

## Neurotechnology for Spinal Cord Injury

An estimated 12,000 new spinal cord injuries occur per year with an estimated lifetime health costs between \$500,000 and \$3 million depending on level and age at the time of injury. Most injuries occur in males between the ages of 19 to 30 and life expectancy is close to that of an average American. Although a relatively small population, this group is a significant consumer in our health care system that investors cannot continue to ignore. Neurotechnology has made rapid advancements in recent history: components have shrunk, electronics improved, and we, as a society, have become more accepting of interacting with technology. Devices are available commercially for SCI treatment in such areas as pain management, spasticity control, breathing assistance and new rehabilitation techniques. There are also many new technologies being investigated in research centers. These devices and technologies are not attempting to "cure" spinal cord injury; they cannot reverse the damage to the spinal cord. Instead, they are tools that can be used to, for instance, minimize damage to the cord, combat secondary conditions, provide further independence or aid in the rehabilitation process. This isn't your uncle's electrical stimulation generation. Images of rusting electrodes, wires protruding from the skin and printer-sized processors are a thing of the past. Although the surface stimulation devices have evolved to become more consumer-friendly, amazing progress has been made in safe and effective implanted devices. Let's explore the many options of neurotechnology for spinal cord injury.

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## Educate: Multiple Applications for Spinal Cord Injury

### *Neuro-what? - the Basics*

Neurotechnology, the use of medical electronics interacting with the human nervous system, can restore substantial function, combat secondary conditions and aide rehabilitation following nervous system disease or injury. The foundation of neurotechnology is the electrical signals the body uses to send messages. The stimulation of these signals is a main feature of this technology. In the 1950's, the first attempt was made to apply electrical stimulation to the phrenic nerve allowing a person to breathe without a ventilator. This developed into a field of science called FES (Functional Electrical Stimulation). FES encompasses a variety of therapeutic techniques and treatments used to activate muscles that may not be functioning properly due to injury, disease or a physical abnormality. Over the decades, this field of science that combines medicine, biomedical engineering and technology evolved into what is now called neurotechnology.

Even though a muscle is paralyzed, it does not mean that the muscle cannot contract when it is stimulated. For those with mobility impairments that do not have peripheral nerve damage, electrical stimulation may be utilized; however not all people with SCI are appropriate for particular technologies. Researchers and clinicians currently working in this area, understand the existing criteria and are developing new guidelines to determine for whom neurotechnology devices and therapies will be most beneficial and successful. Systems are segmented into three main areas implanted, external or hybrid (a combination) of both. Implanted systems tend to be more "invasive" and therefore require a surgical or other procedure to install the system into the body of a potential user. Whereas, external systems are applied outside the body or on the surface of the skin. Finally, hybrid systems have components that are both implanted and external.

As systems move from the lab to the clinic, there are a variety of things to consider before jumping into a treatment, therapy or device protocol. Individuals must consider the time commitment, financial requirements and health benefits and risks that come with any program. Proper evaluation and supervision by a trained clinician, such as a physician or therapist is essential.

### *Applications*

Just as there are many aspects to a spinal cord injury, there are as many applications of neurotechnology. Below are descriptions of applications for different areas related to spinal cord injury. This includes a few advances that are currently available, as well as some progress in research for what is coming in the near future. Lists of devices are available in the Resources section.

### *Breathing and Cough Assistance*

Current neurotechnology alternatives to mechanical ventilation are hybrid systems that include either a phrenic nerve stimulator or diaphragmatic stimulator. Unlike ventilator systems, which use mechanical

current neurotechnology alternatives to mechanical ventilation are hybrid systems that include either a phrenic nerve stimulator or diaphragmatic stimulator. Unlike ventilator systems, which use mechanical pressure to force air into the lungs, the stimulation system pulls air into the lungs by stimulating the diaphragm muscle or the phrenic nerve. As the diaphragm contracts, the chest cavity expands and air is pulled into the lungs. Additionally, persons with cervical and thoracic level SCI often have paralysis of the muscles responsible for coughing. Cough assistance systems (CAS) that are currently available use different pressures to clear the lungs through an external breathing mask attached to a separate control unit. Under investigation is a new hybrid system that uses an external controller and implanted electrodes to achieve a cough. The goal of this electrical stimulation system is to create a 'cough on demand', reduce the need for frequent patient suctioning and allow the person with SCI to clear secretions more easily.

#### *Hand Grasp and Rehabilitation for the Upper Extremities*

The loss of hand and arm function due to a cervical level SCI can severely impact an individual. Regaining hand function is a high priority for this group. Hand control systems can enhance rehabilitation or provide function to the upper extremities which include the hand, wrist or arm. Upper extremity systems can generally be classified as either external or hybrid systems. External systems use electrodes that are attached to the skin over the muscles to be stimulated. These systems are often used for exercise, muscle conditioning and limited function. Other options include hybrid systems that have an implanted stimulator and an external control method. These are for long-term functional use. The first commercial system, the Freehand™, was available through NeuroControl Corporation in the late 1990's. Although the system was successful in producing hand function, the company could not maintain profitability and left the SCI market in 2001. Today, researchers are developing second generations of upper extremity systems designed to provide hand and arm function with control that is as natural as possible, cosmetically acceptable, practical to use, and adaptable to activities and environments.

#### *Pain and Spasticity Management*

Neuropathic (nervous system generated) pain is a significant problem for many with SCI. Discussions with your physician can help you better understand where the pain is coming from and with that understanding, what can be done about it. There are many new areas of neurotechnology for the treatment of pain, such as deep brain stimulation and transcranial magnetic stimulation. Here, we will discuss three areas of treatment that are currently available; transcutaneous electrical nerve stimulation (TENS), implanted drug delivery systems (IDDS) and spinal cord stimulators (SCS).

- *TENS units (transcutaneous electrical nerve stimulation)* are external systems that work by delivering low level electrical stimulation through electrodes placed directly on the skin of the affected area. The contraction of muscles through electrical stimulation may help alleviate pain by blocking pain messages being sent to the brain. TENS can be a non-invasive and economical solution.
- *Implanted Drug Delivery Systems (IDDS)*, also known as *Intrathecal Analgesia Therapy*, refers to the administration of medicine, either pain-relieving or spasticity-relieving, such as baclofen, via a medication delivery pump. The IDDS includes an implanted pump and reservoir for the drug that delivers the medication through a catheter directly into the spinal canal (intrathecal). This system may reduce the need for oral medications, can be more effective and is now a mainstay of therapy for intractable pain including neuropathic pain and spasticity as a result of SCI.
- *Spinal Cord Stimulation (SCS)* systems are hybrid systems comprised of implanted electrodes in the spine and an external control unit. It uses electrical stimulation to block the pain pathways to the brain that travel through the spinal cord. Some pain experiences by people with SCI are particularly suitable to spinal cord stimulation. SCS has also been known to decrease spasticity. The system flexibility allows the user to keep it on permanently or as needed.

#### *Bladder Management*

Most people living with SCI have reduced bladder control. Neurotechnology devices offer several different approaches of bladder management that use electrical stimulation to hyper-reflexive or flaccid functioning bladders. Appropriateness of each specific device or treatment depends on the level of injury and bladder condition. There are five basic types of devices using electrical stimulation in different ways. 1) Sacral nerve stimulator is an implanted device that manages the bladder by sending electrical impulses to the nerve that controls the bladder, sphincter, the muscles around it, and the sacral nerve roots. 2) Tibial nerve stimulator controls the bladder through percutaneous stimulation (an electrode inserted through the skin) of the tibial nerve in the lower leg. 3) Pelvic stimulator uses electrical stimulation applied to the pelvic floor muscle, which is generally delivered by a vaginal or anal probe connected to an external pulse generator. 4) Bladder muscle stimulator is a device that directly stimulates the bladder muscle with an implanted electrode. 5) An implanted device, soon to be in clinical trials, uses an electrode to stimulate the pudendal nerve to provide bladder function. These approaches should be discussed with your urologist and evaluated for your individual situation to determine which may or may not be appropriate for you. Please Note: In some instances, bowel function may coincidentally be a benefit from the use of stimulators for urinary function.

*(Continued on page 2)*

## Educate: Multiple Applications for Spinal Cord Injury

(Continued from page 1)

### *Sexual Function*

Alterations in sexual function are not uncommon for people with SCI. Men will experience dysfunction that involves erection and/or ejaculation, semen quality and sexual satisfaction. Women may experience alterations in the degree of sexual sensation and the type of injury may influence a woman's sexual satisfaction. Electrical stimulation may be a treatment option for males but research is inconclusive as to the role of electrical stimulation for women's sexual function. It has been reported that selected research using a bladder stimulation system (for bladder function) has resulted in some limited return of sexual function. A potential application for women is epidural stimulation, a promising area of research, which places electrodes at the L1-2 area of the spine. The research is still in early stages and not conclusive as of this writing.

### *Pressure Sore Prevention and Wound Therapy*

Most people with spinal cord injury are at high risk of developing pressure ulcers due to muscle atrophy, decreased mobility and altered sensation. Daily use of electrical stimulation can help maintain the bulk or mass of paralyzed muscles. External electrical stimulation has some practical problems because electrode placement in the upper buttock region can be difficult for users. Implanted stimulation systems for long-term therapeutic use have dual advantages; 1) the electrode can be located very close to the targeted nerve for muscle contraction and 2) repetitive placement is no longer an issue. Two research teams are investigating implanted stimulation systems, no system is currently available for commercial use. The use of electrical stimulation for the treatment of wounds has long been used in clinical practice. A wide variety of external stimulation devices, approved by the Food and Drug Administration (FDA) for other purposes, may be adapted for use in wound therapy. Currently approved clinical use is limited to the application of electrotherapy only after there are no measurable signs of healing for at least 30 days of treatment using conventional wound treatments. New devices specifically for wound therapy are under development.

### *Assisted Standing and Ambulation Systems*

The neurotechnology systems available for assisted standing and ambulation are wide and varied. Standing allows persons with SCI additional function and improved quality of life such as, the ability to reach objects from high shelves, gain entry to places inaccessible from the wheelchair, and participate in social or work situations on eye level with their peers. The use of mechanical standing frames and custom bracing has long been used in clinical practice. The earliest introduction of neurotechnology to standing was a combination of external electrical stimulation and bracing. New external systems are being developed that include full exoskeletal suits. As research progresses and technology improves, a hybrid electrical stimulation system is currently being investigated in clinical studies at Case Western Reserve University and the Louis Stokes Cleveland Department of Veterans Affairs Medical Center.

New neurotechnology devices that facilitate ambulation are available for those with paraplegia or incomplete injuries in which voluntary movement is present in the lower extremities. As with standing, devices are available that use external stimulation and custom bracing with the support of a walker. More advanced hybrid systems for those with complete and partial paralysis are being developed by researchers. There are many commercially available options for assisted stepping for persons with walking ability but who need assistance with ankle and foot control. Using external electrical stimulation, these small systems stimulate the calf muscles in coordination with the gait of the user, thus, eliminating the need for ankle-foot orthotic bracing. Implanted assisted stepping systems are also being studied.

### *Exercise and Rehabilitation Systems*

Exercise and rehabilitation is vital but must be accomplished differently than prior to injury. Exercise is essential to prevent secondary conditions in the cardiovascular and circulatory systems of the body. Exercise can be achieved using Electrical Muscle Stimulation (EMS) which relies on the peripheral nervous system. The EMS devices send pulses of electricity into the user's skin that result in a contraction of the muscles. Using EMS, such as FES cycling or rowing, will help minimize the loss of muscle bulk, improve muscle size and performance, and boost physical fitness. Before starting an EMS exercise regime, you should consult a physician or professional therapist.

For those with incomplete SCI and some voluntary movement below the level of injury, muscles may be reconditioned through rehabilitation. Movement enhancement systems are devices that are used to assist with exercise or the work of muscles in a limb. They reinforce the concept behind rehabilitation therapy which is to improve the function of a weakened muscle or to "boost" the voluntary function that already exists. Treadmill systems and robotics technology may improve locomotor skills and upper extremity function with repetitive motion therapy. These systems represent potential tools to augment the work of physical therapists, who are often unable to provide the extensive amount of therapy needed. A recent article in the journal *Spinal Cord*, by a team from Good Samaritan Hospital and Arizona State University, described the use of epidural spinal cord stimulation to facilitate walking in a person with incomplete spinal cord injury. The results demonstrate increases in walking speed and metabolic efficiency with stimulation, as compared to walking achieved by gait training with partial body-weight support.

### *Summary*

The variety of neurotechnology applications for spinal cord injury has expanded over many years of development. Devices have improved and research has expanded; however neurotechnology has not gained the "standard of care" status. You may find resources and clinical trial search terms in the Resources section of this newsletter. For more information, visit the Educate page of our website, [www.NeurotechNetwork.org](http://www.NeurotechNetwork.org)

## Personal Experiences: From the many SCI users

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With such an array of different neurotechnologies for spinal cord injury, in this issue of *The Current* we have highlighted several SCI users of devices and therapies to tell their experiences.

### ***Breathing Assistance*** — Laszlo using the Diaphragm Pacing System

On June 24, 2002, I was injured and became a C3 tetraplegic. Implanted almost one year to the date of my accident, I was the fourth recipient of the diaphragm pacer for breathing assistance. I have been off the ventilator 24 hours a day seven days a week ever since. It has been a true blessing. This procedure is very minimally invasive, and completely done on an outpatient basis. The surgery takes only about two hours. The diaphragm pacer consists of five hair thin wires. Four that go from the chest down into the diaphragm. With two electrodes being attached at phrenic nerve motor points in each diaphragm. The fifth wire being an anode (a ground wire). The wires are then directed through a connector on the chest connected to the diaphragm pacer. It is a hardwired system. There is no transmitter. The electrodes contract and relax the diaphragm muscle used for breathing. Contact [Laszlo](#) to ask him about his experience with a diaphragm pacer.

### ***Hand Grasp System***— Maria using an implanted system

As an avid long distance cyclist, Maria was finishing a 40 mile ride one morning in the Bronx, New York when she was struck from behind by a car. That day she didn't get off her bike achy and sore yet exhilarated by her accomplishment; instead she got off her bike with a C5-6 spinal cord injury. Life in New York as an architect was thrown into upheaval; after months in the hospital she found herself back in Ohio struggling just to turn on a computer. In March 2007, she received an implanted FES hand system through the Cleveland FES Center, providing use of her left hand that was paralyzed as a result of the injury. Since then her self reliance has grown. She no longer carries around special silverware when going to restaurants because she can manipulate whatever is provided, even plastic. "I never really expected that I would pluck my own eyebrows again, but I am quickly becoming a pro." She is now actively working toward a graduate degree in preparation for a new career as a professor. As a result of using the hand system, she unexpectedly found an outdoor activity, tennis. By firmly grasping the racquet using her device, she can hit the ball hard enough sending it over the net! [Click here to contact Maria](#) to inquire about her experiences with the implanted hand system or to offer tennis tips.

### ***Stand and Transfer System***— Jennifer using an implanted system

Injured but active. Jennifer French became a C6-7 incomplete spinal cord injury in 1998 as a result of a snowboarding accident. Prior to her injury, she was recreationally active with such sports as canoeing, snowboarding/skiing, sailing, fly fishing, biking, and scuba diving. Since her injury, she continues to participate in all those activities. She is an active user of an FES system and is the first woman to receive the implanted Stand and Transfer system. She uses the system on a daily basis. "There is functional standing and moving around for instances such as reaching, difficult transfers or narrow doorways. There is also exercise to help combat the common secondary conditions of spinal cord injury." As an advocate for the use of such devices, Jennifer is the co-founder and current Executive Director of Neurotech Network.

### ***Pain Management***— Art using a different TENS system

"On September 17, 1989, Art fell from a ladder and broke his neck in 6 places, (vertebrae: C1 – C2 – C4- C5 – C7 & T1 ). He was paralyzed and being treated with heavy doses of Morphine for pain. Ultimately, a plate with 4 screws was installed at C4 and C5 and at long last - the ordeal was "almost" over – "except for the pain". He had prescriptions for Vicodan, Lortabs, Marinol, Codeine-3 – virtually every narcotic that you could possibly think of to add to the list. He was fast running out of "effective" drugs to take. His friend, Steve Michelson, told him about a pain management surface stimulation device. He tried it and almost immediately – something miraculous occurred. No pain! The device, CT1, is an advanced [TENS](#) device for the control of acute and chronic pain at a variety of body sites. It connects to unique patented electrodes, which are designed to provide stimulation at superficial aspects of the peripheral nerve innervations to the region of pain. It is no bigger than a large faced sports watch with either a 2 or 4-pronged band-aid like adhesive strip – placed in the same position as the straps on a watch. "Amazing" – is the only word to describe this non-invasive pain management device.

### ***Exercise System***—Susan using an FES bike

Motivated by her concern for secondary conditions of spinal cord injury, Susan began to hunt the internet about spinal cord injury and rehabilitation. She encouraged her rehabilitation center to get an FES bike and she began riding during her outpatient physical therapy sessions. "Using the FES bike keeps you healthy," explains Susan, "It helps to control my muscle spasms, fight off pressure sores, increases my range of motion, is great cardiovascular exercise and improves circulation." Excited about the progress made toward spinal cord injury over the past seven years, Susan continues to exercise with her FES bike 4-5 days per week for just over an hour per session. Advice she provides to others with disabilities, "Reach out to others with the same injuries [conditions] and peers," and "Get on an exercise routine and stay with it." *Susan is co-founder of [Unite 2 Fight Paralysis](#).*

## Resources For Spinal Cord Injury

There are many resources available for those with spinal cord injury. The following is a listing of neurotechnology organizations offering solutions. They are segmented by various application related to spinal cord injury. Note that some are not FDA approved and some are being tested in clinical trials. More may be found in our website database accessed from the [Educate Page](#).

### Breathing & Cough Assistance

- Avery Breathing Pacemaker System— [Avery Biomedical Devices, Inc.](#)
- Atrostim Phrenic Nerve Stimulator v2—[Atrotech, Ltd](#)
- NeuRx Diaphragm Pacing Stimulation—[Synapse Biomedical, Inc.](#)
- Cough Assist—[Respironics, Inc.](#)

### Hand Grasp & Rehab for Upper Extremities

- NESS H200—[Bioness, Inc.](#)
- The Hand Mentor—[Columbia Scientific LLC](#)
- STIMuGRIP—[FineTech Medical, Ltd.](#)
- NeuroMove NM900—[Zynex Medical Inc.](#)
- [Freehand User Group](#)

### Pain & Spasticity Management

- Renew, Genesis, GenesisXP—[Advanced Neuromodulation Systems, Inc.](#)
- Precision Plus System—[Boston Scientific Neuromodulation](#)
- RestoreULTRA, RestoreADVANCED, PrimeADVANCED—[Medtronic Inc.](#) (SCS)
- PTM, SynchroMed II—[Medtronic, Inc.](#) (ITB)
- Dyatron STS Rx—[Dynatronics Corporation](#)
- Alpha Stim—[Electromedical Products International](#)
- Epix VT, Hybresis, IF 3WAVE, Infinity Plus, ProMax, Select TENS, Vectra Genisys Laser—[Empi, Inc.](#)
- MSP TENS, Microcurrent Stimulator, EZ STIM TENS, Electric Muscle Stimulator—[Medical Science Products](#)
- RS-4i Sequential Stimulation, RS-2i, RS-TENS Plus—[RS Medical](#)

### Bladder Management

- FineTech Brindley Vocare—[FineTech Medical, Inc.](#)
- InnoSense Minnova—[Empi, Inc.](#)
- Evadri—[Hollister, Inc.](#)
- InterStim—[Medtronic, Inc.](#)
- NeoControl—[Neotonus, Inc.](#)
- NeuroBionix Urinary Implant—[Victhom Human Bionics](#)
- Conti4000—[Zynex Medical, Inc.](#)

### Sexual Function

- Seager Model 14—[Dalzell USA Medical Systems](#)  
Brindley Bladder Control- [FineTech Medical,](#)

### Inc. Pressure Sore Prevention & Wound Therapy

- Implanted Gluteal Stimulation—[Cleveland FES Center](#)
- POSIFECT—[Biofisica](#)

### Assisted Standing & Ambulation Systems

- ReWalk—[Argo Medical Technologies](#)
- NESS L300—[Bioness, Inc.](#)
- STIMuSTEP—[FineTech Medical, Ltd](#)
- WalkAide—[Innovative Neurotronics](#)
- ActiGait—[Neurodan A/S](#)
- Odstock Dropped Foot Stimulator—[Odstock Medical Ltd.](#)
- Parastep I—[Sigmedics, Inc.](#)
- NeuroStep—[Victhom Human Bionics](#)
- Electrical Stimulation Studies—[Cleveland FES Center](#)

### Exercise & Rehabilitation Systems

- SpinoFLEX—[Advanced Fitness Components](#)
- Wearable Therapy—[Bioflex, Inc.](#)
- The Hand Mentor—[Columbia Scientific LLC](#)
- NeoTone—[Neotonus, Inc.](#)
- Quadriciser—[Quadriciser Corporation](#)
- RehaMove, MOTomed—[RECK Technik GmbH & Co. KG](#)
- RT100, RT300—[Restorative Therapies, Inc.](#)
- StepGain GRF—[Robomedica, Inc.](#)
- RS-2m—[RS Medical](#)
- REGYS, ERGYS, NeuroEDUCATOR, SpectroSTIM—[Therapeutic Alliances, Inc.](#)
- NeuroMove—[Zynex Medical, Inc.](#)

### Other Applications

- VitalStim Therapy—[Chattanooga Group](#)
- NeuroSwitch—[Control Bionics](#)

### Clinical Trials

There are many clinical trials being conducted in this area. Visit [Clinical trials.gov](#), search terms with spinal cord injury and any of the following: electrical stimulation, neuromuscular stimulation, exercise, urinary, sexual function, walking, hand function, cough, respiratory.

Prior to considering any new therapy, treatment or device, a proper evaluation must be conducted with a knowledgeable medical professional. There are health, medical and financial risks. Out of pocket costs and available insurance coverage for any treatment must be considered prior to starting a protocol. Finally, this is an evolving field of science and technology development. Updated information regarding these devices and organizations is available in the Educate section of our website at [www.NeurotechNetwork.org](#)

*\*\*Neurotech Network, The Society to Increase Mobility and its representatives do not rate, endorse, recommend or prescribe any products, procedures or services. This fact sheet is for informational purposes only.*

## On the Horizon: Updates in the World of Neurotech

◆ [The Center for Adaptive Neural Systems](#) at Arizona State University is currently pursuing several research projects that may have commercial applications in neuroprosthetics and neurorehabilitation. One project involves adaptive electrical stimulation for locomotor retraining, which seeks to improve outcomes for locomotor therapy following spinal cord injury.

◆ [Rehabtronics Inc.](#), an Edmonton, AB firm founded by University of Alberta professor Arthur Prochazka, has developed an implantable neural prosthesis called the Stimulus Router System. This hand grasp system incorporates a wrist band with surface electrodes and control electronics activated by tooth clicking. The first human patient, a quadriplegic, was implanted with the device in Edmonton. Rehabtronics has

[Jude Medical, Inc.](#), the St. Paul, MN announced the first patient implants in a clinical study investigating whether DBS therapy will help people who suffer from major depressive disorders. The participants, a 59-year-old woman and a 42-year-old man, were implanted at Alexian Brothers Behavioral Health Hospital in Chicago, with the St. Jude Medical Libra DBS system. The study, called BROADEN (BROdmann Area 25 DEep brain Neuromodulation), is a controlled, multi-site, blinded study that is evaluating effectiveness of DBS in patients with depression for whom currently available treatments are not effective.

◆ [NDI Medical](#), the Cleveland, OH manufacturer of neural prostheses, sold its intellectual property involving the Medstim bladder pacing system to Medtronic Inc. for a reported price of \$42 million, according to the *Cleveland Plain Dealer*. The deal includes the rights to the Medstim

first human patient, a quadriplegic, was implanted with the device in Edmonton. Rehabtronics has reportedly sold the technology behind the Stimulus Router System to [Bioness, Inc.](#), the Valencia, CA.

- ◆ [Synapse Biomedical Inc.](#), the Oberlin, OH manufacturer of diaphragm pacing systems, announced it has received approval from the U.S. Food and Drug Administration for its NeuRx DPS for ventilator-dependent spinal cord injury patients who lack voluntary control of their diaphragms. With the FDA's approval, SCI patients and their caregivers throughout the U.S. can now access this technology that was previously only available to clinical trial participants.

- ◆ A study of seven patients with Parkinson's disease suggests that those who have poor results following implantation of electrodes to stimulate the brain may benefit from additional surgery to correct the electrode placement, according to a report in the May issue of *Archives of Neurology*. Implanting electrodes that stimulate the subthalamic nucleus is effective in reducing medication doses and improving the symptoms of Parkinson's disease. However, sometimes the surgery is less effective. "The principal cause of these poor results arises from imprecision of electrode placement, leading to non-stimulation of the target as required," the authors write. Mathieu Anheim, of the University Hospital, A. Michallon, Strasbourg, France and colleagues. [St.](#)

Neurostim bladder pacing system to Medtronic Inc. for a reported price of \$42 million, according to the *Cleveland Plain Dealer*. The company had obtained some of the intellectual property for the implanted incontinence stimulator from Case Western Reserve University. NDI said it plans to reinvest the money in product development.

- ◆ [Neurotech Network](#), will sponsor a forum devoted to physical and occupational therapy at the 2008 Neurotech Leaders Forum Oct. 23-24. The panel will bring together practicing clinicians with leaders in the neurotechnology industry. Discussion topics will be directed at the barriers of acceptance for neurotechnology in clinical practice. Such topics will include concerns of safety and compliance to the patient, financial access, and technology education. For more information on the [Neurotech Leaders Forum](#), contact Neurotech Reports at 415.546.1259

- ◆ The [National Spinal Cord Injury Association](#) and Neurotech Network provide a new resource for spinal cord injured individuals. NSCIA offers Fact Sheets on various areas important to SCI. Together the organizations have created the *Neurotechnology for Spinal Cord Injury Fact Sheet* which will be posted on both organization's websites.

Updates are available on our website. Stay updated by signing up for email notifications too. Visit our website at [www.NeurotechNetwork.org](http://www.NeurotechNetwork.org).

## Neurotech Speaks Out

It not just exposure but gaining an understanding of the available neurotechnologies and the impact they have a people's lives. Over the past several months Neurotech Network has been presenting at events with a focus on education and expansion of awareness among persons with impairments and front-line clinicians.

At the Frontiers on Health Care conference hosted by Brown University, several users of neurotechnology devices presented their experiences. Congressman Patrick Kennedy also presented highlights of the NNTI—National Neurotechnology Initiative Act—a bill he co-sponsors, along with the importance of health care reform.

On to San Antonio, TX for the APTA (American Physical Therapy Association) Annual Conference where a team of presenters focused on neurotechnology education. The three hour session titled "Neurotechnology Fundamentals and Emerging Devices for the Treatment of Paralysis" featured an overview of neurotechnology, demonstrations from people who use devices, presentations of devices in development and feedback on the barriers of acceptance in the physical therapy profession. More details of this session including a final report and observations are available on [this dedicated webpage](#).

The 2008 Neural Interfaces Conference in Cleveland, OH featured a session dedicated to the SCI consumer community. With a demonstration from Maria Sutter who uses her implanted hand system developed by the Cleveland FES Center, she discussed the benefits and challenges of the system. This was followed by Dr. Kim Anderson presenting her findings of priorities from the SCI population. More about this session and other educational presentations, visit our [Educate Page](#). Look for Neurotech Network leading the way to more events through the Neurotechnology Education Series. Corporate Sponsorship opportunities are available by contacting Jennifer French.

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## Adaptive Control Methods Transform Neuroprosthetics

Currently, most of the systems on the market for neural prostheses and neurorehabilitation make use of electronic controllers that send regular signals to surface or implanted electrodes. Neural engineers at several research institutions and commercial firms are developing new systems that will be able to modify control signals automatically based on sensory feedback, discerned user intent, or adaptive algorithms that are modified on the fly.

One of the first categories of neuroprosthetics to employ adaptive control is foot-drop stimulators. The NESS L300 system from [Bioness](#) incorporates a gait sensor that adjusts control signals to accommodate uneven surfaces and changes in elevation. [Victrom](#)'s implantable NeuroStep device incorporates a sensing cuff electrode that is used to detect afferent signals generated by mechanoreceptors in the foot.

[The Center for Adaptive Neural Systems](#) at Arizona State University is currently pursuing several research projects that may have commercial applications in neuroprosthetics and neurorehabilitation. One project involves adaptive electrical stimulation for locomotor retraining, which seeks to improve outcomes for locomotor therapy following spinal cord injury. The research team, led by Jimmy Abbas and Ranu Jung, wants to use more appropriately timed muscle contractions and generate more repeatable movement patterns on a treadmill.

Abbas has spun off a commercial firm called [customKYnetics Inc.](#), which is developing a portable home-based stimulation system incorporating adaptive control. The ASU researchers make use of the entrainment of oscillations phenomenon to design algorithms and electronic circuits that mimic the functionality of neuromotor control systems.

A second commercial spinoff from the lab, [Advensys LLC](#), received a \$1 million grant from the U.S. Army to develop powered limb splints that can be used in combat settings to provide bipedal mobility to injured soldiers. Founded in 2004 by Ranu Jung, the company seeks to commercialize a suite of products to provide new orthotic and prosthetic options for people with lower limb dysfunction or lower limb amputation. The products will integrate biologically-inspired adaptive neuromorphic control systems technology with biomorphic compliant actuators, sensor systems, and lightweight orthotic/prosthetic components. Advensys' first product, NOCS (neuromorphic orthotic control system), is a prototype control system based on neuromorphic principles that senses and controls an active powered orthosis for the lower extremity.

The Center for Adaptive Neural Systems recently received a \$3.3 million bioengineering research partnership award from the National Institute for Biomedical Imaging and Bioengineering for neural-enabled prostheses that make use of sensorimotor integration.

The project proposes to develop a prosthetic system with electrodes implanted within the fascicles of peripheral nerves to provide upper extremity amputees with sensory feedback and active volitional control. The ASU team and its partners at the Mayo Clinic Arizona and two commercial firms seek to elicit meaningful sensations of hand opening and grip force. The team will then focus on using the neural interface to provide both sensation and control. A key feature will be bidirectional communication at speeds that enable real-time sensorimotor control of the prosthesis.

*Commentary provided by Jim Cavuoto, Neurotech Reports*

## Updates from the Neurotech Awareness Coalition

The Neurotech Awareness Coalition is a collaboration of industry and non-profit organizations with three directives:

1. to change public policy,
2. to increase public awareness, and
3. to outreach directly to consumers and medical professionals.

We capitalize on the expertise of partnering organizations to address regulatory, access and awareness issues. We invite you to learn more by visiting this website, [Neurotech Awareness Coalition](#). The larger the coalition, the greater positive impact on the neurotech marketplace and the potential to improve the lives of people living with neurological impairments. An organizational update will be presented at the [Neurotech Leaders Forum](#) on Oct 23-24, 2008.

*Join these organizations in this important effort to break down the barriers to exponential growth in the neurotechnology industry.*

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