tremor (Hassler et al. 1960, Ohye et al. 1964).

What is a brain implant?

A brain implant, then, is a device—typically an electrode of some kind—that's inserted into the body, comes into contact with tissues that contain neurons, and interacts with those neurons in some way.

Brain implants, often referred to as neural implants or neuro prostheses are technological devices that connect directly to a biological subject's brain – usually placed on the surface of the brain, or attached to the brain's cortex. One of the most established clinical uses of neural implants is in a treatment called deep brain stimulation, or DBS.

Purpose of neural implants:

Brain implants electrically stimulate, block or record (or both record and stimulate simultaneously) signals from single neurons or groups of neurons (biological neural networks) in the brain. Brain implants are used for various purpose as Mind Control, depression, seizures, epilepsy, Parkinson's, hearing, vision.

Mechanism behind nerve stimulation: Neurons are cells that communicate in the language of electricity. They fire electrical impulses in particular patterns, kind of like Morse code. A neural implant is a device placed inside the body via surgery or an injection that interacts with neurons

In this therapy, electrodes are surgically placed deep into the brain where they electrically stimulate specific structures in an effort reduce the symptoms of various brain-based disorders. Neural implants can also send pulses of electricity to neurons, overriding native firing patterns and forcing the neurons to communicate in a different way. Brain implants electrically stimulate, block or record (or both record and stimulate simultaneously) signals from single neurons or groups of neurons (biological neural networks) in the brain. The blocking technique is called intra-abdominal vagal blocking. This can only be done where the functional associations of these neurons are approximately known. Because of the complexity of neural processing and the lack of access to action potential related signals using neuroimaging techniques, the application of brain implants has been seriously limited until recent advances in neurophysiology and computer processing power. With these devices, it's possible to record native neural activity, allowing researchers to observe the patterns by which healthy neural circuits communicate.

A common purpose of modern brain implants and the focus of much current research is establishing a biomedical prosthesis circumventing areas in the brain that have become dysfunctional after a stroke or other head injuries.

Types of implants:

Current brain implants are made from a variety of materials such as tungsten, silicon, platinum-iridium, or even stainless steel. Future brain implants may make use of more exotic materials such as nanoscale carbon fibers (nanotubes), and polycarbonate urethane. Available devices now in practice include the following.

Flexible Neural Implants

1. Nonchronic and Non-Bioresorbable Electronics

One rudimentary consideration for neuro-prosthetics is whether they provide biological signals in the long term, bypassing immune responses from the body.[26] However, insertion of the implantable device itself causes several problems for the host body. First, a penetrating probe passing through tissue surfaces gives rise to tissue wound by damaging blood vessels. Direct contact of the implantation site with a device, such as an electrocorticogram (ECoG), results in a mechanical mismatch between the tissue and the device applying constant pressure to the nerve cells. The immune response caused by an implantable device is called a "foreign body reaction" (FBR).[27] As the device is inserted into the tissue, protein adhesion to the device, called "acute inflammatory response," is immediately accelerated. Protein adhesion due to the process of phagocytosis specifically occurs in the wound area by generating blood scabs. Then, it forms a provisional matrix on the surface of the tissue. Subsequently, the immune cells adhere to the wound site and continuously influence the surrounding tissues to increase the range of infection. Eventually, a foreign body giant cell and fibrous encapsulation formation appear in the area around the wound.

A nonchronic device that does not prevent cell adhesion after implantation encounters an inflammatory reaction on the surface of the implanted device, which leads to device failure by continuous growth of fibrous cells. The formation of fibrous capsules on the electrode array increases the impedance of the sensing pad, thereby deteriorating the device's sensitivity and reliability, as shown in Figure 2a.[28] An implanted electrode can no longer record or modulate electrophysiological signals after being fully covered with fibrous cells, and additional surgery is needed to replace the device.

2. Wireless Electronics

Movement constraints from physically tethered, externally wired implants can be resolved by using integrated wireless systems.[83] Here, we discuss wireless electronics for a neural interface from two perspectives: i) classification by the type of wireless communication and ii) actuation of device operation by wireless stimuli. The first approach includes the Bluetooth system, near-field communication (NFC), and radiofrequency identification (RFID). The second approach mainly focuses on wireless mild-thermic, light-induced actuation, and ultrasonic wave.

What's next in neural implants?

The invasiveness of any implant limits its use. It's hard to justify brain or spinal surgery unless a person is in severe medical need. So engineers are constantly inventing better devices that reach deep in the body with less impact on tissues.

Engineers have concocted dust-sized brain implants, electrodes that climb nerves like a vine, electrodes made from flexible materials such as a nanoelectronic thread, stent-like electrodes, or "stentrodes," that can get to the brain via blood vessels and record electrical activity, injectable electronic mesh made from silicon nanowires, electrodes that can be injected into the body as a liquid and then harden into a stretchy taffy-like substance, and more.

Neuromodulation can even be performed non-invasively using electrodes or magnetic coils placed on or near the skin. The strategy has proven effective for some conditions, although so far it doesn't have the specificity or efficacy of implants.

Researchers still need a basic understanding of the physiology of neural circuits, says Civillico. They need maps of how neurons are communicating, and the specific effects of these circuits on the body and brain. Without these maps, even the most innovative implants are effectively shooting electrical impulses into the dark.

Future of implants:

It sounds like science fiction, but a neural implant could, many years from now, read and edit a person's thoughts. Neural implants are already being used to treat disease, rehabilitate the body after injury, improve memory, communicate with prosthetic limbs, and more. In other words, neural implants enable scientists to hack into the nervous system. Call it neuromodulation, electroceuticals, or bioelectronics—interventions involving neural implants have the potential to become tremendously powerful medical tools. Consider the functions of the nervous system: It controls thinking, seeing, hearing, feeling, moving, and urinating, to name a few. It also controls many involuntary processes such as organ function and the body's inflammatory, respiratory, cardiovascular, and immune systems.

The U.S. Food and Drug Administration (FDA) first approved the use of DBS in 1997 for essential tremor. Since then, the FDA or other global regulators have approved DBS for Parkinson's disease, dystonia, tinnitus, epilepsy, obsessive-compulsive disorder, and neuropathic pain. DBS is also being investigated as a treatment for Tourette syndrome and psychiatric disorders such as depression. It is estimated that more than 150,000 people globally have received a DBS implant.

Researchers have also put a great deal of time into manipulating the vagus nerve using neural implants. The vagus nerve connects most of our key organs to the brain stem, and researchers are hacking this communication superhighway in an effort to treat heart failure, stroke, rheumatoid arthritis, Crohn's disease, epilepsy, type 2 diabetes, obesity, depression, migraine, and other ailments. "Engineers are continually pushing the boundaries for what's technically possible," says David McMullen, program chief of the neuromodulation and neurostimulation program at the U.S. National Institute of Mental Health. "It's all about decreasing the surgical burden, increasing the chronic nature of the implant and constantly trying to get ever smaller electrodes that cover a wider area of brain," he says.

DRAWBACK OF A BRAIN IMPLANT:

Brain implants generally target a specific group of neurons. But brain tissue often moves around inside the skull, potentially causing implants to slip from their targeted spots, lose contact with the neurons, and become ineffective. This slippage can also cause more scarring.

The development of implanted neural devices to manage neurological and psychiatric disorders or to restore loss of physiological function is a rapidly advancing area of neuroscience research. We consider whether investigators of brain implant studies have an obligation to facilitate device explantation for participants who request it at study conclusion.

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