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Appendix 10: Neurotechnology Descriptions

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# Neurotechnologies

<table>
<thead>
<tr>
<th>Neurotechnology</th>
<th>Medical term</th>
<th>Description</th>
<th>Benefits</th>
<th>Risks</th>
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<tbody>
<tr>
<td><strong>NON-INVASIVE PROCEDURES</strong></td>
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</tbody>
</table>
| E1. Electrical stimulation over the surface of the arm or hand | Electrical stimulation (E-stim) OR Transcutaneous Electrical Nerve Stimulation (TENS) OR Neuromuscular Electrical Stimulation (NMES) OR Functional Electrical Stimulation (FES) | Electrical stimulation uses surface electrodes (adhesive pads or stickers) over the skin which are attached to a machine. The machine sends a small amount of electrical current to weak or paralyzed muscles. Tingling sensation is experienced over the skin in the area of stimulation. | - Increase in muscle contraction\(^1\)  
- Increase in blood circulation\(^2\)  
- Reduces spasticity\(^3\)  
- Reduce pain\(^4\)  
- Increase aerobic fitness\(^5\)  | - Skin irritation\(^6\)  
- Burning sensation\(^4\)  
- Muscle tears  
- Pain\(^4\)  
- Tingling below application site\(^4\)  |
| E2. Electrical stimulation over the surface of the spine | Transcutaneous Spinal Cord Stimulation | Electrical stimulation uses surface electrodes (adhesive pads or stickers) over the skin of the lower back and abdomen that are attached to a machine. The machine sends small amount of electrical current that can stimulate nerves in the spinal cord from outside the body. | - Immediate effect while the stimulator is on\(^3\)  
- Controlling locomotion\(^7\)  
- Long-lasting effects (up to a week)\(^3\)  
- Reduced pain\(^4\)  
- Reduced spasticity\(^3\)  | - Skin irritation\(^6\)  
- Burning sensation\(^4\)  
- Pain\(^4\)  
- Tingling below application site\(^4\)  |

2. [http://depts.washington.edu/moritlab/?page_id=718](http://depts.washington.edu/moritlab/?page_id=718)
### Appendix 10

| E3. Electrical stimulation over the surface of the head | Transcranial Direct Current Stimulation (TDCS) | Electrodes are placed over the scalp directly over the brain area to be stimulated. A small amount of electric current is passed through. | - Temporary improvement in emotion and mental functioning⁹  
- Fatigue⁹  
- Improvement of language in aphasia¹⁰ | - Tickling or burning sensation over the head¹¹  
- Headache¹¹,¹²  
- Skin lesions or burns¹¹  
- Nausea¹¹,¹²  
- Difficulty concentrating¹²  
- Fatigue¹¹  
- Redness¹²  
- Mood changes¹¹,¹² |
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<tbody>
<tr>
<td>Stroke, Depression, anxiety, pain, Parkinson's disease</td>
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<td><a href="https://www.ncbi.nlm.nih.gov/proxy1.lib.tju.edu/pmc/articles/PMC5702643/">Image</a></td>
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| E4. Magnetic stimulation over the surface of the head | Transcranial Magnetic Stimulation (TMS), Repetitive TMS (rTMS) | A magnetic coil is placed over the head, creating changing magnetic fields over the surface of the brain. It is used to create electric current at a specific area in the brain. (FDA approved) | - Improves mood¹³ | - Cannot be used with metal objects near the head  
- Headache¹⁴  
- Pain over scalp  
- Loud machine noise  
- Crying  
- Seizure¹⁴ |
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<tr>
<td><a href="https://www.medpagetoday.com/psychiatry/depression/56168">Image</a></td>
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<tr>
<td>Cost: $200 to $300 per session (20 min) – Needs 5 sessions/wk for 4-6 wks</td>
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| E5. Braces that are powered to amplify movements | Myoelectric brace | The electrical signals from weak muscles are converted into large movement of the brace to allow improved movement. | - Improved movement¹⁵,¹⁶,¹⁷  
- Allows the patient to perform movement they otherwise are unable to complete¹⁵,¹⁶,¹⁷  
- Effective in improving motor control¹⁵,¹⁶,¹⁷  
- Improvement in self-reported function and | - Pressure sores  
- Chafing of the skin  
- Mechanical irritation |
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<td><a href="https://myomo.com/what-is-a-myopro-orthosis/">Image</a></td>
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</table>

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### Appendix 10

<table>
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<tr>
<th>E6. Brain computer interface with a cap</th>
<th>EEG driven brain computer interface</th>
<th>Brain computer interfaces or brain machine interfaces are hardware and software systems that allow brain activity to control a hand brace to move the hand. Some brain computer interfaces are implanted in the brain and others use an external cap.</th>
<th>perception of recovery&lt;sup&gt;15, 16, 17&lt;/sup&gt;</th>
</tr>
</thead>
</table>

Brain computer interfaces or brain machine interfaces are hardware and software systems that allow brain activity to control a hand brace to move the hand. Some brain computer interfaces are implanted in the brain and others use an external cap.

- Communication<sup>19</sup>
- Movement control<sup>19</sup>
- Control of external devices<sup>19</sup>
- Improved motor function<sup>19</sup>
- BCIs placed outside of the skull have a limited ability to read brain signals<sup>20</sup>
- Signal connection problems<sup>20</sup>
- Quality of electroencephalography signals is affected by scalp, skull, and many other layers as well as background noise<sup>20</sup>
- Skin irritation or hair loss secondary to cap pulling on hair follicles<sup>21</sup>

### INVASIVE PROCEDURES

| E7. Baclofen pump | Intrathecal Baclofen Therapy (ITB) | The medicine Baclofen is placed in a round metal disc under the skin of the abdomen and delivered by a pump and a catheter directly into the spine. Refills are done every 1 to 6 months and battery is changed every 5 to 7 years. (FDA approved) | - Reduces spasticity<sup>22</sup>
- Improved ambulation/wheelchair seating
- Reduced spasticity-related pain
- Improved sleep
- Dosing errors
- Weakness<sup>23</sup>
- Sleepiness<sup>23</sup>
- Upset stomach<sup>23</sup>
- Nausea<sup>23</sup>
- Vomiting
- Headache
- Dizziness
- Confusion
- Catheter, Battery or pump malfunction (CSF leakages)<sup>23</sup>
- Hypotonia<sup>23</sup>
- Infection
- ITB withdrawal syndrome (rare)<sup>23</sup> |
|-------------------|-----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|

The medicine Baclofen is placed in a round metal disc under the skin of the abdomen and delivered by a pump and a catheter directly into the spine. Refills are done every 1 to 6 months and battery is changed every 5 to 7 years. (FDA approved)
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| E8. Implanted stimulators for the nerves of the arm and hand | Peripheral nerve and field stimulators (PNFS) | Peripheral nerve and field stimulation involves placing the electrodes directly on nerves or under the skin in the painful region. It is a minimally invasive procedure, requiring a small incision over the targeted area. | -Pain reduction for chronic pain<sup>24</sup> | 30 to 40% rate of complications
- Hardware complication: movement, breaking or malfunction of the electrode
- Infection, pain over electrode
- Rare: headache, neurological damage |
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<td><img src="https://connect.springerpub.com/content/book/978-0-8261-3775-3/part/part05/chapter/ch48" alt="Peripheral nerve and field stimulators" /></td>
<td><a href="https://connect.springerpub.com/content/book/978-0-8261-3775-3/part/part05/chapter/ch48">Peripheral nerve and field stimulation</a></td>
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| E9. Implanted stimulators for the spine | Epidural Electrical stimulation (EES) or Epi-stim | Stimulators for the spinal cord are surgically placed directly on the cord for continuous electrical current. | -Increases muscle contraction<sup>25, 26</sup> | -Programming issues for the device
- Movement, leakage of current, & failure of electrode
- Nerve injury<sup>27, 28</sup>
- Infection<sup>28</sup>
- Pain at the site<sup>28</sup>
- Equipment failure<sup>27, 28</sup> |
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<td><img src="https://www.spinalcord.com/blog/what-to-know-epidural-stimulation-spinal-cord-injury" alt="Implanted stimulators for the spine" /></td>
<td><a href="https://www.spinalcord.com/blog/what-to-know-epidural-stimulation-spinal-cord-injury">Epidural Electrical stimulation (EES) or Epi-stim</a></td>
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Spinal cord injury – traumatic and non-traumatic:
Cost: $15 - 50K without insurance, Covered by some insurance such as Medicare and Blue Cross and Blue Shield
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<tbody>
<tr>
<td><strong>E10. Braces powered by implanted sensors in the brain</strong></td>
</tr>
<tr>
<td><a href="https://www.extremetech.com/extreme/102927-brain-computer-interfaces-creep-closer-to-bionic-mecha-dream">Image</a></td>
</tr>
<tr>
<td>Brain computer interface (BCI), Neural-control interface (NCI), Direct neural interface (DNI), Brain machine interface (BMI)</td>
</tr>
<tr>
<td>A small chip is surgically placed in the brain and connects to an external brace that can move the arm or hand.</td>
</tr>
<tr>
<td>-Increased movement</td>
</tr>
<tr>
<td>Communication&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>-Increased perception&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>-Increased motor activity&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>-Increased sensation&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>-Infection</td>
</tr>
<tr>
<td>-Anesthesia risk</td>
</tr>
<tr>
<td>-Scarring over brain</td>
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<tr>
<td>-Pain at location site, headaches</td>
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| **E11. Deep Brain Stimulation for Parkinson's disease** |
| Deep Brain Stimulation |
| A brain pacemaker is placed surgically on specific areas of the brain. (FDA approved) |
| -Reduces tremor<sup>30</sup> and epilepsy |
| -Reduced dyskinesia<sup>31</sup> |
| -Increased control with movements |
| -Infection |
| -Electrode movement, damage or malfunction |
| -Scarring over brain |
| -Worsening of gait, balance, and/or speech<sup>31</sup> |

| **E12. Nerve transfers** |
| [Image](https://www.mayoclinic.org/diseases-conditions/brachial-plexus-injury/diagnosis-treatment/drc-20350241) |
| Nerve transfer |
| A nerve transfer is a surgical procedure where a nerve with a less important role is transferred surgically to another more important nerve that is not functioning. |
| Regain important movement<sup>32, 33, 34</sup> |
| -Anesthesia risk |
| -Infection |
| E13. Tendon transfers | Tendon transfer | A tendon transfer is a surgical procedure where a tendon with a less important role is transferred to serve the function of a weak tendon with a crucial role. | Regain important movement\(^{32}\) | -Anesthesia risk -Infection |

[Image of Tendon Transfer]

http://blog.handcare.org/blog/2017/04/26/4-reasons-you-may-need-tendon-transfer-surgery/
Appendix 10

References


Appendix 10


Appendix 10


